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CONTRIBUTIONS

TO

THE BIOLOGY OF THE DANISH CULICIDÆ

BY

C. WESENBERG-LUND

WITH 21 PLATES AND 19 FIGURES IN THE TEXT

D. Kgl. Danske Vidensk. Selsk. Skrifter, naturv. og mathematisk Afd. 8. Række, VII, 1.

KØBENHAVN
HOVEDKOMMISSIONÆR: ANDR. FRED. HØST & SØN, KGL. HOF-BOGHANDEL
BIANCO LUNOS BOGTRYKKERI
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Preface.

The history of the work which I hereby take the liberty to offer to the scientific world has been rather peculiar. More than twenty years ago I saw that our temporary forest ponds which got water in November—December very often, a few days later, contained living mosquito larvæ; I saw that these larvæ hibernated under the ice and that they could be found again when the ice melted in the spring. To me it was rather an astonishing fact to find in 1900 air-breathing insect larvæ below the ice, locked out by the ice from the atmospherical air. In the following years I often visited the temporary ponds in spring and ascertained that they teemed with mosquito larvæ. Even the slightest study with a magnifying glass showed that these larvæ differed very much from the hibernating larvæ.

In the admirable chapter in "Histoire des insects" Réaumur has shown that *Culex pipiens* hibernates as imago and lays its eggs in batches, eggboats. In his work "History of Aquatic Insects" Miall has had nothing to add; as far as I know, Réaumur's exposition of the biology of *C. pipiens* has for more than a century been used as a model of the development of all mosquitoes. In accordance with this fact year after year I searched for the eggboats in the temporary ponds of our forests; I never saw a single one.

In the following years I slowly came to understand that there was also upon another point a striking discrepancy between what we have learned and what I found out on studying Nature herself. Scientists as well as ordinary people have all been inclined to suppose that a great number of generations are hatched during the year. Without any more thorough exploration I felt sure that most of the mosquitoes really had only one single generation. In the spring of 1905 I tried to hatch the above-named two mosquitoes, the one with the hibernating larvæ, and the one with the larvæ which only appeared after the ice had melted; the former larva had very large antennæ and a long sipho; the latter very small antennæ and a very short sipho; of course I got two species of mosquitoes; but the one with the hibernating larva was unquestionably new to our fauna. Having however taken material from different forest ponds, to my astonishment I saw that those mosquitoes which derived from the hibernating larvæ always gave the same species, whereas those deriving from the larvæ in spring, gave specimens which unquestionably belonged to two or three different species.

I now understood that here was a very wide field for further exploration; as however a long series of papers: my plancton work, many papers relating to the biology of freshwater insects, and the bathymetrical explorations of the Furesö-district first had to be carried out, I could only at rare intervals get time for these observations during the 10 years from 1905 to 1915. Still the mosquito studies were not quite laid aside, and in 1916 a more thorough study of the mosquito larvæ and their biology began. In 1912 the first volume of the great work of Howard, Dyar and Knab relating to the mosquitoes of North and Central-America appeared; the volume did not reach me before 1916. I immediately saw that all my above-named more cursory conjectures were indeed correct, but also, that if published they could not be regarded with any really new interest.

In the time from 1910—1920 a series of shorter papers, dealing with the biology of the European species, appeared, and the biological facts, mentioned by the American authors, were generally corroborated by the European ones. In my opinion this literature very often by no means comes up to the standard which should be exacted for scientific work.

After brief reflection I resolved that I would carry to an end my own studies in spite of the whole American and European literature, and moreover that during the study I would not take the slightest notice of it. My leading scientific views were the following.

From a purely scientific point of view, I have always regarded the question, who first made a biological observation as a matter of sublime indifference. It must never be forgotten, that even with regard to biological observations which can only rarely be committed to paper with the same convincing exactness as an anatomical structure, the exact apprehension of a given fact can only be acquired through repeated observation. It is further of the greatest significance that the biological observations are tested by different scientists and in different latitudes; only in that way can our suppositions and hypotheses be registered among real scientific facts. It must further be remembered that the study of Nature must always begin with the slightest possible literary ballast. He who has first crammed his head with all that has been written upon a subject, will at the moment of observation, when standing face to face with Nature, soon understand that his whole learning is only felt as a burden and restricts his power of observation. I for my own part have always been of the opinion that it is exactly the smallest equipment of human knowledge which gives the greatest peace in my studies, creates the scientific sovereignty over observations and thoughts and — as far as possible — moves the milestones of time nearer to the borders of eternity.

Having used the neighbourhood round Hilleröd for more than twenty-five years for my studies relating to the freshwater organisms, and often visiting the hundreds of temporary ponds which were scattered within a radius of about 7 kilom. over the country, especially in the forest, I had a rather extensive knowledge of these ponds; having often hatched larva material from many of these ponds, I knew well which would give the best results, if more thoroughly studied. In accordance with this knowledge twenty-five temporary forest ponds were selected, and in the time 1916—1919 subjected to a regular fortnightly exploration. After the establishment of the Freshwater Biological Laboratory at Tjustrup lake, near Sorö, in the middle of Seeland, I soon found 15 other ponds, mainly belonging to the open meadows and large plains which were simultaneously included in the exploration. The ponds were explored every fortnight, viz. during the winter, when the ponds were frozen and covered with snow, at longer intervals, but in spring, when the different larvæ appeared, and the imagines arrived, as often as possible, i. e. many of them almost every day. The ponds were so selected that in the course of a single excursion I could reach from five to seven. On schemata the results of every excursion were noted and observations with regard to the freezing and drying periods taken down. At first I took the temperature of the ponds, but later on I learned that this was quite useless; on sunny days the temperature might be about thirty degrees Celsius, the next day, if the weather was cold and rainy, only about ten. The temperatures could only acquire, scientific significance if I had been able to indicate the total sum of heat-units which in the course of the year was conveyed to the ponds. As this was impossible, the temperatures were not regularly taken.

In 1916 I thought that I should only find very few mosquitoes in the different ponds; in Denmark we had hitherto, viz: STÆGER in his valuable old work: Systematisk Fortegnelse over de i Danmark hidtil fundne Diptera, only found ten species of *Culicini* and of these two were doubtful (*C. annulipes* Meig. and *C. nigripes* Zett.) and one restricted to brackish water; the greatest number that I could expect to find, in my area of distribution, was therefore only seven. At that time I had not the slightest idea that the determination would cause troublesome difficulties. I supposed that I could only expect to clear up the biology of the well known species: *C. nemorosus* Meig., *cantans* Meig., *ornatus* Meig., *pipiens* Linné and *annulatus* Schrank; further I did not know that the larvæ of these species practically speaking were quite unknown, or at all events insufficiently described; the valuable work of MEINERT: De eucephale Myggelarver 1886, deals only slightly with the larvæ of *Culicini*. Already in 1916 I understood that this number would be augmented with several new species, but the determination of these species was quite impossible to me. A closer examination of the large larva material from the many ponds, worked out in the winter months, showed that there were especially some ponds, which must be examined with special care next year. In 1917 these ponds were examined almost weekly from 15 April to the first part of July. In this time I then saw from five to seven species appear and disappear after each other. Some of them were detected in the larva stage, separated in this stage, and then hatched in special vessels; others appeared from larva material which I first thought was homogeneous. In 1917 I had demonstrated about 15 different species, and in 1918 I tried to elucidate the biology of all these species. To my great satisfaction I saw that I almost always might be sure that the different species year after year were hatched in the same ponds and almost always at the same temperature. As the larvæ appeared in the ponds, they were separated, and about a hundred placed in a special vessel and the vessel set in a hatching cage. The skins were preserved and where I got a quite homogeneous imago material from a vessel, I was sure that I had the right connection between larva and imago.

In 1919 many doubtful questions were tried and tried again; and several of them were now nearer to being solved; especially the group *O. nemorosus*, was extremely troublesome. Again and again I came to the conclusion that there are species which may easily be distinguished in the imago stage, but which as larvæ cannot be distinguished from each other; further that there are species which as larvæ may be distinguished at a first glance, but as imagines are almost indistinguishable. At this time the final determination of the species was desirable; most of them at that time had only numbers. Having myself tried to determine the material, I saw, that if I used the ordinary works on the European mosquitoes for some of the most characteristic species, this gave no result. I then reguested my friend Prof. SIMON BENGTSON of Lund to compare some of my material with ZETTERSTEDT's specimens in Lund; as I however compared the determinations with my larva material I saw that somewhere there must be some mistake. I then sent some of the most troublesome species to Mr. EDWARDS at the British Museum and asked him to look them over. From him I got the wholly unexpected result that, in my material, there were no less than three American species: *O. abfichii* (Felt), *fletcheri* (Coquillet) and *diantæus* (H. D. K.), which have hitherto not been found in Europe; in a following collection Mr. EDWARDS then determined a fourth species *O. prodotes* (Dyar), which also hitherto was only found in America; this species I had overlooked; having examined the preserved larva material from the pond in which this species should have been hatched, I really found a very few highly characteristic larvæ which most probably belonged to this species. Next year these larvæ were found again in the same pond, separated and, when hatched, really gave *O. prodotes*. Later on it was found out by Mr. EDWARDS that *O. fletcheri* was identic with *O. lutescens* (F.) and *O. abfichii* with *O. excrucians* Wlk. Mr. EDWARDS further came to the same conclusion as I, that the old species *C. ornatus* Meig. could not be found in my material; those determined by STÆGER and now in the collection of the Royal Museum, Copenhagen, being partly *Culicella morsitans*, partly *C. communis*. As these species, apart from *O. prodotes*, which was studied in 1920, were separated as numbers already in 1918 and with regard to all biological data protocolled separately, it will be understood that with regard to the biology of the species, it was not of the slightest significance that they were not finally determined till 1919.

In 1920 two questions had to be solved before the work could be finished. As the two freshwater laboratories in Hilleröd and at Tjustrup were both situated far from the sea-shore, I had no opportunity to study the sea-shore mosquito fauna, where the habitat of *O. dorsalis* Meig., already found by STAEGER, really is.

It might further be expected, that here also we might find two other species *O. curriei* (Coquillet) an American species, already found in England, and *O. detritus* (Haliday). Both species were found. As almost all my studies hitherto had been restricted to Seeland, with some small trips to the southern islands, it was of interest to become acquainted with the mosquito fauna of Jutland.

My time now being occupied with the preparation of the work for print, I requested Mr. Kryger, whom I know as a very skilled observer, to follow the development of the mosquito life in the brackish-water pools near Copenhagen, and on a journey in Jutland to study mosquito life there. Mr. Kryger was also to gather information with regard to the occurrence of *Anopheles* in stables.

Staeger indicates 15 Culicidæ, of which one *C. nigripes* must unquestionably be cancelled. Thirteen new species have now been found for our fauna, this now consisting of twenty-five species. The new species are: *Ochlerotatus curriei* (Coquillet), *O. lutescens* (F.), *O. excrucians* (Wlk.), *O. detritus* (Haliday), *O. punctor* (Kirby), *O. prodotes* (Dyar), *O. rusticus* (Rossi), *O. diantæus* (Howard, Dyar and Knab), *O. sticticus* (Meig.), *Tæniorynchus Richardii* (Ficalbi), *Culicella morsitans* (Theobald), *Culex ciliaris* Linné, *C. nigritulus* Zetterstedt. Three of the species were new for Europe. Of these thirteen species I have myself found the twelve; *O. sticticus* has been brought me by Mr. Kryger from the western part of Jutland. Of the twenty-five species the twenty have been hatched from larvæ. Most of these larvæ have hitherto only been very badly described or were wholly unknown.

It will of course be understood that the exploration has taken much more time than I had thought, when I began. To a much higher degree than I had first thought the work had to be systematic. Gradually I understood that a redescription of the American species was necessary, that all the species of the *nemorosus-communis group* should be redescribed, and that all the larvæ had to be described and carefully delineated. It was very much against my wishes that I was forced into scientific work to which I have always been a stranger. I soon learned that my descriptions of the imagines would be best if I followed the descriptions by Howard, Dyar and Knab as closely as possible. Everywhere where it has been possible I have therefore followed the descriptions of imagines by these authors. Reference only to the work of Howard, Dyar and Knab was not possible, because slighter differences could almost always be detected. With regard to the description of larvæ the case is different; these are always wholly original, and it will be understood that new characters have been used and the older ones estimated in a way differing from that of earlier authors.

As stated above: What I had intended should be the main points of the work: the statements that almost all our mosquitoes only possess one single generation, and that the eggs of the *Aëdini* are laid singly and not in eggboats, have now been made by others. Now one of the main results of the exploration, a result which was not intended, when the exploration began, is probably, that the North- and Central-European mosquitoes should now be recognisable in the larva and imago stage;

in the pupa stage I do not think that they are so. I first intended in two extensive chapters to give biological sketches of each of the forty ponds, and of the neighbourhood where some of the more peculiar species are found; further to print the large schemes of each of the forty ponds, carried on for almost four years; the schemes show how each of the species appears and disappears in the course of the year. Especially these schemes were extremely expensive to print, and I suppose that their real scientific value is but slight; they may be regarded as rough draughts, and will not be printed owing to the great expense. — With regard to the synonyms I have only given the most necessary information; I refer to the work of LANG (1920) and to others which I know are under preparation.

As it will be understood from the foregoing pages, this work stands in the greatest debt to Mr. EDWARDS of the British Museum; I hereby express my most cordial thanks for all the help he has furnished me with; further to Prof. SIMON BENGTSON and, last but not least, to Mr. KRYGER who with great skill and warm interest has solved the tasks, I have given him. A few months before this work was sent to press, Mr. LANG's valuable work, relating to the British mosquitoes, appeared; more than any other it has shown that my paper, now published, issuing from quite different stand-points, and worked out on other principles, is by no means superfluous. Also the CARLSBERGFUND I bring my heartiest thanks for two sums, by means of which I was able to explore the southern islands, mainly with regard to the Anophilines. For the study of the living larvæ the excellent binoculary aquarium microscope, also presented to me by the CARLSBERGFUND, has been of the greatest value. All the tables are drawn by myself and all figures of the same kind are drawn with the same power and all with camera.

Key to the tables: 1 head (Leitz Ob. 3 Oc. 1) 2 antenna (Leitz Ob. 3 Oc. 6) 3 mandible (Leitz Ob. 3 Oc. 6) 4 maxilla (Leitz Ob. 3 Oc. 6) 5 mentum (Leitz Ob. 6 Oc. 1) 6 the last segments (Leitz Ob. 3 Oc. 1) 7 scales in comb (Zeiss hom. im. Oc. 6) 8 pecten (Zeiss Ob. B Oc. 6) 9 single thorns in pecten (Leitz 6 Oc. 6).

The Freshwater Biological Laboratory.
Hillerød. 10/9 1920.

I.
Culicines.

Chapter I.
Morphological Remarks.
a. The Larva.

In the following pages I have tried to elucidate some points in the anatomy of the Culicin larvæ and as far as possible compared the anatomical structures with the use the larva makes of them. The chapter deals only with our Danish mosquito fauna; it would certainly be desirable if the contents could be based upon larva material gathered in other regions of the world. In the terminology I have followed the excellent work of Howard, Dyar and Knab.

The Head of a mosquito larva is generally wider than it is long, rarely almost isodiametric as in *Finlaya geniculata*; it may be rectangular as in *Tæniorynchus*; it is commonly vaulted, but may be flattened (*Tæniorynchus*) or, as in some of the species of the genus *Ochlerotatus*, semiglobular. The anterior margin is formed by a narrow clypeus furnished with two stout spines, between which the labrum is attached. The greater part of the upper surface of the head carapace is occupied by the front or epistome. It bears a number of setæ, the number and arrangement of which are of significance for classification (Knab 1904 p. 175). Apart from some small tufts, the epistome almost always bears three pairs of tufts, the preantennal tufts, at the root of the antennæ, provided with many and often long hairs; only in *Finlaya* there are three; the two other pairs are either arranged in an arch over the epistome or they are arranged on two lines anterior posteriorly. They are then described as lower and upper frontal tufts. These tufts are rarely multiple in the Danish species. The number of hairs is greatest in the genus *Culicella* (five or six) *Culex*, *Theobaldia* and *Aëdes*. In the genus *Ochlerotatus* the number is commonly only from four to one. The hair formula: two strong hairs in lower frontal tuft and four in the upper, is characteristic of the group *O. excrucians, cantans, lutescens, annulipes*. In *O. diantæus* the arrangement of hair-tufts and their number of hairs are more in accordance with that of the genus *Culicella*. There is always most hairs in the upper frontal tuft; the highest number I have found, is six (*C. morsitans*) in *Theobaldia annulata* commonly four. The lower frontal tufts have generally three or two, but these hairs are stronger than those of the upper frontal tufts. In some species, *O. prodotes* and *caspius*, the number of hairs in both tufts is restricted to one single long hair; *Finlaya geniculata* has two in the upper and one single hair in the lower frontal tuft. In *Tæniorhynchus Richardi* the upper frontal tuft is lacking; in *T. annulata* we find an additional lateral, strong, tuft in the notch between eyes and antenna. Often and especially in *Tæniorhynchus* we find small multiple tufts between the above-named larger ones; these tufts are not marked because they are rather inconstant. The epistome has often drawings, different among the different species, but remarkably constant in the same. I refer especially to the tables of *T. annulata*, *O. rusticus* a. o. The colour of the epistome is commonly either grey or yellowish red. When in spring the drying ponds in our woodlands teem with the large, grey larvæ of *O. communis, prodotes* a. o., ready to pupate, we almost always find, scattered in the swarms, many, smaller larvæ differing by their yellowish red heads from these larvæ; these larvæ with red heads belong to *O. cantans* which will shortly, when the others have disappeared, predominate in the ponds.

The mosquito larvæ have commonly two pairs of compound lateral eyes, ocelli, like those of other aquatic insect larvæ, being absent; in the *Tæniorhynchus* larvæ, living at the bottom of the ponds, between the roots and almost in total darkness, we find only a single pair of very small eyes. The outer form of the two pair of lateral eyes is different in the different stages of the larvæ; in the same species they are often almost separated by a narrow band; the posterior pair has as a rule not been marked in the figures.

The Antennæ consist of a single piece; they are remarkably stiff and possess only very slight mobility; their length differs greatly, commonly they are half as long but often as long as the head; in *F. geniculata* they are extremely short, only one fourth of the length of the head; in some species, as *C. pipiens* and *C. nigritulus*, they are longer than the head, and in *Culicella morsitans* and *Tæniorhynchus Richardi* more than three times longer. In the short antennated species the antennæ are almost straight, only slightly curved. Where the antennæ are very long, they are especially, as in *C. morsitans*, elegantly curved, forming together two large, downward directed arches before the head. The antennæ always taper at the apex and in the middle of the shaft or about two-thirds from the base of the shaft, often, in a constricted part of the antenna, is inserted a fan-shaped tuft of long, commonly feathered hairs. In *Ochlerotatus, Theobaldia* and *Aëdes cinereus* they are inserted directly on the antenna, in *Culicella* on a conspicuous notch. The development of the tuft is very various; in *Finlaya geniculata* it consists of only one single unfeathered hair; commonly, as in most species of the gen. *Ochlerotatus* it has only from five to seven hairs; but in *Culex pipiens, C. nigritulus, Culicella morsitans, O. diantæus* and *Tæniorhynchus* the number is from twenty to thirty; here too, the single hairs are very long, forming in these species two large wheels with feathered spokes. When the larva is hanging from the surface or from a plant, the tuft is always folded out; a movement of the single rays is rarely observed, but I have often seen the whole wheel suddenly thrown inwards or viçe versa. The part of the antenna from tuft to apex is almost always narrower than that from tuft to base; generally it is stiff, but in *Tœniorhynchus* it is modified into a very long, extremely flexible flagellum, bearing a single bristle near the tuft, but ending without any hairs at the apex. — The outer part of the antenna is almost always (except *F. geniculata*) of a much darker colour than the inner part. In *C. morsitans* the inner part is of an elegant ivory-white shining colour, strongly contrasting with the almost black outer part. At the apex the antenna carries a different number of shorter or longer hairs, two of which are as a rule inserted a little from the apex, the others at the apex itself; the latter further carries one or two digit-shaped soft organs, undoubtedly of sensory function.

When we remember that all our Culicin larvæ are almost of the same size, and only a few of them half as long as the largest, further, that the larva of *F. geniculata,* almost of the same size as *C. morsitans,* has antennæ which are only about one-forth of the length of those of *C. morsitans,* it is evident that these organs must play a very conspicuous rôle in the economy of the larva. As far as I can see, they are commonly but slightly developed in those species which live in extremely small water volumina (tree-holes, water reservoirs of plants etc.); they are also small in those species which mainly find their food at the bottom of the ponds or upon plants; with regard to the large, beautiful, many-rayed tufts, which occur in those species that find their food in the water layers, where they produce a circulation in the water by means of the fan-shaped lateral hairtufts of the labrum, I have got the impression, that these large wheels bound a little water area, in which the water currents produced by the labrum come in; the large wheels act as filters, preventing too large particles from entering the area immediately before the mouth parts. I assume this, because I have seen the wheels, when too large a particle has struck against them, turn suddenly round and jerk away the particles. It may be added that the antennæ, especially in the lower part, are spinose; antennæ without any spinosity we only find in *F. geniculata.*

The Thorax, consisting of three fused body segments, is always broad and flat; the integument is membraneous, often furnished with two deep, longitudinal furrows. Along the anterior and lateral margin long hairs, single or in tufts, are inserted. The arrangement of the hairs, single or in tufts, of the anterior margin, is of value as a means of classification. In the description of the larvæ I have used this character and by means of figures given the hairs their number and position. The hair formula of *C. morsitans* 231124421132 is to be understood in the following way: In the median line two hairtufts, consisting of four hairs; laterally two double; they are followed by two single hairs; then follows a tuft with three hairs, and at the extreme end a tuft with two hairs; twelve hairs or hair-tufts on the frontal margin may probably be the original number, but now and then one or other of these tufts are suppressed. The number is almost always largest in the median tuft, commonly three or four; then follows almost always a series of three or four single or double hairs, and lastly at the anterior corner of the thorax a tuft of from two to five hairs; these frontal hairs are all long, stiff hairs, directed laterally and protruding beyond the brushes; in some species of the genus *Ochlerotatus* the median tuft consists of one long hair and two or three very short ones; the second tuft often consists either of one or two very short hairs, which may easily be overlooked. The lateral hairs are arranged in two large tufts, occupying the middle and hindangles. As Howard, Dyar and Knab indicate, they are situated on low tubercles and prevented from bending backward by a smal chitinuous plate. Near both tufts very long stiff single hairs are often inserted. On the dorsal side of the thorax we often find a number of small tufts of hair, commonly serially arranged; most probably they very often fall off after the moult; generally they have not been indicated in the figures.

The Abdomen is long, slender and cylindrical; it consists of nine segments. The integument is membraneous, except that of the ninth segment; still it is much thicker on the dorsal than on the ventral side; between the segments the integument is very thin and delicate; the first segments are always shorter and broader than the following ones, the seventh is commonly the longest; on the lateral borders we find tubercles which support the lateral hairs. As it is well known, the motion of the abdomen is extremely high; the motion of the body is always sidewise, never dorso-ventral; when the animal is to rise from the bottom, the position of the body is vertical and the body is wriggled sidewise upwards; respiratory movements of the abdomen, as it is well known in the larvæ of *Chironomidæ*, *Phryganidæ*, a. o. have never been observed. The six first segments bear long setæ on lateral tubercles; the number is greatest on the two first, on the others commonly only one or two; on the dorsal side we find the so-called subdorsal hairs, shorter hairs arranged in two series, and most strongly developed from the third to the sixth segment. They are often wanting; mostly their number is two; in our Danish species they are generally rather inconspicuous and are well developed only in one single species, the one of the tree-holes *F. geniculata*; further, fairly well in the Danish species of genus *Culex* especially *C. nigritulus*. In *F. geniculata* every segment, from the first to the seventh, bears three pairs of setæ, an anterior, a median and a posterior one; the median pair is best developed and consists of four hairs in stellate arrangement. Owing to these groups of hairs the whole larva has a very hairy appearance.

According to drawings and descriptions of tropical larvæ it seems that luxurious development of subdorsal hairs and hairs upon the thorax, mostly in stellate arrangement, is a very common trait in larvæ living in tree-holes and in water reservoirs in Bromeliaceæ and other plants. — At the base of the lateral hairs, groups of shorter hairs are often to be found. The development of hairs upon segment seven is not so luxurious as on the preceding segments.

The eighth segment is short and bears dorsally the sipho or respiratory tube; it bears three hair-tufts, one dorsally, one ventrally and one posteriorly in the cleft between the sipho and the anal segment; long stiff single hairs in varying numbers are implanted between these tufts; the posterior tuft is best developed and always feathered, but all in all the place and the development of these hair-tufts are so constant that they cannot be used as characters for classification. A peculiar structure is the lateral groups of spines or scales; these scales are either arranged in a single line, as is the case with *Finlaya geniculata* and *Tæniorhynchus*, often, but not always, with *A. cinereus*, or in irregular arched series, covering a triangular spot on the sides of the eighth segment; the largest number of scales is always in the anterior rows. The number of scales is very different in the species, but fairly constant in the same. It is only about from ten to twelwe in *F. geniculata*, *Tæniorhynchus Richardi*; commonly from twenty to forty in most of the Danish species of the genus *Ochlerotatus*, but about one hundred in *C. morsitans*; it seems as if the number is greatest in those species which have the longest siphones and the best development of the flabellæ. The base of the scales is always spatulated; they are often provided with one strong spine, two shorter laterally, and many shorter ones bordering the sides of the spatulated part; they may also as in some of the species of *Ochlerotatus* be broad plates, ending in from five to seven thorn-like prolongations of equal length. They are often laterally covered with a delicate, hyaline membrane, radiated along the borders. Their number, position and form are of great value as characters for classification; in the systematical descriptions they are determined as the comb. The significance of the comb for the animal is in my opinion quite enigmatical. The median spines of the scales may be rather long and very acute; still it is rather difficult to understand, how they can be a weapon for the larvæ; where there are many scales, the comb impresses me as a carding apparatus, but I am unable to see, how the animal should use such an organ.

Dorsally the eighth segment carries one of the most interesting organs of the Culicin larvæ, the sipho; this is always strongly chitinized, of a dark brown or yellow colour; nearest to the base it has almost always a strong chitinized black ring. If we compare Tab. XIX of *C. morsitans* with Tab. II of *C. caspius* we shall see the great difference with regard to the dimensions even in a fauna so small as the Danish one. It is commonly about three times longer than broad but may, as is the case of *C. morsitans*, *C. pipiens* and *C. nigritulus*, be from five to seven times longer than broad; it is extremely short, almost inflated, in *O. caspius*. At the apex we find an opening through which the larva takes air into its tracheæ. The sipho is closed by a set of five flaps; when the larva comes up to the surface, the flaps pierce the surface of the water; then they are folded out and pressed against it; by means of the surface film the larvæ hang down from the surface and draw the air into the tracheæ. When I have had different species isolated in vessels and have examined the surface, from which the larvæ were hanging, with the binoculary aquarium microscope I got the impression that the stars which the five flaps formed upon the surface had quite a different aspect in the different species. The form of the flaps and their bristles differ from species to species; but this can only be thoroughly studied when the larvæ are killed with the flaps open, the sipho cut off and arranged vertically on the slide, so that it is possible to look directly downwards at the apex of the sipho. This is a very difficult process.

The sipho carries hairs and thorns in different arrangement. On the basal third of the sipho are inserted two ventro-lateral series of spines, commonly determined as pecten. This organ is of great value for classification. It commonly consists of from twenty to thirty strongly chitinized spines, arranged on a line and at almost the same distance from each other; at the base they are dentated, carrying from one to six teeth; they may be flattened as is the case with *F. geniculata, C. morsitans, C. pipiens* and *nigritulus*, formed here as oblique feathered scales of brighter, almost yellowish chitin. In *Theobaldia annulata* we find no thorns, but only a series of long soft hairs, without any teeth at the base. In some species the last thorns, those nearest to the apex of the sipho, are at a larger distance from each other than the following; they are not dentated and often inserted out of line (*Aëdes cinereus, O. diantœus, O. lutescens, excrucians, diversus, prodotes*). The position of these spines varies from species to species. In *Tæniorhyncus* the pecten is wanting (see remarks later on). Also the function of this organ is quite enigmatical. It differs from species to species; that it should have no significance whatever I regard as highly improbable. It has so great a similarity to a comb that it must be regarded as fairly probable that it may be used as an organ, by means of which the different hair-tufts may be cleaned. The hair-tufts of the sipho present some of the best structures for purposes of classification we have hitherto been able to find in the Culicin larvæ. According to the drawings published by Howard, Dyar and Knab the tufts may be arranged very differently from what I have seen in the relatively poor Danish fauna; for a more thorough study I refer the reader to the above-named tables. In the Danish larvæ the most constant tuft is the apical one, very near the apical end of the pecten. It consists of from five to seven feathered bristles. It may, as in *O. annulipes, lutescens* and *excrusians*, be highly developed or, as in *Aëdes*, be rather inconspicuous; it may be wholly absent, but we then find another, equally well developed, brush at the basal end of the pecten (*Theobaldia annulata, C. morsitans*). In *Culex pipiens* and *C. nigritulus* we find four or five tufts with two hairs generally arranged serially and ventrally, but with one or two of the tufts out of line. Only in *O. rusticus* four tufts of double hairs are inserted on the dorsal side of the air tube, opposite to the pecten. Dorsally near the apex is further inserted a short thorn; two of the flaps carry two short curved spines which are often used when the larvæ rest on the bottom with the dorsal face downwards, or when they are hanging from or supported by waterplants. With regard to the modifications of the eighth segment of *Tæniorhynchus* I refer to my paper (W.-L. 1918 p. 277).

The ninth segment or Anal Segment is out of plane and inserted upon the eighth segment. It is short, often almost isodiametrical, in *F. geniculata* shorter than broad, in *Tæniorhynchus* twice as long as broad. It is covered with a chitinous plate, short in the larva of the first stage, but in the fullgrown larva often rounding the whole segment, but mostly only covering about two-thirds of it. At the apex it bears the anus, surrounded by four anal or tracheal gills, four appendages varying in size individually. In ponds situated only a few meters from each other I have found in one of the ponds larvæ of *O. communis* with the gills only half as long as the anal segment; in another larvæ with gills more than three times as long; they seem to be most strongly developed in water which is extremely dark and peaty. In some species, f. i. *F. geniculata* and *C. pipiens*, two of them are much smaller than the two others. In *F. geniculata* they are remarkably broad, in *O. caspius* and *O. detritus* extremely short. Some authors regard these organs as having no respiratory value, as being only of locomotorical significance, but most suppose that their main function is really respiratory. (Babak 1912 p. 81; Lima 1914 p. 18). Koch (1918 p. 105) supposes that the chief function of the branchial leaflets is probably the absorption of oxygen, while the elimination of carbonic acid from the blood takes place through the body walls. Lima maintains that larvæ whose branchial leaflets show numerous tracheal ramifications, remain normally longer under water than those with only small ones, and that the former can live longer than the latter when they have no access to atmospherical air.

The anal segment further bears the most important organ of locomotion, the large swimming brushes; these are divided into two parts, the dorsal and the ventral brush; the dorsal is always the smallest in the Danish larvæ; it is inserted on two chitinous pieces; generally it consists of a coarse multiple tuft with rather long hairs; below this tuft are inserted two, often very long, stiff hairs to which, as in *T. annulata*, a few shorter ones may be added; in *F. geniculata*, *C. pipiens* and *C. nigritulus* it is replaced by a few long, stiff hairs. The ventral brush is more highly developed and inserted upon a system of chitin staffs, well described by Howard, Dyar and Knab. "The tufts of the ventral brush hinge upon slender, transverse strips of chitin and towards the middle, where the tufts are inserted, these strips are thickened and perforated. Outwardly these transverse strips are jointed to a pair of longitudinal strips. The tufts are not inserted exactly upon the median line, but alternately a little to one side or the other thus showing the bilateral origin of the structure" (1912 p. 89). The number of the tufts varies from one species to another; it is only about ten in *F. geniculata*, *C. pipiens* and *nigritulus* but more than twenty in *T. annulata*. Each tuft consists of an undivided arched basal part, bearing on its apex the hairs; this number is fairly constant for the different species; it is only two in *F. geniculata*, but about twenty in *T. annulata*; from seven to nine hairs would probably be the most common number. Before the real ventral swimming brush a number of much shorter tufts are often inserted; these are not supported by transversal chitin bands; among the Danish species these tufts are only wanting in *Finlaya geniculata* and *C. pipiens*; they are but slightly developed in *Tæniorhynchus*. Laterally between the dorsal and ventral brush on the above-named shield a short tuft consisting only of one or a few hairs is inserted; among the Danish species it is best developed in *F. geniculata*.

Mouth-parts: The labrum is divided into three parts: an unpaired median lobe, the palatum, and two large lateral lobes, flabellæ; the whole preantennal region of the head and the relations between the labial folds and the black-pigmented apodemes which enter the flabellæ and to which the muscles are fastened are well described by THOMPSON (1905 p. 145). Here we shall restrict ourselves to some remarks with regard to the different development of the hair-coating in the different species.

As far as I can see, we find two quite different types of hair-structures on the labrum. In one group the hairs of the flabellæ are all of almost the same kind; long, soft, yellow hairs. Only the length of these hairs is very different in the different parts of the flabellæ. Sidewards and nearest to the outer margin of the flabellæ they are very long; inwardly and nearest to the palatum they are shorter and have another direction; those of the outer margin are held vertically on the longitudinal axis of the head, those of the inner margin are parallel with it. The large brushes are therefore divided into two parts, a horizontal and a vertical brush, which are separated from each other by a curve; this is most conspicuous in *C. morsitans, C. pipiens* and *nigritulus, Tæniorhynchus Richardi,* but it is also to be observed in *O. diantæus* and *Aëdes cinereus.* When these species, especially *C. morsitans,* are observed with the binoculary aquarium microscope, we see the large horizontal rami of the flabellæ regularly thrust out and in, being expanded and folded together; in the part held horizontally the hairs are pressed together and act against the water as a compact mass; in the part held vertically (the inner part) the hairs are spread out from each other during the stroke outwards, but undulating motions from without inwards may be observed during the strokes. By means of these undulating motions particles caught by the outer rami are carried downwards to the mandibles and then seized by them. We find this type of hair development on the labrum in all those species which, when undisturbed, always hang down from the surface and seek their food in the water layers. This food only consists of all the small particles floating in the water which, by means of the large lateral hairtufts, are carried with the water-currents down to the mouth.

In all other Danish mosquito larvæ we find quite another type of hairs and hairbrushes; the hairs are almost all equally long, there are no large, horizontally extended flabellæ; seen from above the whole apparatus conveys the impression of a compact brush with most hairs arranged in a circular row, inserted nearest to the edges of the brush. Further there is the great difference that the hairs nearest to the palatum have quite another form; they are elegantly curved, flattened, and bear upon their inner side from ten to twenty short teeth; the hairs are changed into combs, and the whole apparatus is a combing apparatus, mainly used in a way quite different to the corresponding one by the above-named species. Most of these larvæ hang down from the surface, producing water currents by the expanding and unfolding of the hairbrushes. Still they are also able to get their food in quite another way. Living in ponds, often with extremely small volumina of water, they go down to the bottom, where they brush and comb off the sedimented particles from the decaying leaves, using this material as food. It is a very common phenomenon to see these larvæ sink down to the bottom and, in an oblique position, with the hair-brushes expanded and pressed down to the substratum, steadily move over the leaves or along the sides of the aquaria. It is a remarkable fact that these two types of hair-brushes and the very different mode of getting food in the mosquito larvæ have hitherto been quite overlooked. It is the last-named form of the flabellæ which we mainly find in *Ochlerotatus*.

The hairs of the labrum as well as the short hairs on the palatum have probably also quite another function; they pay the double debt as organs of nutriment and of locomotion. Undisturbed most *Culex* larvæ hang down from the surface with the apex of the sipho supported by the surface film, and with the flabellæ whirling water currents into the mouth-parts. Apart from the flabellæ the body is motionless. Suddenly we see the larvæ, with the apex of the sipho in the surface, move slowly forward. In quite the same way we see the larvæ which seek their food, either on the sides of the aquaria or at the bottom, suddenly stand still, and suddenly, but slowly, move forward, the flabellæ being pressed down against the substratum. Many of the species are also able to move slowly forward in a peculiarly s l i d i n g manner in a horizontal direction in the free watermasses, stand still for a moment and then move onward again. Otherwise the free watermasses are commonly not the home of the mosquito larvæ; they are only traversed when the larvæ is to go from the bottom to the surface or vice versa. The way is traversed either actively by means of wriggling of the abdomen and of the swimming brushes or passively (see later); the active motion is mainly in a vertical direction with the head turned away and the tail in the direction of the locomotion; it is generally very rapid.

Now I have often thought that the above-named sliding motions were produced by the brushes of the last abdominal segment, but studying the organ in living larvæ under the binoculary aquarium microscope I have convinced myself that this locomotion is not produced by these organs. At all events the tail and its hairs are held quite motionless. There is therefore no other possibility but that the movements are due to the flabellæ. To me there is only this great difficulty that it is quite impossible to see why the organs, though almost always in constant motion, in some moments produce a motion of the whole body and in others, though still moved, produce not even the slightest movement of the body. I have tried with my best microscopes to study this in living animals, but I have been quite unable to see what the larva prepares to do, when it suddenly applies the organ to be used in the service of locomotion. I only feel convinced that it is not the hair-fringes on the mouth-parts which are used; it is the hairs of the flabellæ, which are suddenly either moved faster, or struck out in another direction. In the first year while I was always studying *C. morsitans*, which commonly in the autumn hangs down from the surface, I thought for a long time that the larva was in some way glued to the surface by the apex of the sipho and, without altering the use of the flabellæ, only moved when the agglutination ceased. Later on, when studying the other larvæ, I saw that this supposition was probably wrong. — Most probably the flabellæ have yet a third function; they certainly play a prominent rôle as organs which contribute to the renovation of water in in the neighbourhood of the larva.

The structure of the mandibles is rather complicated; they are well described by some earlier authors, especially HOWARD, DYAR and KNAB, but the use made of them is not clearly understood. They are almost hidden by the large, very broad maxillæ. The dorsal (inner) margin of the mandibles bears a system of thorns, setæ, and strong chitinised teeth, the arrangement of which is common to all mosquito larvæ. — Nearest to the outer angle some strong movable spines are inserted; the number (from two to four) of these spines varies from species to species; the inner margin is further equipped with a series of tubercles carrying thorns in very different states of development in the different species; these thorns are badly developed or almost absent in those species which find their food in the water layers, but strongly developed in those which mainly brush off the food from a substratum. In *T. annulata* the spines are comb-like with very long, curved teeth. On the inner side of the mandibles, parallel with the inner margin, an elegant fringe of long, soft hairs is inserted; they take their rise from a crescentic chitinous ridge; every hair in this fringe is kneed, and all always at the same distance from the crescentic ridge; therefore the whole fringe is kneed; also in the development of this fringe there is great difference in the different species; it is always largest in those species which only live upon suspended material; it may further be added, that the hairs in the fringe are much stronger, almost thorn-like, in those which live upon sedimented bottom material. The apices of the mandibles facing each other bear a number of dark, strongly chitinised teeth, and in front of them commonly a long, movable often dentated tooth; this part of the mandible varies from species to species; it is always chitinised, most strongly in the species living upon sedimented bottom material. Below the teeth we find a peculiarly shaped single or double fork-like lobe, with two constant hair-brushes. Between this lobe and the dark chitin teeth a series of hairs is inserted; these hairs are thorn-like in the bottom feeders. The three above-named parts: the strong spines on the outer angle, the fringe, and the chitin teeth below, play quite a different rôle in the act of feeding. Under the binoculary aquarium microscope it is easy to see, that the mandibles, whenever the flabellæ are folded together, with the above-named two or four spines on the outer angle are struck into the hair-brushes; when refolded, the hairs pass between the spines, acting as teeth between which the hairs are combed free from adherent particles. At the moment when the flabellæ are struck inwards, and the whole organ folded together, the mandibles meet each other in the middle line, and the above-named thorns form the combing apparatus; when removed the mandibles are thrown outwards.

The function of the fringe is most probably partly to bound the space in which the particles are swept down, partly to brush them downwards into the masticatory part of the mandible, the short sharp chitinous teeth between which the particles are to be masticated. The teeth, the rectangular lobe, and the feather-like bristles together with those from the opposite mandible encircle a space and cause every particle swept down into the lower part of the buccal cavity by the combing teeth and the fringe to be caught within this space from which it is not able to escape.

The maxillæ are large flattened plates; they are not of such a complicated structure as the mandibles, but as to form and equipment with hairs they differ in the different species more than the mandibles. They are often roughly conical, longer than broad, but may also, as in *T. annulata*, be broader than long. They are furnished with a longitudinal suture, and carry outwardly a small basal appendage, generally indicated as palpe. In all these species, which find their food in the water layers, living on suspended material, the apex of the maxillæ carries a long thick tuft of hairs; these hairs may be feathered as in *C. pipiens* and *nigritulus*; the same tuft may also be long in most of the species which partly seek their food on the bottom; still the tuft here is never so well developed, consisting as it does of shorter hairs; it may as in *T. annulata* be wholly absent. On the inner edge of the maxillæ is commonly inserted a series of long stiff hairs, and the whole space between the above-named suture and the inner margin is covered with a coating of long, soft hairs, now and then arranged in bands (*C. pipiens* and *nigritulus*). In *F. geniculata* the whole upper and inner part of the maxillæ are covered with a felted coating of very short hairs; outside the terminal brush is inserted a thorn-like hair, very conspicuous in *Tœniorhynchus*. The palpe bears on its top four or five, little digit-like prolongations undoubtedly of sensory function. The maxillæ cover the mouth from beneath; they are but slightly movable; when the catch- or brush apparatus of the labrum is not used, it is folded in, and the large maxillæ form the floor of the space, in which the labrum and the other mouth-parts are concealed. When the brushes are to be unfolded, the maxillæ are unclapped, then the brushes appear, and a moment later these begin to act. During the movement of the flabellæ the maxillæ are quite immovable; together with the long apical hair-brushes they border the space, in to which the particles are swept. It may further be observed that the two maxillæ never reach each other, but leave an open space between them; this is mostly covered by the above-named hairs along the inner margin; but lowest and nearest to the attachment of the maxillæ a triangular space is left hair-free. If now we direct our attention to this point on a feeding larva, we shall be able to see that an irregular row of small pellets passes through this little cleft. The pellets do not come at regular intervals, but irregularly, now and then in long chains. These pellets represent all the material swept down into the buccal cavity, which the larvæ are unable to use. We therefore see that these larvæ too are able to select out of the captured material what they wish to use; as, by means of the binoculary aquarium microscope, we are able to observe those pellets which pass the oesophagus and the swallowing movements during the feeding process, I have also noticed that there are periods in which all material, caught by the flabellæ, passes the above-named triangular space. At other times almost all material is swallowed.

Behind the sharp transverse ridge to which the maxillæ are attached we find the mental and labial structures. Mesially are found four chitinous structures, accounted for by RASCHKE (1887 p. 10) and MEINERT (1886 Tab. I. fig. 5) and mentioned in all works on mosquito larvæ: 1. a delicate, roughly triangular plate with a marginal hair-fringe and protruded into a long tooth at the middle. 2. behind this the mental sclerite, a heavily chitinised, dark, roughly triangular dentate plate. 3. behind this a complicated plate with teeth and spine-like structures, commonly regarded as labium and. 4. at the margin of the pharynx the hypopharynx, a simple chitinous cone (Howard, Dyar and Knab I. p. 87).

Of these organs No. 2, the mental sclerite or m e n t u m, is very conspicuous; it is commonly triangular, on its apex provided with a rather conspicuous thorn and with the sides bordered by a number of shorter spines; the form of the mentum and the number of lateral spines have some significance as a means of classification, and are therefore often mentioned in systematical descriptions. The Danish species of the Genus *Culex* may always be distinguished by means of its high form of the mentum with rectangular sides; *T. annulata* by its many small lateral teeth, and *Tæniorhynchus* by its very few large ones; in the genus *Ochlerotatus* it is triangular with about from ten to fifteen small teeth; as far as I can see, it cannot be used to distinguish the species of this genus from each other. Beneath the mentum is found the very peculiar organ (3) which has been figured by MEINERT (1886 Pl. I. fig. 5) and better by RASCHKE (1887 fig. 13. Tab. VI) but never thoroughly described; it consists of a tube, probably provided with a central pore. It is surrounded by a collar-like part, consisting of plates of chitin which overlap each other and are furnished with teeth along the edges. The organ rests upon a dome-like body, supported by two lists of chitin, and inwardly provided with a thorn-like process. Thorns of chitin are also present on the dome-like part. Meinert's drawing exhibits a circle of hairs rising from the apex of the tube; when cut horizontally, the organ shows a cushion-like layer of cells with large nucleï beneath the dome-like part. Two divergent muscles run to the organ, serving to push it forward and to retract it. Its appearance differs but little within the different Culicin larvæ.

How these four above-named different parts act, I do not know; I have never during the feeding process seen the mentum carry out any movement; the tube with the collar-like expansion lies directly at the entrance to the pharynx; I suppose it has a secretory function. The above-named pellets which leave the triangular space between the maxillæ during the movements of the flabellæ, are wrapped up in a mucous substance, and I suppose that it comes from the above-named pore. Further I call attention to some peculiar movements of the larva, easily to be observed and often figured in old as well as in new literature. When the larvæ are hanging down from the surface, we often see them release their hold; the body is bent, and the apex of the sipho is put into the mouth. In this position the larva sinks to the bottom, rests here for a moment and swims upwards to the surface again. I have often been surprised at the facility, with which the apex of the sipho, when it touches the surface-film, pierces it, and the rapidity with which the flaps are folded out. I suppose that the apex of the sipho is oiled and that the oil comes from the pore of the above-named tube. I have vainly tried to see if there is any real connection between tube and sipho and do not think that this is possible to observe, but I have often seen that the sipho is pierced into the buccal cavity, and that the flabellæ are folded round it. As far as I can understand, we have here to do with two processes: a cleaning and an oiling one, either one of them or most probably both: first a cleaning and then an oiling process.

With regard to the tracheal system, thoroughly described by Meinert (1886 p. 391) and by Raschke (1887 p. 16), I shall restrict myself to the following short remarks. The thickness of the tracheæ and the form of the transversal cuts differ widely in the different species; in some species they are circular, in others elliptical, the tracheæ being then converted into broad flattened bands; this more especially holds good for *F. geniculata*. In the thorax, in particular, the tracheal system presents great variations from species to species.

The tracheal system of the mosquito larva has a double function, respiratory and hydrostatical; the last-named in almost all mosquito larvæ is but slight. In recent years the respiration of the mosquito larvæ has been subjected to many valuable explorations (Babák 1912; Koch 1919; Krogh 1920).

Referring to this literature, dealing with problems which only touch the exploration which is here published, I shall only deal with a few points. Babák (1912 p. 84) as well as many others remark that during the ventilation of the tracheal system respiratory movements are wholly wanting. The most recent observations, (Krogh 1920 p. 95) confirm this. Some authors (Babák 1912 p. 85) suppose that the renovation of the air in the large tracheal trunks takes place owing to the strong movements of the abdomen, by means of the pulsation of the heart and owing to the movements of the intestine. Krogh (1920 p. 96) has however pointed out that all these movements do not suffice for the necessary ventilation and that we must try to find other ways if we are to understand the ventilation here and in all those insects where respiratory movements are not visible. Basing on his excellent studies on some large insect larvæ he has pointed out that diffusion alone is sufficient to produce the air transport in the tracheal trunks.

Babák (1912 p. 90) has shown that the two main tracheal trunks, when the larvæ are forced away from the surface, are flattened and emptied of air. With regard to the summer larvæ I have made quite the same observation. It is however in contradiction to an observation of Koch (1919 p. 467) according to which, instead of gradually emptying during submersion, the tracheæ are filled still more, and when they are quite full, small gas bubbles escape from the sipho which therefore is not always completely closed under water. The author supposes that this air cannot be oxygen, and that it must be regarded as air that has already been breathed and is now stored up in the tracheæ. Further observations are here necessary. I only wish to make the following remark: In the winter-larvæ of *C. morsitans* which for weeks hang down from the submerged leaflets of water plants without leaving their place I have never seen a flattening or emptying of the tracheæ; they are always filled with air and an air-bubble is often seen at the apex of the sipho.

In his interesting paper (1919 p. 463) KOCH, as one of his main results with regard to the respiration of the *Culex* larvæ, mentions the following: »Die *Culex*-Larven sind Saprozoen, die vorwiegend im Schmutzwasser leben, das infolge der sich darin abspielenden Fäulnes- und Zehrungsprosesse äusserst wenig freien Sauerstoff gelöst enthält. Die *Culex*-Larven können nur eine relativ kleine Menge Sauerstoffes bei der Submersion aus dem Wasser aufnehmen und zur Energieproduktion benutzen. Höher Partialdruck von O_2 (bei niedrigem CO_2-Gehalt) verlängert zwar die Zeit bis zum Eintritt der Lethargie, bietet aber nicht die Möglichkeit zu einer grösseren durchschnittlichen Energieproduktion sondern scheint im Gegenteil die Bedingungen dazu zu verschlechtern«. Most probably these statements are quite correct with regard to the larva of *C. pipiens*; it must however be maintained, that most probably they are quite wrong with regard to all those mosquito larvæ which live in natural ponds, often with green bottom, and cannot be correct with regard to the mosquito larvæ of those species which regularly hibernate under the ice. With regard to the respiration of these larvæ, I refer to *C. morsitans*. Like many before him KOCH has taken the biological and physiological results relating only to *C. pipiens* as a prototype for all mosquito-larvæ; this is in my opinion inadmissible.

Used hydrostatic the tracheal system in the mosquito larvæ has a locomotorical significance. The specific gravity of the mosquito larvæ is almost that of the surrounding medium; gravity compensation depends upon the size of the larvæ, the degree to which the intestine is filled with food, and the condition of the tracheæ; every one who has studied large and small mosquito larvæ in a vessel, has almost always had an opportunity to see that the larvæ of the first and second moult are mainly or often supercompensated; old larvæ after the last moult are very often undercompensated; it may further be shown that larvæ in Nature are very often supercompensated, in aquaria with a rich supply of food often or mainly undercompensated; if kept for days in pure water undercompensated larvæ will, as the intestine is emptied, be altered into supercompensated ones. With regard to the hydrostatic function of the tracheal system, KOCH arrives at the following result: »Der jeweilige Füllungsgrad der Tracheen bei *Culex*-Larven wird einzig und allein durch die physicalisch-chemischen Vorgänge bei der Atmung bestimmt; die dabei auftretende Gewichtsverschiebung, die wiederum eine bestimmte Änderung der passiven Geschwindigkeit der Larve nach sich zieht, ist nur eine Folge des Atmungsmechanismus, hat also keinen Selbstzweck. Der Füllungsgrad der Tracheen wirkt zwar mitbestimmend auf die passive Geschwindigkeit der *Culex*-Larven während der Submersion, es muss bei den die Hydrostatik bedingenden Faktoren in Rechnung gestellt werden, aber eine automatische Regulation der passiven Sink- und Steiggeschwindigkeit infolge Gasdiffusion durch die Tracheenwände wie bei *Corethra* findet bei *Culex*-Larven nicht statt".

Generally these statements are most probably quite correct; many of the experiments which KOCH has carried on, I have occasionally had an opportunity to observe. It is quite right that the larvæ of many mosquitoes, when they leave the bottom for the surface, rise slowly in a vertical position without any motion; the head is always downwards; that the sipho plays the rôle of "Schwimglocke" is most probably quite correct; many species, f. i. *C. morsitans*, can often be seen in quite the same manner sinking from the surface down to the bottom; but here the head is also directed downwards and not upwards as KOCH supposes; in this case the sipho has no significance as "Schwimglocke". With regard to *O. rusticus* I have very often seen the larva with an air-bubble at the top of the sipho rise vertically from the bottom and without making any actual movement reach the surface. But of this species I have also seen larvæ, which first passively sank downwards and then, before they reached the bottom, stood still for a moment in the water layers and then again passively rose to the surface. I have only observed this in this same larva; that the tracheal system in this case played a hydrostatical rôle is in my opinion unquestionable. I am inclined to suppose that the mosquito larvæ, with regard to the use of their tracheal system as a hydrostatical apparatus, differ from each other. A more thorough exploration of the tracheal system of the different mosquito larvæ and the greater or less use of it as a hydrostatic apparatus would probably give good results. It may further be pointed out that the most elaborate tracheal system is found in those larvæ which live under bad respiratory conditions (tree-holes, polluted water, on the bottom with the sipho pierced into the tissues of water plants, *Tæniorhynchus*). In these larvæ the tracheæ are more band-like, especially in the thorax, the meaning of which may probably be, that tracheæ of this structure are able to store up larger amounts of air than those whose transversal cuts are circular. We shall here only deal with the highly remarkable tracheal system of the *Tæniorhynchus* larva.

Between the thorax and the first abdominal segment are situated two large bladders. At the first glance these bladders resemble those of the *Corethra* larva, but differ from these in being connected with the two main tracheæ by two smaller, rectangularly curved tracheæ. The point of insertion is situated at the line between the thorax and the abdomen. Fig. 12 and 13 Tab. XV illustrates the description. It will be seen that the front parts of the bladders are furnished with some few, short, slender tracheæ, and that the two large longitudinal stems of the body are broad, band-like in the thorax and the first part of the abdomen. In fact these main tracheæ are double, their double derivation being still indicated by a longitudinal fold; in the thorax each of the two trunks is further divided by another fold. The result is two broad, flat, band-like bodies, terminating in front in three tracheæ, the first of which has a lateral course, whilst the second is directed forward and sends branches to the head; the third, inner, branch is smaller and communicates with that from the other side. In the abdomen each of the main tracheæ sends a smaller branch to the alimentary canal and a larger, outer one with branches in a star-like manner; one of these branches is stronger than the others and runs into the preceding segment. In the eighth segment a strong trachea branches off, running into the anal segment, sending out branches to the gills.

The function of this very peculiar tracheal system is difficult to understand. I have tried to understand the mode of action of this peculiar tracheal system, it being as far as I know unique among the insects. Later on Prof. Krogh has been kind enough to read my manuscript and has discussed the problem with me.

From the very broad band-like tracheal trunks it can only be concluded, that the larvæ must be able to produce a very powerful respiration. This may probably be of great significance for the larva, because the air in the plant from a respiratory point of view is a very bad medium, by no means rich in oxygen. This has been ascertained by Ege (1915 p. 183). The main result of his investigation is "that the composition of the air in the intercellular spaces of different aquatic plants is very variable. The oxygen percentage is low, rarely higher than 10 % and may especially in winter sink to about 1—2 % and even still less". When we remember that the larva probably fixes itself to the plant until September and probably detaches itself in May, the animal living as imago or egg during the time May—September, it will be understood that the larva is dependent on the plant air, especially at the season when the oxygen percentage is lowest. For a long time I therefore thought that the tracheal bladders might be used to pump the air from the plant into the body of the larva by pressure and dilatation. Prof. Krogh has now at my request been kind enough to go into the matter and tells me that this however cannot be the case. He pointed out that the larva, as far as he could see, made no visible respiratory motions. He varied the composition of the air in the intercellular spaces of the plant, but even then, if the amount of oxygen only was three per cent., no respiratory motions were traceable. If the larvæ got only nitrogen, all motion ceased and the brushes stopped; if then atmospherical air was again conducted through the plant, they were soon restored. If the larvæ were exposed to various different pressures, it could be shown that the tracheal system really would be somewhat compressed; but the compression of the tracheæ which was the result of the pressure, possible for the larvæ themselves to procure by the contraction of their body, (not more than 0·2 atmospheres), is so inconspicuous that it would be without any practical significance, even if the larva made respiratory motions. Furthermore it could be shown, that it was only the flat band-shaped tracheal trunks and not the bladders which were compressible.

It must therefore be taken for granted that the transport of oxygen from the plant to the larva only can take place by means of diffusion. The bladders on the tracheal system are said in *Tæniorhynchus* to have quite another function. They augment the respiratory surface and the amount of air which is at the disposal of the larva. Further they act hydrostatically; they diminish the weight of the animal, more especially of the anterior part, which would otherwise be much heavier than the posterior.

Moults. As far as we know hitherto, all mosquito larvæ moult four times and transform into pupa with the fourth moult; the moulting processes, the different aspects of the larvæ in the different larva stages, have been mentioned by different authors. I more especially refer to the very valuable paper by Eysell (1911 p. 320), to the remarks in Howard, Dyar and Knab (1912 p. 97), and to the most recent investigations by Lang (1920). The ripe larva ready to pupate is always easily recognisable, the body being more opaque; the compound eyes are dorsally drawn out into a sharp point, and the trumpets appear as dark spots below the larva skin and near the anterior angles of the thorax.

Here I only wish to call attention to a few facts, hitherto as far as I know overlooked.

It has been mentioned that two of our Culicin larvæ, *Culicella morsitans* and *Ochlerotatus rusticus*, hibernate in the larva stage. These larvæ are hatched in September or late autumn, but they have commonly passed the third moult before the winter sets in. The wintering generally takes place in the last larva stage before the pupation. In the long time from November—December to May—June when *C. morsitans* pupates, the larvæ, at all events in my aquaria, do not moult. The same remarkable fact I have observed with regard to the *Perlidæ*, *Ephemeridæ* and *Zygopteridæ*, which are hatched in autumn and are ready to leave the water in spring. In the course of the autumn as the temperature sinks they hasten to reach the last larva stage before winter sets in. It seems as if all these different insects are under the same law, that hibernation can best take place in the last larva stages. It is very remarkable that the first larva stages are often passed in the course of a few days, whereas the last may take more than a half year. The larvæ eat in the last moult as well as in the earlier; in the first, the result of the nutriment is growth and new moults, in the last there is no, or extremely little, growth. With regard to *Perlidæ* and *Ephemeridæ* the phenomenon is intelligible, because the reproductive organs ripen during the last months; in the last days before the nymphs leave the water, the abdomen bulges with ripe eggs. In the *Culicin* larvæ this is however not the case; here the process is by no means carried so far, the reproductive organs in the pupa too being only small; as far as we know the imagines of the Culicidæ regularly use a fortnight or more to ripen their eggs after metamorphosis.

Further it is peculiar to see how all the larvæ of the same species in a pond keep time with each other with regard to the moults; they are hatched almost on the same day and moult on the same day; in the course of a few days all larvæ are altered into pupæ and in one or two days all animals leave the pond as imagines. When therefore in these spring-ponds with older larvæ, new broods of larvæ in the first stage suddenly arrive, it has been ascertained, that these young very often belong to another species, the hatching temperature of which is higher than that of the first hatched. Only when heavy showers have raised the water line, and some eggs of the first-arrived species, have thus been reached by the water, it happens that new material of newly hatched larvæ of the very same species which now fills the pond with full grown larvæ, appears. Then it is interesting to see how fast the development of these newly hatched larvæ goes on; especially if the weather is fine, it happens that all larvæ, the old ones and the newly hatched, all pupate almost simultaneously; the old having taken about three weeks for their development, the others, only five or six days; this is of course due to the temperatures, by which the young larvæ have been hatched and lived their lives, which were much higher than those which regulated the rate of development of the older larvæ.

Especially the first larva stage is in spring passed in the course of a very short time, commonly only a few days. If we fill an aquarium with thousands of *O. communis* larvæ, in the course of a few days we shall find the bottom of the aquarium covered with thousands of small, black larva heads, provided with their egg breaking tooth and thus proclaiming themselves part of the skin of the first larva moult; of the rest of the skins we hardly ever see anything. Simultaneously we find in the larva swarms many larvæ with very large, broad, flattened and snow-white heads, which strongly contrast with the very short, dark and often almost black body of the larvæ. On more thorough study it proves that the head-carapace is moulted much earlier than the rest of the skin, and that the new skin, when leaving the old one, immediately after the moulting process, is rather dark, whereas the head preserves its snow-white colour for days.

Summary: If we combine the knowledge we have now gained of the structure of the Danish mosquito larvæ, with our knowledge of their life, we shall in my opinion come to the following result: From a biological point of view I suppose that our mosquito larvæ of the drying ponds may be divided into two groups: the surface- and the bottom dwellers. This must not be understood to mean that these two groups are quite distinct; on the contrary, they are connected with each other by a long, unbroken series of intermediate stages: What I wish to point out by means of the above-named statement is, that in these ponds there exist species which almost always hang down from the surface, and others which generally rest upon the bottom and only rarely come to the surface. Both groups use the atmospherical air for respiratory purposes, but to the latter group the respiration through the skin is of much greater significance than to the former; further the nutriment of the first-named group takes place when the larva is suspended from the surface, that of the last-named mainly from the bottom; the first-named group are plancton- and suspended detritus feeders; the last-named scrapes microscopical organisms and deposited detritus from the decaying leaves, or twigs, or seeks its nourishment in the diatom-coverings etc. upon living plants.

It is of course self-evident that animals which live their life in these two entirely different ways, cannot be constructed in the same way.

Larvæ which always hang down from the surface, taking in atmospherical air, need not resort to respiration through the skin. If we combine my own observations with regard to the biology and anatomy of our own little mosquito fauna with the remarks with regard to biology and the drawings in the large work of HOWARD, DYAR and KNAB, we shall come to the general result that we find the slightest development of the tracheal gills in the surface feeders, and the strongest development of these organs in the bottom feeders. Only where we have to do with larvæ which are really surface feeders, but hibernate below the ice and therefore for a great part of their life are shut out from the surface, do we find highly developed tracheal gills. Larvæ from brackish water *Ochlerotatus caspius*, *O. detritus* seem regularly to have very short, button-shaped tracheal gills.

As plancton-eaters the surface-dwellers must possess large, fanshaped organs, by means of which water currents, which carry the organisms and detritus into the mouth, are produced; this extremely fine material must further be caught by organs which are so constructed that the same water currents do not release it again. On the other hand the material is triturated to such a degree that a further subdivision is almost unnecessary; we therefore find that in the surface dwellers (*Culiceta morsitans*, *Culex pipiens*, *nigritulus*) the flabellæ of the labrum, the fringe of the mandibulæ, and the apical hair-tufts of the maxillæ are all highly developed, whereas the triturating part of the mandibles is always feebly developed.

On the other hand, in the bottom feeders, the material destined for nutriment is not suspended in the water layers, but of a much coarser solid condition, and must be scraped off from solid bodies and not, like suspended material, be whirled into the mouth; in accordance with that we find feebly developed flabellæ, with many of the hairs transformed into comb-bristles which we only rarely find developed in the surface dwellers; the fringes of the mandibulæ are more slightly developed, and the hair-tufts on the maxillæ may be wholly absent (*T. annulata*). On the other hand the inner edges of the mandibles are provided with strong thorns which may be dentated, and the triturating part of the mandibles is very strong.

With regard to the main organ of locomotion, the great swimming brushes, it would seem upon more superficial consideration, that this organ has not been influenced by the different mode of life in the two groups; still it must be pointed out that some of those larvæ which are very sluggish and live in extremely small water masses, such as *F. geniculata* or the great group *Sabethini*, have either very few hairs in the tufts of the swimming fan (*F. geniculata* only two) or totally lack the ventral fan (*Sabethini*). In many of the bottom feeders, f. i. *T. annulata*, we find a highly developed fan with a large number of hairs in the tuft (about fifteen).

Finally it may be pointed out that in the Danish fauna we always find the larvæ with the longest siphones among the surface dwellers, and those with the shortest among the bottom dwellers; further that pecten and comb in the surface dwellers differ very much from those of the bottom dwellers; as we are however quite unable to understand these structures, we cannot further comment on, though we are forced to pay attention to, these facts.

On the other hand it must be taken for granted that there is a connection between life conditions and larvæ structures on yet another point. In the bottom dwellers we find a remarkable development of special hairs on the apical part of the sipho which are either missing or only but slightly developed in the surface dwellers. These hairs play a certain rôle in the life of the bottom dwellers, providing them with points of support when they rest on the bottom with the dorsum downwards, or hang down from water plants.

b. The pupa.

It is a well-known fact that the pupa stage of the insects is mainly a resting-stage. In total repose, without any supply of food and often in darkness, the great alterations in external and internal anatomical structures are now to be accomplished. The power of locomotion in the pupa stage is therefore commonly very greatly restricted. Many pupæ are known to be quite unable to change their place. Some of them, more especially those which live in water, are able to make respiratory movements, oscillations with the abdomen (pupæ of *Chironomidæ* a. o.). The real power of changing locality is, if present, commonly restricted to the last days of the pupa life. At this time these pupæ push themselves out of their holes and corridors to be as near as possible to the air and the sun when the last ecdysis takes place.

In the *Culicidæ* we apparently find the most movable pupæ stages known in the whole animal kingdom. Strong power of locomotion demands a supply of food; it might therefore be expected that the mosquito pupæ would be able to take food; this is however not the case. The appendages of the head and thorax of the future fly is wholly enclosed in a common chitinous covering. This apparent physiological contradiction is in accordance with two facts which probably have not hitherto been sufficiently estimated. Firstly the pupa stage is extremely short; in the tropics there are species e. g. *Psorophora* which, according to Howard, Dyar and Knab, pass the pupa stage in a shorter time than one day, and even in our latitudes it does not regularly last more than a few days. In periods of very cold and rainy weather the pupa stage can be prolonged beyond a week or more, but this is against the rule. Only once have I in my laboratory seen the pupa stage prolonged beyond three weeks; these pupæ belonged to the last broods of *C. pipiens*, taken as larvæ into the laboratory on October the fifth; pupæ arriving on October the tenth, lived even on the fifth of November; a few reached the imago stage, but the others died. The temperature of the room was not more than 10° C. and for a week always less than 5° C.

Leaving a more thorough description of the mode of locomotion for a later paragraph, we will here restrict ourselves to the following remarks. It may generally be maintained that we have highly overrated the power of locomotion.

Howard, Dyar and Knab (1912 p. 98) write as follows: "The pupa is active and capable of moving rapidly through the water" further: "The pupa is very easily alarmed and at the appearance of a shadow or at a slight disturbance of the water, it immediately darts towards the bottom". The statements are in accordance with the common opinion and contain also what can be termed half of the truth, but the thesis gives no expression to the other half.

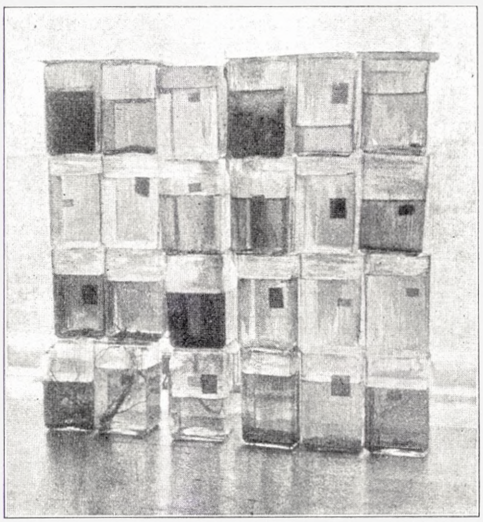
It must be remembered that the mosquitoes pass from larvæ to pupæ immediately below the surface, live their whole life as pupæ in the same locality, and even pass the last ecdysis from pupæ to imagines in the very same place. As far as I know this is not the case with any other insects but the mosquitoes.

If we keep mosquito pupæ in aquaria, it can be shown that voluntarily they never leave the point of support which they have once acquired, that is to say: if the acquarium is never moved and if it always stands in the shade. I have in my aquaria reared imagines from pupæ which most probably have never made a single somersault movement. I suppose that even in Nature it may happen that many pupæ moult without having made more than very few movements.

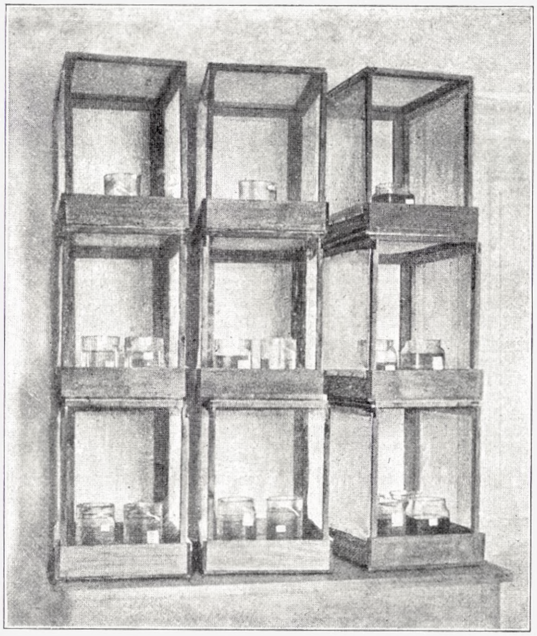
If we observe a pond where almost the whole swarm rests as pupæ in the surface, we see, in fact, that the single individual moves very little and that there are long pauses when we see no movement at all. Only two alterations in the surrounding medium: different light reflexes and disturbing agencies of the water layers, are able to make the pupæ release their hold and alter their place below the surface. The light reflexes are especially brought about by sunbeams which suddenly strike the surface of the pond from a cloudy sky. As highly phototactic the pupæ often arrange themselves after a line, corresponding with the edges of the sunbeams in relation to the shadow. The pupæ are directed by their highly developed compound eyes which do undoubtedly function, a remarkable feature by which the mosquito pupæ diverge from most insect pupæ.

The disturbing agencies are mainly heavy raindrops, the circles of which produce a curious influence upon the swarm, and enemies of the pupæ; of these they have mainly three kinds. The *Hydrometridæ* pounce upon the pupæ from above and insert their rostrum in the cephalothorax. It is very remarkable to observe how numerously the *Hydrometridæ* appear upon ponds where most of the swarms have been altered into pupæ; how suddenly they appear, and how suddenly they disappear again as soon as the pupæ have been hatched. From below the pupæ are preyed upon by *Notonectidæ* and the larvæ of various *Dytiscidæ*, more especially by those belonging to the genus *Rhantus* which are always found in great numbers in mosquito ponds; it seems as if their whole existence is dependent on mosquito larvæ and pupæ, their whole development coinciding with the development of the mosquito larvæ; this coincidence is adjusted to such a degree that the Dytiscid larvæ and mosquito larvæ follow each other with regard to the single ecdysis; it is a very curious picture to see the Dytiscid larvæ, black with white venters, on a morning when the total number of mosquitoes in an almost dry pond have suddenly left the water, cross the water-masses like sharks in search of that prey which they were deprived of almost at once, and which even on the foregoing day was found in enormous masses. Then the larvæ have only one thing to do: to dig their holes near the borders of the pond and pupate.

It is further of interest to see how the larvæ of a pond which belong to the same species almost all follow each other with regard to the rate of development. In periods of cold rainy weather the larvæ can be forced towards their last ecdysis and then stop in their further development, awaiting the days when the temperature is higher, when it is bright sunshine and calm weather. When such days come, suddenly the whole bulk of larvæ are transformed into pupæ in the course



Textfig. 1. My mosquito cultures.



Textfig. 2. My mosquito cages.

of only a very few hours. When at nine o'clock in the morning I have passed one of my experimental ponds, I have often found several larvæ; when at twelve o'clock I passed the pond again, the majority of the larvæ had been transformed into pupæ. More than once when I have taken material from such a pond, in which there still remained plenty of unaltered larvæ, it proved that these larvæ belonged to another species whose temperature of transformation lay at a higher point than that of those first transformed. This has more especially been the case with the larvæ of the two species *O. communis* and *O. cantans*, the latter species being always about one or two weeks later than the former.

Now when we remember that the whole period of life which the mosquitoes pass in the pupa stage is normally restricted to a few days, and in the tropics often to some hours, and if we remember that the power of locomotion is only used when reflexes of quite a definite kind are released according to definite variations in the surrounding medium, it will be understood that the postulate, that the above-named paragraph in HOWARD, DYAR and KNAB only contains half of the truth, is really correct. The pupæ are able to move, but commonly they do not for the whole period of their life actively use this power. They are much more stationary than one would think; as stated above, this more especially holds good for the last day before ecdysis, the pupæ being then almost glued to the surface.

If we will try to understand the peculiar pupa stage of the mosquitoes, we must compare it with similar stages in the water insects; it will then be clear, that the pupa is constructed in accordance with the purposes which at all events we are not accustomed to put in the first line, when we discuss the peculiar shape and mode of life of these pupæ.

If we survey all those aquatic insects which are going to perform the last ecdysis in the water before leaving this element for ever, we shall see that, just at the time when the last ecdysis is to take place, there appear organs of quite a new type; further we find old organs which are now modified in such a way that it is clearly understood that they have only significance at the moment when the insects leave the water; nay, in several groups of insects we find even more than that, either peculiar biological phenomena or quite new developmental stages intercalated between the old well-known stages.

In all those aquatic insects which leave the water as larvæ, climbing on shores, we find none of these peculiar structures and phenomena. We may only note that some of the *Perlidæ* crawl out of the water, throw their whole anterior part of the alimentary canal out of the mouth, fasten it to stones to which it is glued, now using this organ in this quite uncustomary manner as a cable by means of which they crawl out of the nympha skin. Other *Perlidæ* use their larval gills as glutinating organs, by means of which these insects are fastened at the same moment for the same purpose to the slippery stones.

A second group of aquatic insects live as nymphs or as pupæ in the water and complete their last ecdysis upon the surface of the water; to these belong the *Ephemeridæ*, the *Trichoptera* and some Diptera (*Chironomidæ*). As a transition stage between the aquatic and aërial life we find in the *Ephemeridæ* intercalated the highly peculiar subimago stage. In this stage, which only lasts for some hours or, rarely, for a few days, the legs and nervatures of the wings are often covered by a coating of minute thorns which hinder the wings from getting wet; a remarkable oily appearance, f. i. on the wings of *Ephemera danica*, has the same purpose. These structures are undoubtedly inconvenient when the wings are used as flying organs during the mating processes and egg-laying phenomena. Lying in my boat on calm summer evenings, I have seen the large *Ephemera danica* nymphs rise to the surface from a depth of from four to five meters; with undulating movements of the abdomen they lie for a few seconds below the surface-film fastened to it by the outspread tracheal gills and peculiar thorns upon the dorsal side of the abdomen. Then the skin bursts and in the course of a second the subimago stands upon the surface, whereupon it takes wing and reaches the coast. A few hours later the subimago undergoes a new ecdysis, and the aërial wings appear, hyaline and without thorns.

I am inclined to suppose that even many naturalists are unacquainted with the fact that the *Trichoptera* pupæ, after a resting stage in the closed and fastened larva cages on the bottom of the water, are free-swimming organisms for a short time of their life; as such, without using air in any way, they actively ascend to the surface; the swimming apparatus is the second pair of legs, furnished with a brush of long swimming hairs; at the very moment the surface is reached, the tracheal gills, the lateral line of long hairs round the abdomen are thrown out upon the surface; partly by means of these organs, partly by peculiar thorns and plates on the dorsal side of the abdomen, the pupa is now fastened to the surface and supported by the surface film. In this position the cuticula bursts in the middle line over the thorax; its lateral parts are, just as in many *Ephemeridæ* and *Culicidæ* pupæ, spread out upon the surface; a swimming bridge, a point of support is thus gained; by means of reception of air the imago pushes itself out of the skin, using the broad outspread thoracic plate as a support for the legs; some of these pupæ (*Leptoceridæ,* f. i. *Mystacides* a. o.) ascend vertically from the bottom at such an almost incredible speed that they only use their legs for three or four strokes; the moment they arrive at the surface, the skin bursts with an audible sound, and the imago is almost hurled out of the skin into the air, where it immediately takes to its wings. In these species the free-living pupa stage is almost incredibly short, the time from the moment it leaves the pupa-case till it is, so to speak, thrown into the air as a flying insect, may be counted in seconds. But even in these few seconds of life a swimming apparatus is necessary, and just and only for that purpose and, as far as we can see, for these three or four strokes of the middle legs, these legs are formed as swimming legs with broad tibia and brushes of long soft hairs.

The *Chironomidæ* from the bottom of our deepest lakes act almost in the same manner; there is only this difference that the pupæ do not reach the surface by active motions, but ascend passively and perpendicularly to the surface by means of air formed between the pupa- and imago skins; here they occupy a horizontal position; the thorax bursts and the mosquito creeps out and stands for a moment upon the outfolded pupal thoracic skin. Lying in a boat on calm summer evenings I have heard a sound of bursting bubbles round the boat, and convinced myself that it originated from the bursting pupal skins when the air escaped.

To this same group of water insects which complete their last ecdysis upon the surface of the water belong also the *Culicidæ*; from the *Ephemeridæ Trichoptera* and

Chironomidæ they differ only in so far that the pupæ do not ascend from the bottom of the water but live their whole life fastened to the surface film.

There is yet a third group which are hatched as imagines at the bottom of the water and as such ascend through the water layers to the surface; to these belong the *Simuliidæ* and the few aquatic *Lepidoptera*. The *Simuliidæ* use the air from the pupal tracheal system as air-bubbles wrapped up in which they ascend as imagines to the surface with an extraordinary rapidity. The moment this is reached the bubble bursts, the fly stands dry upon the waves, whereupon it takes to its wings.

The few *Lepidoptera* which undergo the last metamorphosis in the water, also use an air-bubble by means of which they reach the surface; but these insects are not wrapped up in this bubble; they only hold it between the wings and thorax in a manner similar to that in which the bubble is held by the Culicid pupæ. Moreover the whole body of the butterfly, at the moment it leaves the pupa case, is covered by a wax-like substance which prevents the body from getting wet and which for a moment remains as a column in the water after the butterfly has left the water. All the above-named structures and biological phenomena, appearing in the aquatic insects on the threshold between aquatic and aërial life: the peculiar fastening of the alimentary canal in *Perlidæ*; the subimago stage in the *Ephemeridæ*; the free swimming part of the pupa life of the *Trichoptera* with the peculiar modification of the second pair of legs; the store of air in the pupa of *Chironomidæ*, the air-bubble of *Simuliidæ* and *Lepidoptera*, and the wax covering of the last-named insects are in my opinion all phenomena which tend to the same purpose: to carry the insects rapidly and in dry condition up into the new element. Just this perfectly dry condition, more especially with regard to the wings, is a conditio sine qua non for all the insects which are unable to change element if the wings are wet.

It is from this point of view that the peculiar free-swimming pupa stage of the *Culicidæ* must be interpreted. Like all other pupæ the mosquitoes in the pupa stage are quite defenceless; in contradistinction to most other insects which at this very stage hide themselves, the pupæ of the mosquitoes live in quite the same localities as the larvæ, exposed to quite the same dangers. The pupa is therefore adapted to escape from these dangers by means of active motions, but as the pupa stage is simultaneously a resting stage in which the great alterations from larvæ to imago are to take place, the power of active motion is only used if dangers appear or in search of water with the highest temperature. Otherwise the pupæ are at rest, and the stage is also used by these insects as a real resting-stage. As however the pupæ even as such are to pass their lives in an element which is hardly ever perfectly calm, a series of peculiar physiological and anatomical structures must be formed, by means of which the pupæ even in a locality so mobile as the surface of the ponds can be fastened to the spot where they have once got hold.

We shall now study the power of locomotion of the mosquito pupa a little more closely. It will then be seen that it is really of a very peculiar kind. As briefly mentioned above and often pointed out by earlier authors, it must firstly be remembered that the specific gravity of the pupæ in contradistinction to that of the larvæ is smaller than that of the surrounding medium. They are always supercompensated, more especially as they approach the last ecdysis; this is due to secretion of air beneath the pupa skin (silvery gloss). By means of this supercompensation the pupæ are pressed against the surface, this being their natural plane of support, just as the bottom of the ponds is the support of all undercompensated animals.

The supercompensation is due to a large air globule, already mentioned by Meinert as "Flydekugle" (1886 p. 389) but more thoroughly described by Hurst (1890). The air-globule comes from the air in the tracheal system of the larva. In a manner not hitherto thoroughly studied, it is carried down between the wing-sheaths and legs of the pupa, being in connection with the trachealsystem of the pupa through two large spiracles. As mentioned by Hurst the air globule has probably mainly a hydrostatic function (p. 7), but also serves to keep the pupa afloat in a particular position, with the thorax uppermost and the apertures of the trumpets at the surface of the water; further, to enable it to ascend to the surface passively in a vertical direction and with the broad cephalo-thorax lying horizontally.

The supercompensation is however so great that it would force the pupa out of the water, on to the surface, if it were not counterbalanced by other forces. If the pupa, after one of its somersault-movements downwards, again passively ascends to the surface, the motion always takes place along a vertical line; the animal is always directed in such a way that the broad cephalo-thorax turns upwards; reaching the surface the pupa will always touch it with four points lying above the rest of the body, viz. the edges of the openings of the trumpets, and the two stellate hairs on the first abdominal segment. By means of these four points the body is fastened to the surface and prevented by the surface film, from being forced out of the water.

The pupa never voluntarily leaves its place below the surface unless forced either by light reflexes or by currents in or upon the waters, produced by enemies. More especially in the last hours before ecdysis, the pupa is almost glued to the surface film, being supercompensated to so high a degree that its power of locomotion is too slight to take it downwards.

Otherwise, if variations in the surrounding medium force the pupa away from its resting place, active motions set in. These are really very peculiar. They are restricted to a series of downward-directed somersaults, but whether these somersaults are to conduct them to the left, to the right, or vertically downwards, the pupæ are not able to determine; they cannot direct their motions, being unable to produce any steering motion in any direction; they are only able to dart away from the point to which they were fastened. The moment the activity ceases, the pupæ rise following vertical lines as do air-bubbles to the surface.

No one can observe a mosquito pupa without being struck by the peculiar disproportion between the bulky cephalo-thorax mass and the slender abdomen; it is upon this incongruity that the peculiar somersault motion depends. When the ecdysis is going to take place, the thorax splits in the middle line, the large sides of the chephalo-thorax are clapped downwards and now rest upon the surface of the water; they thus form a swimming point of support upon which the imago may rest during the ecclosion and a few minutes immediately after. The actual process of ecclosion of the imago will not be mentioned here; with regard to that point I refer to the excellent paper by Eysell (1913 p. 320).

In the above I have tried to elucidate some points in the biology and anatomy of the mosquito pupa. Its many peculiar anatomical structures: its highly remarkable form, the air-globules below the wing-sheaths, the use of the tips of the trumpets as points of support, the stellate hairs, combined with the short life-time of the stage and the peculiar manner of motion may all be regarded as adaptations directed towards the same great general end: to bring the imago as soon as possible and in dry condition out of the water. The common significance of the pupa stage of insects: that of being a stage of repose, has in the pupa stage of the mosquitoes been subordinated to this purpose; it is the life as free-swimming organisms exposed to dangers of every kind, very different from the common pupa life of insects, which has made this subordination necessary. It is often very difficult to distinguish the species from each other in those immature stages which have the shortest existence. In the development of the mosquitoes the pupa-stage, as is the case with other insects, is the shortest. It is a well-known fact that it is almost quite impossible to distinguish the species in this stage; even species which belong to different subfamilies: *Anophelines* and *Culicines*, are extremely alike in the pupa stage. This has also been pointed out by Howard, Dyar and Knab (1912 p. 103). These authors remark that there really are some striking differences between the pupæ of the two tribes *Culicini* and *Sabethini*; further, that there are some differences in the shape and length of the trumpets and of the paddles. The greatest diversity may probably be found in the number and arrangement of the setæ on different parts of the body; by this structure Meijere (1911 p. 1146) has tried to distinguish the pupæ of *C. morsitans, Theobaldi, C. cantans* and *communis* but, as far as I can see, without any result. I have been unable to detect real differences between the pupæ of the Danish species. The very large pupæ of *C. annulatus* and *C. morsitans* can, if they appear in the swarms of *C. communis*, be distinguished only by their size. With regard to the pupæ of *Tæniorhynchus* I refer the reader to that genus.

Chapter II.

The Danish Culicines Systematically and Biologically Described.

Genus I. *Aëdes.*

Tab I.

1. A. cinereus Meig.

A. cinereus occurs in North and Central Europe. Over this area it may easily be recognised among all other mosquitoes more especially in the male sex, the palpi of which are not longer than those of the female; but also the female is easily recognisable, especially owing to its minute size, the black colour of its abdomen, and the rusty brown or reddish colour of the thorax. In the male sex the thorax is black.

The species varies a good deal with regard to colour; several species have been established upon these variations (*A. obscurus* Meig., *rufus* Gimmerthal, *leucopygos* Eysell) which now are regarded as synonyms for the species. With regard to the dentition of the ungues the reports differ greatly. Kertész (according to Schneider) indicates that the hind ungues of the females are uniserrate, Theobald (1907 p. 539) that the ungues of the female are equal, simple and not uniserrate; Grünberg (1910 p. 90) the same.

Eysell (according to Schneider) Goetghebuhr (1910 p. 86) (Edwards 1912 p. 261) and Schneider (1914 p. 24) state that the ungues of the female on all legs are uniserrate and the latter author gives a figure of the claws. He gives the following formula ♀ 1.1—1.1—1.1. ♂ 1.0—1.0—1.1. With regard to the Danish specimens I have got quite the same result as the latter author.

Larva. Head rounded, wider than long; a notch at insertion of antennæ; front margin arcuate. Antennæ rather long, tapering at front, spinose; tuft moderate, inserted nearer to the base than to the apex; on apex three hairs and a digit. Antennal tuft multiple; frontal hairs long; lower and upper frontal tuft multiple with six or seven hairs. Eyes large.

Thorax long, rounded, angled at hair-tufts. Hair formula of frontal margin 321100001123. No real hairs upon frontal margin, only two extremely small tufts consisting of from two to five hairs; the other nearer the lateral margin strong. Lateral hairs in multiple tufts; some single, strong hairs.

Abdominal segments narrow, almost equally long. Lateral tufts of first segment with four hairs, second with two, third to seventh with one single hair; subdorsal hairs: a series of very short hairs between lateral tufts. Tufts of eighth segment in common arrangement, the dorsal tuft double. Lateral comb only consisting of about twelve to fifteen scales, commonly arranged in a row, each scale with a spatulated base, very long, without median spine, but feathered along the borders. Sipho long, four times longer than broad, tapering a little at apex; pecten very long, reaching over the middle of the sipho, consisting of about twelve to fourteen thorns; the thorns, more especially those nearest to the apex, not being in line; these thorns at greater distance from each other than the following; the thorns of the middle part of the pecten with one single tooth. Anal segment much longer than wide, almost ringed by a plate. The dorsal tuft with two long hairs; the ventral brush in the barred area with about ten rays, carrying from five to seven hairs; before the barred area two small free tufts; lateral tuft consisting of a single hair; anal gills very long, acute, equal.

Lateral tufts of labrum long, distinctly divided into two parts, but without comb teeth; palatum covered with very long hairs. Mandibles quadrangular with two strong spines and a shorter one before collar; a row of long cilia from a collar. About ten long thorn-like bristles; before them a dagger-like thinner thorn; a few long feathered cilia below; process below indistinctly furcate with strong hair-tufts; a group of hair at base. Maxillæ elliptical, divided by a suture; at apex a brush of long hairs; a seta near the apex beyond the brush; near the inner margin between it and the suture a coating of long hairs and at the margin a series of long stiff thorns; palpe rather small with three digits. Mentum high, triangular, without any conspicuous median tooth and with fourteen to sixteen teeth on each side.

Colour almost white or yellowish white, head black and sipho and plate of anal segment yellow. Length 6·5 m.

The description and figures of the larva agreed well with those of Meijere (1911 p. 148), his description being one of the most accurate of the hitherto published of European mosquito larvæ. The larva has probably been observed by Galli Valerio in Svitzerland (1907). He has not however given any description of it; he only says: "Die Larven sehen denen von *Culex pipiens* zum Verwechseln ähnlich; sie haben denselben langen charachteristischen Atmungsfortsatz und die gleiche Haltung; die Analdrüzen (i. e. anal gills) sind etwas länger und schlanker und viel durchscheinender. Die Farbe der Larve ist ein helles Gelbbraun und lässt sich leicht gegen den dunklen Grund erkennen; während die stärker pigmentierten Larven von *C. nemorosus* und *annulipes* sich den Blicken vollkommen zu entziehen wissen". Further it has been described by Schneider from Bonn. The rather short description agrees well with Meijeres and mine. In 1919 it has been briefly described from Strassbourg (Eckstein 1919 p. 294).

Biology. *Aëdes cinereus* is a little mosquito, which Staeger has mentioned as rare in Denmark. As far as I know, nobody has found it later in this country. In the days from 23/v to 2/vi 1918 *A. cinereus* was found flying over different small ponds in North Seeland; the ponds were all almost quite dry, only containing a few litres of water; about 15/vi they were dried out. On 1/vi 1918 I found the species in enormous swarms over the vast meadows at Lyngby on the southern coast of Arresø. The above-named ponds were dry until 15/x and were icecovered almost the whole time from about 1/i 1919 to 1/iv 1919. In the time from 15/x to 1/i the ponds contained no *A. cinereus* larvæ. Being interested in finding the larva I explored, in 1919, the localities where the imagines were found in 1918. On the meadows at

Arresö I never found the larva, but with regard to the above-named ponds (*Mochlonyx*-pond I), the *Bidens*-ponds at Clausen's brick-factory and the ponds in Stenholtsvang I had better luck. In the time from 20/v to 31/v I found a very little larva here, at once recognisable as something peculiar by its almost black head and white abdomen. The larva grew no larger, and on 31/v *A. cinereus* was hatched. About 20/vi all the ponds were dry; none of them got water again before the last fortnight of October. On 20/v, when the larvæ were found, the depth of the ponds was only about a decim. In the last part of June 1919 I saw very little of the imago, but on my return to Hillerød in September I found the imago in enormous swarms over the same ponds where they were hatched in the spring. Large tufts of *Cyperaceæ* covered the ponds, which were wholly dry; sitting on one of the tufts in hope of observations relating to the egg-laying process of *O. cantans*, I found my hand covered with a number of these very small vampires. They were deep down in the Cyperacee-tufts, crawled more than they flew; after having sucked themselves so full that they resembled little blood pearls, they were so thick and so heavy that their power of flight was only very slight. Many of them which were caught in my vessels, only crawled and did not try to fly. The sting was almost imperceptible and they had great difficulty in getting blood, the skin being too thick; afterwards, as my hands had got more than fifty punctures, it was covered with a common purple colour and rather aching. On 3/iv I only found a few specimens but on 10/ix all had disappeared, and I did not see them any more this year. In 1920 I got the larvæ in the same ponds in May, and in July I found the species on the island Lolland. The same observation which I had an opportunity of making that year, I had made the year before at Arresø; the mosquitoes sit deep down in the grass, and do not fly up before they are disturbed by some one walking through the grass. They attack only that part of the body which is moving through the grass, the legs, when walking, and the hands when they are held down in it; this was the case in the brightest sunshine and in twilight about 7 o'clock. Especially in the forest it was very remarkable that I never saw them flying; if I sat only a few meters from the pond, I was fiercely attacked by *O. cantans*, but not by a single *A. cinereus*. Only when I placed myself in the centre of the pond, on one of the tufts of Cyperaceæ, the attack took place.

Having never been able to find the males in Nature, I have only observed them in my hatching-cases. I have got the impression that this tiny mosquito is much more bound to the ground than our other Culicidæ. The difficulty with which they got blood seems to indicate that blood can only be sucked from animals with rather thin skin. I suppose that small rodents and insectivores are perhaps their principal prey.

The life-history of *A. cinereus* is in our country most probably as follows: Males and females die off before autumn; the males most probably already in June—July; the larva stage is extremely short, only from eight to ten days; the pupa-stage lasting normally only a few days; the species hibernates only as egg; the eggs are hatched rather late, not before the last part of May; the pools, in which they are hatched, are dried up a fortnight later; the eggs must therefore be laid upon dry land and undoubtedly singly; most likely there is not time for more than one generation; this generation has only one brood, and this brood lives for three or four months.

In the literature the reports with regard to the life-history are very contradictory. GALLI VALERIO and ROCHAZ DE JONGH in Switzerland maintain that they have found hibernating single eggs, attached to fallen leaves in depressions of the ground SCHNEIDER (1914 p. 28) and ECKSTEIN (1919_1 p. 68 1919_2 p. 100) state that the species has probably "mehrere" generations in the course of the year. For Strassbourg this is also highly probable but for our country this supposition is undoubtedly wrong. SCHNEIDER says that he found the first larvæ at Bonn on 1. March; they were newly hatched and pupated already in the course of twelve or sixteen days; the first imagines arrived on 16. March. He has also found the larvæ in the middle of July, and this seems to prove the correctnes of his supposition. In our country where the larvæ do not appear before the last part of May, and the ponds normally are dried out before the end of June, more than one generation cannot be the rule.

With regard to the blood-sucking process THEOBALD contradicts himself. In 1901 Vol. II (p. 225) he implies that probably neither male nor female attack animals or man "as a rule". This supposition is stated by FICALBI, who maintains that they do not attack man or mammalia. On p. 235 in the same volume (1901) THEOBALD says that *A. cinereus* (female) bites viciously. This last statement is in accordance with that of all observers from recent years. EYSELL (according to SCHNEIDER 1914 p. 26) maintains that it is very bloodthirsty and so does SCHNEIDER (1914 p. 26). He has given a description of the attack of many specimens very like my own. ECKSTEIN says with regard to the neigbourhood of Strassbourg that it "trägt mit einem Hauptheil an der Stechmückenplage". LANG (1920 p. 80) maintains "that the general situations, indicated in the British records, suggests that *A. cinereus* mainly is a river-haunting species". This is by no means in accordance with the observations in our country; it may be found in the forests, along the shores of larger ponds and upon the open plains; I have never seen any special predilection for river valleys.

Geographical distribution: known in almost all European countries. It is probably identic with *Aëdes fuscus* Osten Sacken North America.

Genus II. *Ochlerotatus.*

Tab. II.

1. **O. caspius** (Pallas).

Description. Female: Proboscis moderate, subcylindrical, uniform, labellæ conically tapered; vestiture of blackish-brown scales intermixed with a few creamy-white; labellæ dark; setæ minute, curved, black. Palpi short, smaller than one-fourth of the length of the proboscis; vestiture black, with a few white scales intermixed, setæ moderate, black. Antennæ moderate, with the joints subequal, rugose, pilose, blackish, the second joint a little longer with a yellow base; tori subspherical, with a cup-shaped excavation, bright brown, shaded with blackish scales; the inner half covered with flat, sordid-white scales. Clypeus rounded-triangular, prominent, blackish brown, nude. Eyes at all events on the newly hatched individuals (in May—June) metallic green. Occiput rather broad, black, densely covered with narrow curved coarse scales, nearly pure white in a broad median zone; brown laterally and with a patch of flat, blackish ones on the sides; a series of black bristles along the hind edge of the eyes and long, snow-white bristles between them; on the occiput many erect, broad, and rather short white forked scales centrally, a few black ones laterally.

Prothoracic lobes narrowly elliptical, remote dorsally, clothed with narrow coarse brown scales at tip, whitish ones below and with short, brown bristles. Colour of mesonotum extremely variable; four main varieties.

1. Mesonotum black, densely clothed with coarse, narrow curved, dull-yellowish scales, laterally golden-brown ones in a broad median stripe, borded by a yellowish-white narrow stripe, running from anterior angles to near the root of wing; scales pale in the region of antescutellar space.

2. Mesonotum brown, either densely clothed with coarse, narrow curved, dull white scales over the whole surface or with a bright brown and usually narrow median stripe.

3. Mesonotum covered with almost snow-white scales with an almost black, narrow median line.

4. Mesonotum covered with almost snow-white scales, with an almost black, broad median line and laterally with two other black lines much shorter, only half as long as the median line.

Bristles dark, brown or yellowish white. Scutellum trilobate, luteous, clothed with coarse dull white scales, each lobe with a group of about twelve very pale bristles. Postnotum elliptical, prominent, nude, brownish luteous. Pleuræ and coxæ brownish, clothed with flat, white scales and pale bristles.

Abdomen: Subcylindrical, flattened, posterior segments tapering. Also the colour of the abdomen extremely variable. The main form as follows: dorsal vestiture of flat, sordid-white scales with two large patches of black ones on each segment, the patches becoming smaller posteriorly and may be absent on last segment; first segment almost white with many long white hairs; venter clothed with sordid-white scales, a very narrow median broken line of black ones or row of rather large, black spots; cerci black; setæ mostly pale. Two colour variations are especially common: 1. the whole dorsum of abdomen snow-white, only with small black, divergent lines near the borders, most developed on segments two to six. 2. the whole dorsum black, only with small basal bands of white scales.

Wings rather broad, hyaline, very irridiscent; petiole of second marginal cell and second posterior cell both a little shorter than their cells; vestiture of black and white scales; in some individuals almost all scales are white, in others the black preponderate; outstanding scales narrowly lanceolate, both black and white; fringe commonly grey, with white reflexions which give a mottled appearance. Halteres yellowish with white-scaled knobs.

Legs rather slender; femora clothed with whitish scales, mixed with a few black ones dorsally, these predominating at apex; extreme tip narrowly white; tibiæ with whitish scales with black ones intermixed and a small annulus before tip of hind ones; tarsi black scaled, with a white ring at base and apex of each joint; hind tarsi with the first joint also largely white scaled in the middle, the last joint almost quite white; fore tarsi with apex of second and all of last three joints black; mid tarsi with apex of third and all of last two joints black. Claw formula: 1.1—1.1—1.1.

Length: Body about 5 mm, wing 4 mm.

Male: Palpi exceeding the proboscis by nearly the length of the last joint, which is somewhat swollen; vestiture blackish with white scales intermixed; end of long joint and last two joints with long blackish or greyish hairs: Antennæ plumose; the last two joints long and pilose, the rest short, blackish at insertions of hair-whorls; hairs long and dense, grey and black. Coloration similar to the female, but the variation not so great. Wings narrower than in the female, the stems of the fork-cells a little longer, vestiture less abundant. Abdomen long depressed with dense, pale, lateral ciliation. Claw formula 2.1—1.1—1.1.

Length: Body about 6.5 mm.

Genitalia: Side-pieces more than twice as long as wide, apical lobe well developed, rounding, running uniformly down to base; basal lobe quadrate, protuberant, clothed with short, coarse setæ from tubercular bases, from its lower angle a stout thick spine and a shorter one. Clasp-filament slender, long, slightly swollen medianly, distally serrate and bearing several short setæ, a long slender, articulated terminal spine. Harpes rather narrow, concave, slightly curved, margins revolute, inner one thickened, curved over at tip in a short point. Harpagones slender, columnar, uniform, with an articulated filament at apex, which is ligulate, a little expanded beyond the middle and tapered to a point at tip, shaft with a few setæ. Unci approximate with revolute margins, forming a short stout cone. Basal appendages narrow, with short stout spines at the tip.

Larva: Head rounded, rather small, wider than long; a notch at insertion of antennæ; front margin arcuate. Antennæ short, slightly tapering at apex, spinose; tuft inserrated only a little below the middle, small, consisting of about ten hairs. At apex three hairs and two digits; two of the hairs a little below apex. Ante-antennal tuft short, multiple; lower and upper frontal tuft with only one single hair; the lower always, the upper rarely with two hairs. Eyes large.

Thorax wider than long, angled at hair-tufts; hair formula at frontal border 3121551213. Lateral hairs in multiple tufts and some single strong hairs. Tuft 5 with the hairs in different sizes and different numbers; from three to six, but five is the most common number. Lateral hairs in multiple tufts and some single strong hairs.

Abdominal segments broad, almost equal, the first two a little shorter than the others. Lateral hairs on the first segment with tufts in common arrangement. Lateral comb consists of about twenty to twenty-five scales, arranged in rows, covering a triangular area. The scales are spatulated, very broad with the median thorn only a little longer than the two lateral ones.

Sipho short; about two or two and a half times longer than broad, slightly tapering at apex; a long pecten reaching over half the length of the sipho; all thorns at line, the first and last without thorns, the middle with from one to three, very feeble thorns. A tuft of five hairs between end of pecten and apex. Anal segment almost isodiametric, ringed by a remarkably small plate. Dorsal tufts well developed with two long stiff spines. Ventral brush in the barred area with about twelve rays, each ray carrying about eight to ten hairs; before the barred area a few free tufts. A lateral tuft consisting of one single, strong hair. Anal gills extremely short, budshaped.

Lateral tufts of labrum rather long, the inner part modified in comb-hairs, arranged as a crown round the palatum, which is bordered with long, soft hairs. Mandibles quadrangular, elongate, spinose at base; two curved spines before a collar and a row of strong spines (nine) from margin. Dentition five strong teeth and before them a very long curved spine and a short dagger-like one; a remarkable group of minute thorns at base; a few curved setæ within and a row of long hairs at base. Process below, distinctly furcate, with strong hairs at apices; a group of hairs at base. Maxillæ broader than long with rounded apex; divided by a suture, furnished with two teeth-like processes. At apex a tuft of hairs and at the base of the tuft one spine. The space between suture and margin covered with short hairs; no spines from margin. Palpe well developed with three or four digits from apex: Mentum high, triangular, no especially developed median tooth and from ten to twelwe almost equally large, lateral teeth.

The skin of the abdominal segments covered with transversal series of minute thorns.

Colour greyish dark.

Systematical remarks: Stæger (1838 p. 554) has only found this species on the shores of the island Amager near Copenhagen. He states that it is "not rare" in the months of June and September; in August he has found the larva in countless numbers in small water reservoirs along the coast line of Amager. It was described as *C. dorsalis* Meig.

In 1917 Howard, Dyar and Knab (p. 634) reported that they have had specimens from the Zool. Museum in Copenhagen and compared them with the two American species *Aëdes onondagensis* and *A. Curriei.* These two species are identical as imagines, but as larvæ they differ from each other; the first-named species have both pairs of dorsal head-hairs single, whereas in *A. Curriei* they are multiple; there are also differences with regard to the structure of the skin and the anal gills. Moreover, of the two American species, *A. onondagensis* breeds in brackish water along the sea-coast, *curriei* breeds in temporary pools of snow-water or rain-water on the prairies. The American authors suppose, as MEIGENS specimens of *C. dorsalis* derive from Berlin (freshwater), and subsequent authors (STÆGER, MEINERT, THEOBALD a. o.), state that it breeds in brackish water, that also in Europe we possess two species, the relations of which cannot be cleared up before the larvæ have been studied.

C. dorsalis was described by MEIGEN, but already in 1771 PALLAS described a species from the Caspian which is most probably identic with the above-named; it has been deemed necessary to revive the ancient name *O. caspius*. As *C. dorsalis* it has been indicated by STÆGER in Denmark, by ZETTERSTEDT in Sweden, by SCHINER in Austria, bei VAN DER WULP in Holland and by FICALBI in Italy; it was last found by ECKSTEIN near Strassbourg. The Danish specimens are much more in accordance with the description of MEIGEN and ZETTERSTEDT than with the later one by THEOBALD. The larva has only been described by ECKSTEIN (1919 p. 293). He says that the larva very much resembles that of *C. nemorosus* and *C. cantans*. "Die Striegelborsten am 8 Segment, etwa 25, haben ebenso wie die der *C. nemorosus*-Larva lauter fast gleichlange Zähnchen, doch ist der mittlere meist ein wenig verdickt. Dagegen fehlt ihnen das Basalblättchen das für *C. nemorosa* so characteristisch ist".

With regard to the biology of the European *C. dorsalis* we do not know much. PIFFARD (1895 p. 227) states that at Aldeburgh on the Suffolk coast it is known as the Norway mosquito, having lived here for at least the last twenty-five years. "A tradition" says PIFFARD "assigns its introduction to a particular yacht, which used to ply between this port and Norway". Also in Sweden (Lund-Lomma) and in Norway (Christiania) as well as in Denmark it is restricted to brackish-water pools near the sea-shore. Later on, in a paper which I have not been able to consult, DYAR and KNAB (Insec. Inscit. 1917 p. 122) have maintained that the description of *O. curriei* larva in the monograph (Howard, Dyar and Knab) was founded on a misidentified species of *O. canadensis*. The correct description of the species is under *onondagensis* (acc. to letter from Mr. Edwards $^{22}/_{4}$ 1920). As the American authors, as stated above, have got material of *O. caspius* from the Royal Museum of Copenhagen (1917 p. 634), and all this material derived from Amager, they have determined the specimens from this locality, where the species still lives, as *O. caspius*; later on EDWARDS has done the same. According to me this material is homogenous, but on the authority of Mr. EDWARDS and in accordance with him and Mr. LANG I have separated the specimens with thorax without brown coloration and with broad white bands on mesothorax from *O. caspius* as *O. curriei* (Coquillet). Of the American species, which seem to be either identic with the two above-named European species or at all events very closely related to them, *A. onondagensis* lives as larva on the flat marshes of the Pacific coast in pools of salt water, left by high tides: a set of larvæ appear after each high tide. QUAYLE (H. D. K. 1917 p. 632) has given a description of their life. *A. curriei* inhabits the open arid country; the larvæ live in temporary pools. In the north there is but a single annual generation in the snow-water of early spring. Southward the appearance of the larvæ is governed by the formation of pools by heavy rains and consequently occurs at irregular intervals. It has especially been studied by KNAB at Saskatchevan with other mosquitoes of the large prairies (1908 p. 540).

Biology. For a long time it has been a well-known fact that countless mosquito-masses are a real plague to all the suburbs of Copenhagen, especially those lying near Kalvebodstrand, the strait between Copenhagen and Amager; one of these suburbs, Valby, has given the mosquitoes of this district their name, they have been called the Valby mosquitoes; they appear almost every year, more especially at the beginning of August; later on they spread over Copenhagen, being most common in the large park Frederiksberg-garden, the Royal Garden, at Lange Linie and northwards along the shores of the Sound. These mosquitoes belong almost entirely to one and the same species *O. caspius*. Curiously enough they have hitherto only been found in the vicinity of Copenhagen, and it has hitherto not even among zoologists been a well-known fact that Copenhagen had its own special mosquito, hitherto only found in it and in its neighbourhood; indeed we also find *C. pipiens* and *T. annulata*, but these two species do not, as far as I know, attack people, at all events not like the above-named species; a few specimens of *O. communis*, *lutescens* and *cantans* may be found in the parks, but they are of no great consequence. — It was of course most natural to search for the hatching areas of *O. caspius* in the old locality of Amager where STÆGER had found them almost a century ago. As I wished to make a special study of our brackish-water mosquitoes and my time was too much occupied with other mosquito-work, I asked Mr. KRYGER in 1920 to explore the brackish water coast of Amager and Seeland from Copenhagen and southwards towards the bay of Kjøge at regular intervals in the time from medio Marsh to September. In the time from 24/III to 8/VII he made twenty excursions at regular intervals; then he was on a journey in Jutland from 8/VII to 1/VIII and in the time from 2/VIII to 20/IX five excursions were undertaken. From every excursion he brought living material to my laboratory, and thousands of specimens were hatched in the hatching cages.

Most of the explored area belongs to the Amager common lying between Kalvebodstrand and the little village of Taarnby; it is used by the soldiers for gunpractice, and is now therefore rather difficult to use for study of nature. The whole country is extremely flat, the height over the sea leavel being only a few feet; formerly the sea often covered the whole area and after heavy showers, especially in spring, it is even nowadays changed into an almost inundated area which is difficult to cross. From the plain it is now separated by a dike along which a channel runs landwards. Between the dike and the sea numerous brackish water pools are to be found; on the other side, scattered over the flat ground, countless small holes may be seen. After June the whole plain is commonly quite dry, and cattle and horses are driven over the rich meadows. The area between the dike which prevents the sea from inundating the plain, is filled with brackish water pools; after June commonly wholly dry; the pools are however often filled with brackish water which is stagnant for months in winter and spring, but soon evaporates in summer. In rainy summers the pools hold the water for a shorter or longer time.

In autumn again most of the pools are often red from purple sulphuric bacteria and are bordered by *Scirpus maritimus, Aster tripolium* a. o. plants. At certain periods they contain thick layers of green algæ, and it is only in those pools, the bottom of which are covered with a layer of algæ in decomposition, that we find the huge masses of larvæ. The above-named dike forms a very distinct border-line between the mosquito fauna of the area; landwards in the numerous drying ponds enormous swarms of *O. communis* are hatched. The first larvæ were found on 24/III; they pupated and were hatched as imagines in the time from 21/IV to 5/V. The whole area was inundated and almost impossible to cross. As the water fell again clouds of *O. lutescens* appeared, and a very few belated larvæ were found on 9/VI. In the last part of May and in the first part of June *O. lutescens* has most probably populated the numerous ditches. As *O. rusticus* was found in the last part of May as a regular tormentor on stretches bordering the meadows, it is probable that some of the holes have been hatching localities for this species.

Outside the dike between it and the sea no larvæ of mosquitoes were found during the whole of April and first part of May; in the brackish water pools *Nereis diversicolor, Crangon vulgaris,* and other marine animals were common, but always in company with *Corixæ,* various *Hydrophilidæ* and *Dytiscidæ.* On 26/V mosquito larvæ were for the first time pointed out in these ditches; in the samples were enormous amounts of newly-hatched larvæ, some halfgrown larvæ but no full grown ones; most probably the hatching process was not more than a week old. Already by 12/VI many of the pools were dried up, and by 16/VI all pools were wholly dry. In the time from 26/V to about 15/VI, i. e. about three weeks, enormous masses of *O. caspius* were hatched; in the material also appeared the supposed *O. curriei,* but I was never able to find any differences in the larva material, though many thousands of larvæ have passed under the binoculary microscope; once only I also found a larva of *O. lutescens,* and on the coast of Sealand nearer to human dwellings larvæ of *C. pipiens* and of a few *T. annulata* often appeared. In the two first weeks of June numerous *O. caspius* were sitting in the grass round the holes; in the last part of June they left the locality and began their attack nearer the town where we in the evening, were attacked by them, *O. lutescens* and *rusticus.*

In the time from 16/VI to 8/VII all pools were quite dry; then when Mr. KRYGER returned to the locality on 2/VIII the pools were full again after the rainy summer; they now contained incredible numbers of larvæ, the water was black; again the holes were visited, and in the last part of August the whole stock was hatched. Again enormous masses of *O. caspius* were hatched; in the last part of August they were found nearer the human dwellings, and in the whole of September they tormented the inhabitants of Copenhagen. In order to clear up the manner of hibernation I explored and got information from many buildings in the outer part of the town. It was shown that *O. caspius* was often to be found in cellars etc. till the last part of November and even the beginning of December. In the last part of the winter it seemed as if the material had everywhere died out; only *C. pipiens* and *T. annulata* were left.

Regarding it as almost certain that egglaying processes have taken place in the last part of July and most probably also in September, there can be no doubt upon the point that *O. caspius* and most probably also *O. curriei*, if this species can be separated from *O. caspius*, both have two broods, the one hatched in the first half of June, the other in the last part of August. In summer and winter there is a resting period which is passed as eggs.

Having elucidated the life history of the Valby mosquito the question was, whether *O. caspius* was really restricted only to the brackish water pools near Copenhagen. This was of course very improbable. In the two years 1919 and 1920 Mr. Kryger and I explored different parts of the Danish coasts. It can now be stated that it has been found near the coasts of Roskildefiord; on the southern coast of Lolland, on the coast of the straits of Guldborgsund, which separates Lolland from Falster; along the eastern coast of Jutland, more especially in the deeper parts of the fjords. Most probably it may be found everywhere in brackish water pools, along the shores of Kattegat and the Baltic; I could not find it in the brackish water pools along the North Sea. It has never been found away from the coast. It is always accompanied by *O. curriei* but in spring rarely by any other mosquito. In autumn, at Guldborgsund and upon Amager and at Roskildefjord, I found it associated with *O. detritus*, which also otherwise has often been found with it. (England: Edwards, Lang). The localities are always the same: tidal brackish water pools, which are often exposed to complete desiccation. According to the more casual observations it seems as if two generations are typical for our country. At Roskildefjord I have found the two generations in the last part of June and in the last part of August; the last generation was found at Guldborgsund.

Geographical distribution: Found in almost all European countries, Asia and Northern Africa. With regard to the peculiar biology of the Saltmarsh mosquitoes I further refer to the papers of Buttrich (1913 p. 352), Schmidt (1913), Headlee (1916 p. 339 and 1917 p. 211) and Chidester (1917 p. 299).

2. **O. curriei** (Coquillet).

This species is in my opinion indistinguishable in the imago-stage from *O. caspius*. It especially represents variety 4 on pag. 40. As I however possess almost all intermediate stages in the above-named four varieties, it is with the greatest hesitation and upon the authority of Mr. Edwards that I maintain the species. It has hitherto been regarded as species, differing from *O. caspius*, partly because of the larva, partly because of a different habitat. Howard, Dyar and Knab firstly indicated (p. 637), that in the larva of *O. curriei* both pairs of dorsal head-hairs are multiple, and that the lateral comb of the eighth segment has about twenty-five scales in an irregular patch, whereas in *O. caspius* the dorsal head-hairs are all single, and the scales of the eighth segment are many and arranged in an elongate patch, moreover in *O. curriei* the single scales have a long central spine whereas in *O. caspius* the central ones are equal and not differentiated. According to the later report (see p. 43) the larva must be regarded as unknown.

From the numerous brackish water pools I have had unlimited amounts of larvæ for my observations. I have never found a single larva with the characters indicated by Howard, Dyar and Knab for *O. curriei.*

According to Howard, Dyar and Knab *O. caspius* is a brackish water species; flat salt-marshes being essential to its occurrence. *O. curriei* on the other hand inhabits temporary pools throughout the arid regions.

As all Danish mosquitoes with white rings, involving both apex and base of each tarsal joint, only belong to brackish water pools, and mosquitoes of this kind have never been found in the poor remains of an arid region which our country still possesses, I for my own part would be most inclined to refer all these specimens to one single species *O. caspius* (= *dorsalis*). When I suppose it to be most correct provisionally to maintain the species for the Danish fauna, it is because Edwards, without having got the larva, has done the same for England, has looked over my specimens and indicated them as *O. curriei*; further because I must confess that this variety, more especially with regard to the colour of the thorax, really is more sharply defined than the other varieties.

Here as — according to a letter from Mr. Edwards — in England the two species occur in the same pools and simultaneously, but *O. curriei* is much rarer. In more than twenty-five samples of mine, hatched in my laboratory, in the time from May to July I have never got more than about fifty *O. curriei* as compared with thousands of *O. caspius.*

Geographical distribution: Sweden, England, North America.

3. **O. cantans** (Meig).

Tab. III.

The three species *O. cantans* Meig., *O. annulipes* Meig. and *O. vexans* Meig. are in their different colour varieties very difficult to distinguish. Many authors, Stæger (1838 p. 554), Zetterstedt (1850 p. 3461) a. o. have been inclined to regard *O. annulipes* as a variety of *O. cantans.* The confusion has been augmented because Ficalbi has redescribed *O. annulipes* and *O. vexans,* and these descriptions have been adopted by Theobald.

As far as I can see, the old descriptions of Meigen are much more in accordance with the specimens found in our country than those of Ficalbi, whose descriptions perhaps are more in accordance with specimens from more southern countries. The typical *O. cantans* with its banded legs, dark thorax, covered with reddish and golden-brown curved scales, the brown abdomen with its pale basal bands is an easily recognizable species among the Danish Culicidæ. In the old descriptions of MEIGEN (1818 p. 6) and ZETTERSTEDT (1850 p. 3461) we always find statements, relating to two black or brown lines running over the mesonotum; these lines, more or less conspicuous, I have found upon all my specimens, but I often miss them in the later descriptions.

MEIJERE's description (1911 p. 144): a broad brown median stripe is in accordance with many of my specimens but this stripe is then often bordered by lines frequently yellowish-white. This is also indicated by EDWARDS (1912 p. 218). When Eckstein (1918 p. 65) states, that the last abdominal segment always possesses "Andeutungen von Schuppenbindern am hinteren Rande" I cannot verify this.

From *O. vexans* Meig. *O. cantans* Meig. may probably always be distinguished by means of the white tarsalbands which are always very narrow in the first named species, whereas they are broad in *O. cantans*; further *O. vexans* Meig. is of a very small size being only about 5 mm. whereas *O. cantans* is about 7—8 mm. Also the male genitalia of *O. vexans* are very peculiar, the claspers being forked.

The two species *O. cantans* and *anulipes* merge with regard to the colour, and are rather indistinguishable more especially in the autumn. The best character is that the distal joint of harpago is flattened, about twice as long as wide in *O. anulipes* whereas in *O. cantans* it is not much flattened and has a large, membraneous expansion on one side. — Besides the reader is referred to the description of *O. annulipes.*

Larva. Head rounded, strongly vaulted, large, wider than long, conspicuously notched at insertion of antennæ; front margin slightly arcuate. Antennæ short; spinose, especially on the innerside, tapering at apex; tuft small, only consisting of a few, about 7 hairs. Near the apex a long hair, three short hairs and a digit. Anteantennal tuft short, multiple, lower frontal tuft with four hairs, upper double, the hairs being very strong. Eyes large.

Thorax subquadratic, angled at hair-tufts. Hair formula of frontal border 131114411131; tuft four consisting of one long hair and three very short ones; hairs after tuft 4 always very short; the others strong. Lateral hairs in multiple tufts and some single strong hairs.

Abdominal segments broad, the first much shorter than the last. Lateral hairs on the first and second segments triple, on the third to sixth double; subdorsal hairs absent. The eighth segment with tufts in common arrangement; lateral comb consisting of about 30—40 scales, arranged in rows, covering a triangular area; the scales are spatulated at base, obliquely rhomboidal, bordered by long bristles; in the middle a rather short spine, only insignificantly longer than the bristle nearest to the middle thorn.

Sipho about three times longer than wide; tapering at front, on basal third a pecten highly developed, consisting of about twenty strong thorns with four or five large teeth and some smaller ones at their base; a tuft of about six hairs between end of pecten and apex. Anal segment almost isodiametric, ringed by a plate. Dorsal tuft consisting of a tuft of short, soft hairs and two very long and strong ones. Ventral brush in the barred area composed of about 16 rays, every ray carrying about six to nine hairs; before the barred area five free tufts; a lateral tuft consisting of a single hair. Anal gills long, acute, equal.

Lateral tufts of labrum short, the inner part modified in comb-hairs, arranged as a crown round the palatum which is covered with long, soft hairs. Mandibles quadrangular, with two strong spines before the collar; a row of short cilia from a collar and a row of about ten strong spines from margin. Dentition: four or five strong teeth and before them two spines; a series of bristles below. Process below distinctly furcate, with strong hair-tufts on both tips; a group of hairs at base. Maxillæ subquadratic with almost straight sides, divided by a suture. On the top a tuft of long, soft hairs; at its base a thorn; area between suture and inner border covered by long soft hairs; inner margin furnished with a series of long, strong spines. Area between suture and outer margin with tufts of soft hairs; palpe well developed with four digits at top. Mentum large, high, triangular, with the median tooth rather small, borders arcuate. carrying about twelve to fourteen rather small teeth.

Colour bright grey, often milky; that of the head always yellowish red; by means of this colour it can commonly be distinguished from *O. communis*, with which it has the structure of sipho in common; but also the more vaulted head, the armature of eighth segment, and the more straight sides of the maxilla, may be used as distinguishing characteristics.

The larva has been shortly described by Meijere (1911 p. 144) by Schneider (1914 p. 29) and Eckstein (1919 p. 392). The descriptions quite agree well with each other and also with the above given; the number of scales on eighth segment varies very much.

Biology. More than ten years ago I had observed that, at a time when *O. communis* had almost ceased to sting, another larger mosquito with white-banded tarsi appeared. The bite of this species (*O. cantans*) was much worse. Everywhere in the forests of North Seeland as well as in probably most of our Danish forests *O. cantans* is extremely common in July and August; it is a well marked forest-mosquito which only rarely leaves the woodlands. For more than a year I could not detect, from where the myriads of these troublesome vampires came, and only regular hatching experiments revealed the fact.

In 1917 to my great astonishment I saw that all my aquaria, filled in April with what I supposed was only *O. communis* material, which produced immense numbers of *O. communis* on the first day of May, now in the time from about $^{10}/v$ to $^{25}/v$ only produced *O. cantans*. A more thorough examination of the material showed that in all my cultures there were really two species of larvæ, the one first hatched with only one single hair in the frontal tufts, and the other, the last hatched, with four and two. Also in the structure of the scales the two species differed a little from each other. Testing these observations in Nature I saw that the ponds after having given off *O. communis*, still contained a lot of larvæ, which almost everywhere were never hatched till a fortnight later than *O. communis*. In the two following years the relation between the two species was more thoroughly studied.

I now feel convinced that all the mosquito-larvæ which appear during the winter or the first days after the ice has melted, all belong to *O. punctor, O. communis, O. prodotes.* Later on, commonly not before 5/IV—1/V at a time when the larvæ of *O. punctor—communis* are almost fullgrown, very small, newly-hatched larvæ appear. These larvæ are larger than those of *O. communis*, the head is yellowish-red, and the body brighter. As they are hatched later than *O. communis*, the volumina of water, in which the larvæ and especially the pupæ live, are often extremely small, being often only a few deciliters. At the beginning of a dry period the development may be shortened, the pupa stage not lasting more than a few days. Very often I have observed the peculiar fact that the species which bites belongs to *O. communis*, where as the species which is hatched from pupa is *O. cantans*. If we sweep the catcher through the vegetation, we shall see that all that we get near the pond is *O. cantans* which is sitting deep down in the grass near the ponds, whereas the mosquito which makes our sojourn in the forest and round the pond intolerable is *O. communis.* Flying out of the dark shades of the wood, they anounce their attack by their burz, their smell having directed their way. Their real resting places were far away from the ponds on the trunks of the large beeches and below their foliage.

With us *O. cantans* uses more than a fortnight to be able to sting. Then there may be some weeks when *O. communis* and *O. cantans* attack simultaneously and side by side; little by little *O. communis* disappears and *O. cantans* predominates.

There is undoubtedly only one generation in the course of the year. The larva is hatched in the middle part of April and the imagines about a month later; the life of the imago lasts about three months; the eggs are not ripe before two or three weeks after hatching; then the ponds dry out, and in summer (July—August) the eggs are laid on the dry bottom; here they hibernate; when in autumn the ponds get water again, this has no influence upon the hatching of the eggs. I have never found a single *O. cantans*-larva in autumn, the eggs must undoubtedly pass a freezing period before being hatched.

The larvæ live as the *O. communis*-larvæ, in the surface, hanging down from this by the sipho. — Still I suppose that they are more pronounced bottom feeders than those of *O. communis*.

In 1920, as cold and rainy weather was a hindrance to the hatching of *O. communis*, there was a week in which the larva-swarms in our forest ponds were composed of almost equal numbers of *O. communis* and *O. cantans*; then the *O. communis* larvæ changed into pupæ, whereas the *O. cantans*-larvæ remained unaltered for one or two weeks. Even then it was by no means difficult to distinguish the *O. cantans* larvæ from those of *O. communis*, the first-named being larger, brighter and having a red head which immediately distinguished them from those of *O. communis* with their grey heads.

With regard to the biology Breslau (1917 p. 524) states that there is only one generation in the course of the year, that the eggs are laid singly or in small batches and upon almost dry land. Already SCHNEIDER (1914 p. 31) has pointed out that the species winters as egg and ECKSTEIN (1918 p. 65) confirms this. GALLI VALERIO (1909 p. 91 and p. 345) maintained that the eggs were laid in batches, EYSELL (1908 p. 717; 1909 p. 203; 1910 p. 21) that they were laid singly; the last-named author is undoubtedly right. — ECKSTEIN (1919 p. 100) has arrived at the same result as I "dass die Weibchen die Eier erst in der 2 Hälfte des Sommers ablegen". He has further observed that the eggs are laid remarkably high up above the water level.

Geographical distribution: As LANG (1920 p. 86) remarks *O. cantans* has been so confused with *O. annulipes* that it is not possible to determine its range with certainty. Most probably it is distributed over the whole of Europe.

4. **O. annulipes** (Meigen).

Tab. IV.

Description, Female: Proboscis moderate, subcylindrically flattened, the labellæ conically tapered; yellowish-white in the middle, black at base and apex, brown hairs in the white part and white in the black especially at base. Palpi stout, about one-fourth as long as the proboscis, clothed with blackish-brown hairs, with scattered white ones especially at tip. Antennæ with the joints equal, second joint a little larger and thicker, yellow, the remaining joints rugose, brownish pilose; tori subspherical, with a cup-shaped apical excavation, luteous, bright brown and with a patch of small white scales on the inner side. Clypeus brown, conical, prominent, nude. Eyes black. Occiput brown, clothed with curved, narrow, red-golden scales and many slender, erect, black, brown scales, on the vertex; cheeks clothed with flat, red golden, a little brighter scales; bristles bordering the eyes black, a tuft of bright yellow hairs, projecting between the eyes.

Prothorasic lobes elliptical, remote dorsally, blackish brown, clothed with bright, yellowish-red hairs not brown as in *cantans*. Mesonotum dark brown, almost black, very hairy, clothed with a uniform tomentum of red or red-brown hairs either without any darker lines or paler scales at the margin or with lines yellower and brighter than in *O. cantans*. Scutellum trilobate, luteous, each lobe with bright yellow bristles and curved pale yellow scales. Postnotum elliptical, short, luteous. nude. Pleuræ and coxæ pale brown, clothed with elliptical white scales.

Abdomen subcylindrical, flattened, posterior segment tapering; chitin uniformly bright brown, very hairy, reddish-brown, with more or less obsolete bands of creamy white basal bands; no indications of apical bands on the last abdominal segments; venter clothed with creamy white or yellow scales, mingled with some black ones especially on the last segments and forming a continuous median stripe in every segment with slightly lateral projections. Wings rather large, hyaline, with a yellow tint; veins yellow, clothed with yellowish-brown scales; petiole of second marginal cell shorter than its cell; that of second posterior cell almost of the length of the cell; basal cross-vein almost its own length distant from anterior cross-vein; fringe yellow. halteres entirely pale. Legs yellow, femora yellow with intermixed black scales especially distally and dorsally; no dark scales proximally and ventrally (as in *O. cantans*); tibiæ and metatarsi yellow with some more intermixed black scales; tarsi almost black at apex with three or four white basal bands, progressively narrower in the lower joints; the last joint commonly quite black. Claw formula 1·1—1·1—1·1. Length 7—8 mm.

Male. I have only had badly conserved specimens of this species in the male sex and have been unable to distinguish them from males of *O. excrusians*. According to Mr. Edwards the males of *O. annulipes* may be distinguished from *O. cantans* by the structure of the genitalia. In *O. annulipes* the harpes are long and strap-shaped, in *O. cantans* however they are shorter and provided with a large, membraneous expansion near the tip; in this particular my few badly conserved specimens agree with Dr. Edwards' indications, but, as far as I can see, they are rather difficult to distinguish from those of *O. excrusians*.

Larva: Head broad, rounded, wider than long, restricted before eyes, and slightly notched before the antennæ; front margin slightly arcuate, almost straight; Antennæ short, strongly attenuated at apex, spined, serration none or a very indistinct one along inner border; tuft almost in the middle consisting of from four to six hairs; at apex two long spines, one shorter and a digit; yellow between base and tuft, dark between tuft and apex. Eyes large, transverse, pointed. Anteantennal tuft multiple, lower frontal tuft with four, upper with two thick hairs. Thorax rounded, wider than long, angled at hair-tufts; hair formula of frontal border most probably 3111441113; in tuft four, three of the hairs short, and hair 1 after tuft four, short. Lateral hairs in tufts; besides some single strong hairs.

Abdomen moderate; anterior segment short, posterior ones narrower and elongate: hairs rather long, lateral hairs of the first segment triple, on the second to seventh double; subdorsal hairs double on fourth to sixth segments. Eighth segment with tufts in common arrangement. Lateral comb consisting of about forty-five scales, occupying a triangular space; the single scale spatulated at base, ending in a very strong and long spine and furnished with a series of long, remarkably strong lateral spines; sipho long, slender, about three and a half times longer than broad, remarkably straight, not so much tapering at apex as the siphones of *O. excrusians* and *O. lutescens*; pecten reaching less than halfway, all spines at the same distance, all wide at base and with from four to six large basal thorns without any smaller one at base; in contradistinction to the larva of *O. lutescens* also the two last spines have basal teeth; a large tuft at middle of tube beyond pecten. Anal segment almost twice as long as wide; the dorsal plate almost covering the sides; dorsal hair-tuft consisting of a coarse tuft, and two strong and long hairs; ventral brush large in the barred area, consisting of about from twelve to fourteen rays, each ray carrying about six or seven hairs; before barred area six free hair-tufts; the lateral hair-tuft consisting of one single strong hair; four gills equal, acute.

Lateral tufts of labrum short; the inner part modified in comb hairs, arranged as a crown round the palatum, this is covered with short soft hairs. Mandibles remarkably high in the interior part; with two strong spines before collar; a row of rather short cilia from collar, and about eight to ten rather feeble spines from the inner edge; dentition: four, strong spines; before them a long dagger-like thorn; hairs below, process distinctly divided, with hairs on both apices; a group of hairs at base. Maxillæ almost undivided at the apex, a rather long tuft of hairs and, at its base, one spine. The whole space between suture and inner border covered with long soft hairs and long bristles along the inner border; between suture and palpe an area covered with soft hairs. Palpe well developed, short with four digits. Mentum triangular, an indistinct median tooth and from ten to twelve lateral thorns.

Systematical remarks: *O. annulipes* has always been a very disputed species. Described by Meigen it has later been found in Austria, Germany, Russia, Sweden, Holland, England; Theobald was not able to find it in England but later on Edwards has described it from there. Staeger like many others regarded it as a variety of *O. cantans*; differences in the male genitalia and in the structure of the larva makes this supposition untenable. It may be mentioned that the Stægers specimens, now in the Royal Museum at Copenhagen, have been reexamined by Edwards and myself; they are unquestionably *O. excrusians*; this may probably be so in many other cases.

Biology. I have only found this disputed species in various localities near Arresø in North Seeland. My material was never good and not large enough for me to make a more thorough study of the biology.

It is quite in accordance with my own experience when Lang (1920 p. 88) maintains that the larvæ of *O. cantans* are to be found in shaded pools of thick woods, those of *O. annulipes* in open pools.

Geographical distribution: See under *O. cantans*.

5. **O. vexans** (Meigen).

It is only with the greatest hesitation that I include this species among the Danish Culicidæ. Staeger (1838 p. 554) mentions it and indicates that the species is to be found in the forests, and that it is rather rare.

Most probably Staeger has only been able to distinguish it from *O. cantans* by means of its smaller size and very narrow white bands upon the tarsi. Specimens of this kind I have also found in our forests; a little pond near Tjustruplake was regularly visited for more than two years, more especially because I thought that this pond contained what I supposed was the true *O. vexans*; the specimens which where hatched in July were very small, only five or six mm. and the legs were narrow banded. I have never seen the male; as the claspers are forked, the species is, in the male sex, easily distinguishable from all other Danish mosquitoes.

According to Edwards (1912 p. 195) its occurrence has not hitherto been demonstrated with certainty in England, but according to Lang (1920 p. 85) it has now been found there but is rare. In Germany it seems to be common. In the neighbourhood of Strassbourgh it is said to be one of the most troublesome mosquitoes; its life-history has there been worked out by Bresslau in an excellent study (1917 p. 507). It is hatched in the large meadows which are flooded with water twice a year, in spring and summer, owing to the hayharvest. It was ascertained that no mosquitoes were flying before the first inundation took place; only two days after this the water teemed with larvæ which, at a tp. of 20—25° C., in the course of from 14 to 18 days, gave enormous swarms of mosquitoes. In June and July no other brood appeared in the small waterpools which remained in the now dry meadows. The mosquitoes were to be found at first in the meadows, later

Textfig. 3. Pond near Tjustrup. *O. vexans, communis, cantans.* Stamm phot.

on in cottages and stables. In June the mosquitoes appeared again over the meadows, and the egg-laying process took place; the eggs were laid upon wholly dry ground. Experiments showed that the eggs were laid singly or in small batches, and that they had no apparatuses which could be used for floating purposes. After the second inundation the water teemed with larvæ again and, owing to the higher temperature, in the course of a week this generation was hatched. In the middle of July this second generation visited the meadows and laid their eggs. The species most probably hibernates as eggs, but it is possible that they also hibernate as larvæ. Schneider (1914 p. 33) maintains that he has found females in December. Galli Valerio on the seventh of March. — I refer also to the interesting supplementary remarks by Eckstein (1919 p. 97). The larva has been described by Schneider (1914 p. 32) and Eckstein (1919 p. 294). The larva must resemble that of *O. can-*

tans very much, but the two or three last thorns in the pecten are said to be detached from the other thorns. It may be added that the larvæ from the little pond in which my supposed *O. vexans* was hatched, had no detached thorns in pecten; apart from their small size and remarkably late occurrence (July) they were in full accordance with the larvæ of *O. cantans*. As pointed out by Edwards (1912 p. 195) and stated by Howard, Dyar and Knab (1917 p. 699) the species is identified with the American species *Aëdes sylvestris* (Theobald) (Dyar and Knab).

Geographical distribution: It seems widely spread over the whole of Europe, but has as far as I can see a more southerly range. It also appears over the greater part of Asia.

6. **O. excrucians** (Wlk.).

A. abfitchii (Felt) Dyar and Knab.

Tab. V.

Description. Female: Proboscis moderate; vestiture of brown-black scales. Palpi rather stout, short, about one-fourth as long as the proboscis clothed with black scales, tips and bases of joints with yellowish-white scales. Antennæ with tori subspherical, with a cup-shaped apical excavation, luteous, brown, and with a patch of small white scales on the inner side. Occiput blackish, broadly clothed with narrow, curved creamy-white scales in the middle, a diffused patch of brown ones laterally, and many slender erect forked black scales on the vertex. Bristles bordering the eyes black.

Prothoracic lobes elliptical, remote dorsally, blackish, clothed with pale yellow scales and black bristles. Mesonotum dark brown, clothed with narrow curved scales, a broad median stripe of golden brown ones, anterior margin narrowly and the whole of sides of disk as well as the antescutellar area with pale yellow ones; bristles moderate, black. Scutellum trilobate, luteous each lobe with a group of black bristles and clothed with narrow, curved, pale yellow scales.

Abdomen subcylindrical, flattened, posterior segments tapering; dorsal vestiture of black scales with a few pale ones intermixed, each segment with a broad basal band of creamy-white scales and a narrow row of pale scales at tip; on the sides the basal bands widen into large triangular spots, particularly on the sixth and seventh segments; first segment with a large patch of white scales and many pale ciliæ; venter clothed with creamy-white scales and with median segmental spots of black ones, tending to form a longitudinal stripe. Cerci black.

Wings moderate, hyaline; petiole of the second marginal cell somewhat shorter than its cell, that of second posterior cell about as long as its cell; basal cross-vein less than its own length distant from anterior cross-vein; outstanding scales long, broadly linear, with blunt tips. Halteres entirely pale.

Legs moderately slender; femora clothed with creamy scales below, black and whitish ones about evenly intermixed above, the tips narrowly white; tibiæ with black and whitish scales intermixed, the black ones predominating at the apex, the stiff outstanding setæ mostly black; tarsi black, each joint of hind legs with a broad basal ring of white scales; the first joint with many white scales scattered over the surface and tending to form lines; on the front and middle tarsi, the basal bands are narrow and nearly obsolete on the last joints. Claw formula 1·1—1·1—1·1.

Length: Body about 6 mm, wing 4,5 mm.

Male: Proboscis slender, straight. Palpi exceeding the proboscis by about the length of the last joint; end of long joint and the last two joints somewhat thickened and bearing many long dark-brown hairs; long joint clothed with black scales and white ones intermixed, a broad white ring at middle and near base; last two joints with many white scales at their bases. Antennæ plumose, the last two joints long and slender, black, rugose, pilose, the others short, largely pale; hairs of whorls long, dense, black, with yellowish brown bristles. Coloration similar to the female. Wings narrower than in the female, the stems of the fork-cells longer, vestiture sparse. Abdomen long depressed, the basal bands broader, lateral ciliation long and abundant, pale yellow. Claw formula 1·1—1·1—1·1.

Length: Body about 6 mm.

Genitalia. Side pieces over twice as long as wide, slender, distal lobe roundedly prominent, continued along the inner margin, narrowly to the basal lobe; basal lobe quadrately expanded, bearing many small setæ with tubercular bases, but without a stout spine. Clasp-filament slender, bearing a few small setæ outwardly, at the tip a long articulated terminal spine. Harpes slender, concave, the inner margins revolute, hooked at the tip, the point directed outward. Harpagones with a slender cylindrical base, curved, minutely pilose, bearing a terminal filament which is nearly as long as the stem and angularly expanded at middle. Unci approximate, revolute, forming an indistinct basal cylinder. Basal appendages stout and approximate bearing a row of stout setæ at the tip. (After H. D. K.).

Larva: Head rounded, wider than long; restricted before the eyes; a notch at insertion of antennæ; front margin broadly arcuate. Antennæ short, attenuated at apex, tuft small, only consisting of a few, about six or seven, hairs inserted almost in the middle of the antennæ; spinose; the spines remarkably long and with a fine serration along inner edge. Near the apex two long spines, and at the apex three short ones and a digit. Anteantennal tuft multiple, lower frontal tuft with three or four hairs, upper double. Eyes large. Thorax rounded, wider than long, angled at hair-tufts. Hair formula of frontal border 221113311122 or 231213312132. The median tuft three, with one long hair and two very short, tuft 1 after the median tuft three, also very short. Lateral hairs in multiple tufts and single strong hairs. Abdomen rather broad, the first segments much shorter than the following. Lateral hairs of the first segment triple, on the second to the seventh double, eighth segment with tufts in common arrangement. Lateral comb consisting of about thirty-forty scales, arranged in rows, covering a triangular area; the scales spatulated at base, ending in a very strong spine and furnished with rather long spines at the borders of the spatulated part. Sipho about four times longer than broad, strongly tapering at apex; on basal third a pecten, rather short with about fifteen to eighteen thorns, the first of them without lateral thorns, the others rather broad with four strong ones. The last two thorns large, detached, out of line and with a much greater distance between than the others; a large tuft at middle of tube, consisting of seven hairs.

Anal segment longer than broad, covered by a rectangular plate, almost reaching the barred area of the ventral brush; dorsal hair-tuft consisting of a coarse tuft and two very strong and long hairs. Ventral brush in the barred area consisting of about ten rays, each ray carrying about six or seven hairs, before barred area six free hair-tufts; the lateral tuft consisting of one single hair; four gills, equal, acute.

Lateral tufts of labrum rather short, the inner part modified in comb-hairs, arranged as a crown round the palatum; this is covered with short, soft hairs. Mandibles quadrangular with two strong spines before collar; a row of short cilia from collar and a row of strong spines, about ten, from margin. Dentition four strong spines, the first much stronger than the others; before them three long acute dagger-like spines, one of them faintly dentated; a series of bristles below. Process below distinctly divided with hairs on both apices; a group of hairs at base. Maxillæ elliptical, divided, by a suture; on the apex a long tuft of hairs and at its base one or two short spines. The whole space between suture and inner border covered with long soft hairs; long bristles along the inner border; between suture and palpe an area covered with soft hairs. Palpe well developed with four digits. Mentum triangular, an acute median tooth and from ten to twelve lateral teeth. Colour commonly green, often milky, very transparent, the head also green, the sipho yellowish-red.

Systematical remarks. The description of the female and male is taken from Howard, Dyar and Knab (*A. abfichii*) with which my specimens have been careful compared; they have been determined by Dr. Edwards. As far as I know, the species has hitherto not been described from Europe; most probably it is concealed in one of the fairly numerous insufficiently described older species. With regard to the imagines there is full accordance between the American specimens and the Danish ones; with regard to the larvæ there are some discrepancies. H. D. K. (p. 690) indicate that both frontal tufts are double; in my larvæ the lower frontal tuft has always three or four hairs; further, the lateral hairs on the abdomen on third to sixth segments are single in the American specimens, double in the Danish specimens.

Biology: In North Seeland we often find, on the plains in the forests or in the outskirts of the wood, small ponds, the bottom of which is not decaying leaves, but grass; the ponds are always extremely shallow and dry up in May, often before other ponds are laid dry. They are almost always dry from May to January, and the water these ponds contain is almost only melted snow; it disappears again in the course of one or two months. In these ponds, the true habitats of *Branchipus Grubii* and *Limnetis brachyura*, we find the above-named grassy-green Culicin larvæ which, when hatched, always give *O. excrucians.* In one of the ponds the larvæ appeared 16/IV 1918 (Hestehave Hillerød), a few days after the ice had disappeared; they were full grown 30/IV and pupæ 14/V. At that time there was only a few centim. of water in the pond; though the temperature of the air was only eight degrees C., the temperature of the water was twenty. In 1919 the development was quite the same as in 1918; pond icecovered 25/IV; full grown larvæ 2/V; pupæ 10/V. The pond was dried up by 1/VI. In 1920 the ponds were already icefree in the latter part of February, but the *O. excrucians* larvæ did not appear before the

Textfig. 4. Pond: Hestehave, Hillerød. *O. prodotes, O. excrucians, O. cantans.*

middle of March; they were fullgrown in the first days of April; bad weather was a hindrance to further development; pupæ did not arrive until 8/V; imagines not before 15/V. In May 1920 I found the *O. excrucians* larvæ in the ponds of the Eremitage plain. Now and then I have also found the larvæ in the common forest ponds teeming with *O. communis* larvæ. It was on 21/V in such a pond, in Arnehave forest near Tjustrup, that I observed this fact. On a day with bright sunshine, standing near a pond with huge swarms of *O. communis*-larvæ hanging down from the surface, I saw that below the layer of the perpendicularly hanging *O. communis*-larvæ there was another layer of almost horizontally standing Culicin-larvæ; they were larger and almost white; most of them rested on the bottom or got support from the fine leaves of *Hottonia.* These larvæ were caught, isolated, and eight days later gave *O. excrucians.*

It may be pointed out, that the *O. excrucians*-larvæ, in contrast to those of *O. communis*, almost always lie on the bottom, often on the dorsal side, or very often are found hanging down from water plants; they rarely come to the surface, brushing the bottom and the plants free from detritus. — The life history of the species is the same as for the other mosquito larvæ in drying ponds. They are hatched immediately after the melting period, probably a little later than *O. communis*, they left the pond on 15/v; a few days afterwards the ponds were quite dry and did not get water before the spring. The mosquito have only one generation. In one of the ponds which got water in December, a few larvæ developed but did not hibernate, dying out under the ice. The number of larvæ in the ponds hitherto explored is always slight; I have never found them in huge swarms; also as imagines the mosquitoes are rare; I have only found them in the vicinity of the ponds where they were hatched; they bite vigorously, sitting deep down in the grass, and flying out when this is moved. A few have been observed in the latter part of August.

Geographical distribution: It has hitherto only been found in Northeastern North America (H. D. K. 1917 p. 691).

7. **O. lutescens** (F.).

O. fletcheri (Coquillet).

Tab. VI.

Description. Female: Proboscis moderate, vestiture of brown-black scales. Palpi stout, rather long, more than one-fourth as long as the proboscis; vestiture of black scales with a few pale ones. Antennæ with tori subspherical, with a cup-shaped apical excavation, ocher yellow, on the inner side black and with small, flat, broad whitish scales. Occiput rather broad, clothed very broadly with dense, narrow curved brassy scales on the vertex, a large patch of golden brown ones on each side close to the eyes; bristles bordering the eyes pale brown.

Prothoracic lobes elliptical, well separated, brownish, clothed with narrow, golden scales below, golden-brown ones above and pale bristles. Mesonotum black, a broad median stripe of narrow curved golden-brown scales, a detached stripe of similar scales on each side on posterior half; sides of disk and ante-scutellar space clothed with pale brassy scales. Scutellum trilobate, each lobe with a large group of whitish bristles. Pleuræ gray, the coxæ pale brown.

Abdomen subcylindrical, flattened, the posterior segments tapered; dorsal vestiture nearly wholly of dull ochraceous white scales intermixed with a few black ones, these latter predominating along lateral margins, forming an ill-defined stripe becoming obsolete towards the tip; no traces of bands along the borders of the segments, venter similarly coloured, the black scales forming an ill-defined median longitudinal stripe. Cerci black.

Wings rather broad, hyaline yellow irridiscent; petiole of second marginal nearly half as long as its cell, that of second posterior cell about as long as its cell; basal cross-vein nearly its own length distant from anterior cross-vein, outstanding scales linear to ligulate, very long, both black and pale. Halteres pale with blackish white scaled knobs.

Legs rather long, clothed with pale, ochraceous scales, the long outstanding setæ black; femora with some black scales on upper side, which predominate towards tip; tibiæ similarly coloured; first tarsal joint clothed with ochraceous scales with black ones intermixed which predominate at tips, the other joints black, with basal white rings, the hind tarsi having the basal halves white, the rings narrower on the other legs and nearly obsolete on the last joint of front legs. Claw formula 1.1—1.1—1.1.

Length: Body 7,5 mm; wing 6 mm.

Male: Proboscis slender, nearly straight. Palpi exceeding the proboscis by about half the length of the last joint; vestiture of ochreous and blackish scales, the latter very sparse, tending to form rings near the false articulation of the long joint and at the apices of the other joints; apex of long joint and last two joints with long, dense, golden and brownish hairs. Antennæ plumose, the last two joints long and slender, rugose, pilose, black, the others short, black at the thickened insertions of the hair-whorls; hairs long, dense, brown, shining. Coloration similar to the female. Wings narrower than in the female, the stems of the fork-cells longer, the vestiture sparse. Abdomen long, depressed; dorsal vestiture of sordid yellowish white scales, with an ill-defined, narrow median stripe of black and golden brown scales; lateral ciliation long, fine, and dense, pale yellowish. Claw formula 2.1—1.1—1.1.

Length: Body 7 mm; wing about 6 mm.

Genitalia: Side-pieces nearly three times as long as wide, the tips conically rounded. Distal lobe large, prominent, conical with short setæ. Basal lobe a rather large, but slightly elevated area, bearing numerous dense, short setæ with tubercular bases; a stout spine with hooked tip within the basal lobe, accompanied by two slender hairs. Clasp-filament slender, attenuated above base. a long stout articulated spine at apex, nearly one third as long as filament; three small setæ subapically. Harpes elliptical, edges recurved and thickened, tips pointed and directed outward. Harpagones with stout base, tapering outwardly, minutely hirsute, bearing at its tip an articulated filament which widens, broadly lanceolate, with a short, somewhat recurved branch on inner side near middle. Unci invisible. Basal appendages small, rather approximate, bearing about six stout setæ.

Larva: Head rounded, wider than long, restricted before the eyes and slightly notched before the antennæ; front margin arcuate. Antennæ short, attenuated at apex; finely spined, a fine serration along inner edge; the hair-tuft a little below the middle, consisting of six hairs. Near the apex one long hair; three short ones and a digit. Anteantennal tuft with from five to seven hairs; lower frontal tuft with five, upper with two hairs, all hairs remarkably long. Eyes large.

Skin of body very smooth. Thorax rounded, wider than long, angled at hair-tufts. Hair formula of frontal border 132114411231; the median tuft with four hairs, two of which are long and two short, the one often indistinct; at the base of the first median single hairs two or three smaller ones. Lateral hairs of the first segment triple, on the second to sixth double. Eighth segment with tufts in common arrangement. Lateral comb of about forty scales, arranged in rows, covering a triangular area; the scales are spatulated at base, ending in a strong spine and furnished with rather long spines at the borders of the spatulatea part. Sipho stout, a little less than four times as long as wide, slightly tapering at apex; pecten rather fine, consisting of about twenty thorns, reaching nearly to tne middle of the tube, the last two teeth but slightly detached without dentitions, the others with from three to four teeth followed by a large tuft, consisting of six or seven hairs. Anal segment longer than broad, covered by a large dorsal plate, dorsal hair-tuft consisting of a coarse tuft and two very strong and long hairs; ventral brush large, in the barred area consisting of about 11 rays, each ray carrying about six or seven hairs; before barred area six free hair-tufts; the lateral hair-tuft consisting of one single strong hair; four gills, equal, acute.

Lateral tufts of labrum rather short; the inner part modified in comb-hairs, arranged like a crown round the palatum; this is covered with short, soft hairs. Mandibles quadrangular with two spines before collar; a row of rather short cilia from collar and about twelve spines in row from inner margin; dentition four strong spines, the first strongest; before them two dagger-like thorns, the one dentated. Process below distinctly divided with hairs on both apices; a group of hairs at base. — Maxillæ indistinctly divided by a suture; at the apex a rather long tuft of hairs, and at its base one or two spines. The whole space between suture and inner border covered with long soft hairs and long bristles along the inner border; between suture and palpe an area covered with soft hairs. Palpe well developed, short with four or five digits. Mentum triangular, an acute median tooth and ten lateral thorns.

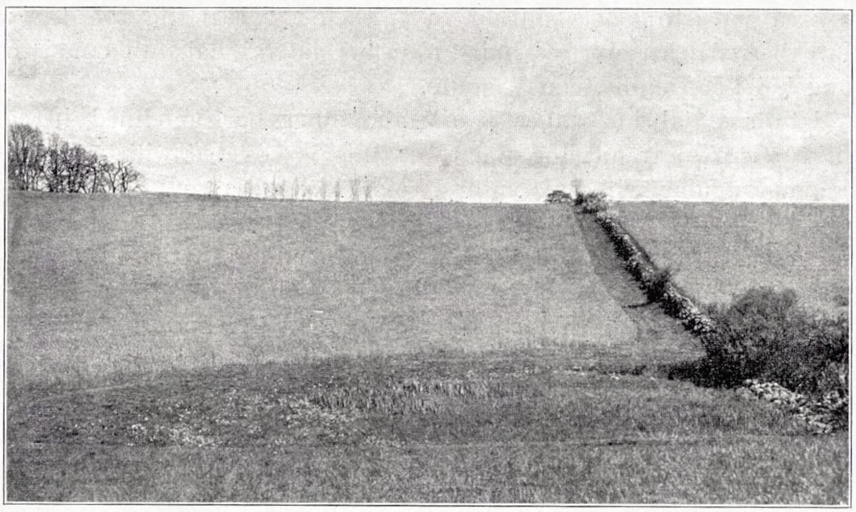
Colour bright yellow, rarely gray; the strongest chitinized parts of the body yellowish-red; body highy transparent.

Systematical remarks. The description of the female and male is mainly taken from H. D. K. (1917 p. 675) (*A. fletcheri*) with which my specimens have been carefully compared; they have been determined by Dr. Edwards. Most probably the species is identical with *Culex flavescens* Theobald (1901 p. 410). With regard to the imagines there is full accordance between the American specimens and the Danish ones, with regard to the larvæ there are rather significant differences. I have never seen any fine hairs on dorsal surface towards base of the sipho as indicated by these authors for the American specimens; the number of scales are greater in my specimen (30—40 against about 25); further the last two thorns are but slightly detached from the others; and the frontal hairs are not triple in both tufts as indicated by the American authors, but double in the upper, and with five hairs in the lower, frontal tuft.

As however the imagines also with regard to the male genitalia are indistinguishable from the American specimens, I suppose that it is temporarily most correct to refer the Danish specimens to the American species.

Biology. I have mainly found the species in four localities resembling each other very much: in the meadows near the outflow of Susaa in Tjustruplake, on the large moors south of Arresø and on the southern coasts of the island Lolland. The large meadows near the outflow of Susaa in Tjustruplake only a kilom. from my summer laboratory are regularly inundated in the winter; ice covers the whole area and in spring it is changed into a large lake. In May the water disappears, and herds of horses and cattle graze in the vast meadows, dry from June to November. Some of the pools left were under direct observation for almost three years.

In the spring of 1917 the ponds contained plenty of larvæ which were fullgrown in the first part of June; the larvæ were hatched in my laboratory and gave *O. fletcheri.* In Nature they were hatched about 15/VI, on 1/VII the pond was dry,



Textfig. 5. Pond near Tjustrup-lake. *O. lutescens, rusticus.* Stamm phot.

and the bottom was covered with grass which was cropped by the cattle. The pond was never filled with water before the middle of November, and by 14/II 1918 the pond contained many mosquito larvæ, but only *O. communis*; from the middle of January and till the latter part of March the pond was ice-covered, and when the ice had disappeared crowds of mostly fullgrown *O. communis* larvæ appeared. On 12/IV I found a great number of newly-hatched yellow larvæ; they did not swim as the *O. communis* larvæ and only rarely hung down from the surface, but moved in smaller or larger circles along the sides of the aquarium; the larvæ in my cultures were fullgrown by 23/IV and metamorphosed into pupæ on 30/IV. On 4/V the imagines appeared. In Nature the whole stock of larvæ died off. On 30/IV the temperature fell below zero and heavy snow fell at 9 o. cl. a. m.; the low temperature retarded the development and, as the pond was wholly dry about 15/V, the whole mass of larvæ died off. — Other ponds near this, which were somewhat deeper, were filled with water till July, and in these ponds the development was accomplished. The pupæ appeared on 20/v and before the 1st of June all *O. lutescens* larvæ were hatched. The imagines sat in a rather restricted zone round the pond, especially below the *Caltha*-bushes. The mosquitoes did not begin to bite before about 15/vi. The ponds were dry till November; contained no *O. lutescens* larvæ in the winter of 1919, and were open about the first of April. On 16/iv the ponds teemed with *O. lutescens* larvæ halfgrown, fullgrown on 3/v, and on 19/v the imagines were hatched. — In the rainy summer many of the ponds contained water, and in some of them a few *O. communis* larvæ were hatched. In a few of them there was no water, but the cattle had made deep holes with their hoofs and in these holes there was some water, only about half a deciliter. These holes contained rather few *O. lutescens* larvæ; the larvæ were found on 29/vii and the imagines were hatched on 1/viii. Another of the ponds got water on 10/vii; larvæ appeared on 20/vii; they were hatched in my aquaria and gave imagines by 28/vii, but in the pond no larvæ were developed, they all died off because the pond dried up. The ponds were dry the whole of the autumn, at all events till 15/x.

Textfig. 6. The vast meadows at Arresö. *O. lutescens.*

I do not know with certainty if we have here to do with a new second brood or only with larvæ derived from eggs which have only now got developmental conditions. I suppose that the latter supposition is most correct, and that the species in our country normally has one single generation.

I have further studied the species on the moors south of Arresö. On 20/vi 1919 as I was driving through the forest Neiede Vesterskov, almost bordering the lake, the horses suddenly became extremely nervous. Clouds of large, yellow mosquitoes rushed over them, attacking especially venter and the inside of the thighs. The mosquitoes made any stay in the forest impossible. Some hours later I was driving over the meadows and arrived at the hatching area of the mosquitoes that had attacked me in the forest. This area, too, is in spring covered with water, but in summer the water dries, and only some ditches and pools remain; herds of cattle live here the whole summer. The mosquitoes were probably hatched in one or two weeks; the landowners told me that they had even begun to sting; and that every year they stood like clouds over the grass making any stay for people or cattle almost impossible. They pounced upon us in vast numbers and bit us very severely.

In the following year I was again examining Neiede Vesterskov, and the meadows south of Arresö. The water-line had receded, but in the ditches there was still plenty of water; in this I found many yellowish-grey larvæ, from which was hatched *O. lutescens* on 21/v. 23/v when I was in the same locality, the meadows were dry, and only a few holes had water. In one of them I found a great number of pupæ, and in the grass over the pond plenty of newly-hatched *O. lutescens*. On 29/v the mosquitoes were on the wing, but they had not begun to bite. The meadows were quite dry from 29/v to the latter part of October. On a visit in the last part of June I was fiercely attacked by clouds of *O. lutescens* which stung vigorously.

Another locality where I have studied this species is the southern coast of the islands Lolland-Falster: Time: June. Here we find large meadows, bordering on the shores of the Baltic; in spring the water goes over the meadows, in summer they are commonly dry. Everywhere in the large forests of *Phragmites*, deepest down in the old, now almost dry, fjords, often surrounding smaller lakes, and in the forests I found *O. lutescens* in enormous masses. I hardly ever saw any other mosquito; more especially on damp evenings, in the large *Phragmites* svamp behind the castle of Aalholm, the mosquitoes were extremely troublesome. Here, as well as near Maribolake, and on the long peninsula of Knudshoved, on the southern coast of Seeland, I observed that the species attacks cattle and horses much more than man. Near Maribo I had an opportunity to make sure that *O. communis*, *cantans* and *lutescens* were simultaneously on the wing. Whilst we in the forest were attacked by the two first-named, *O. lutescens* attacked the horses in the meadow bordering the lake; more than forty were simultaneously sucking one horse.

Textfig. 7. The vast meadows at Aalholm. Lolland. *O. lutescens.*

On the island of Amager near Copenhagen man and cattle in the meadows are attacked by clouds of *O. lutescens*. In the Royal Museum of Copenhagen some large yellow mosquitoes from Stægers time are labelled *C. annulipes*. As we know that Stæger has explored Amager with regard to mosquitoes, it is most probable that these specimens really derive from this locality. Most probably the species is widely spread over the whole island; at all events I have found it on both seashores and in the middle. The island is bordered by numerous brackish pools, in which the huge masses of *O. caspius* and *curriei* are hatched. Often separated from these pools by means of dikes, which preserve the low-lying island from inundations, we find hundreds of freshwater pools all over the meadows, more especially in spring, in which *O. communis* are hatched in early spring, and later on *O. lutescens*; I have only taken the larva of *lutescens* in one single brackish pool and only one specimen; it seems as if the above-named dikes form a very conspicuous barrier between *O. curriei* and *O. caspius* on one side and *O. lutescens* on the other. Later on, as imagines, they have the same flying areas.

From these observations we are able to state that the home of *O. lutescens* seems to be the open meadows bordering on lakes and sea-shores; they do not dwell in forests, the outskirts of which is the natural home of *O. excrucians*, only on very warm days do they now and then seek them. There is unquestionably regularly only one single generation, hatched in the latter part of May and on the wing the whole summer, attacking cattle and horses more than men. Curiously enough, this species, which has not hitherto been described in our country, is perhaps the one which forms the greatest swarms, standing in clouds over the meadows; the males disappear before the last part of June, and the females begin to throw their numerous single eggs over the vast plains, then dry, but inundated before January, at all events in the following spring.

Geographical distribution: England, Germany, Russia, and Scandinavia; it is identic with *O. fletcheri* Coq, hitherto found in North America. H. D. K. (1917 p. 678) indicate Prairies of western Canada and north western United States.

Systematical remarks with regard to the four last-named species. In the above-named localities I found, in 1917—1919, the larvæ of the now mentioned three species *O. lutescens, excrucians* and *annulipes*; these larvæ were at that time unknown. By means of the remarkably long sipho and short antennæ I was always able to distinguish the larvæ of these three species from those of *cantans, communis* and *Theobaldia morsitans*; I first regarded the three larvæ as belonging to the same species. A closer examination showed that, between these long siphoed larvæ there were slight, but conspicuous, differences; later on I therefore regarded them as belonging to different species, and made drawings of them. As the imagines appeared, I immediately saw that I had at all events two species before me; regarding those from the small ponds at Hillerød as differing from those from the meadows near Arresø and Tjustrupsø. Later on I was inclined to regard some of the material from the ponds in North Seeland as belonging to two different species, one being *O. annulipes*; if this was right, however, I was unable to distinguish this species from *O. cantans*, taking an intermediate position between *O. cantans* and *O. excrucians*. — Later on, when in July—August I examined the same localities, where I had gathered the larvæ in spring, and from which I had hatched the presumed three species in the latter part of May, the case was much more troublesome. The males had disappeared; at that time we find only females in all the above-named localities. When the lust of blood of this sex has been satisfied, when the mating and egg-laying processes are finished, the females of all three species have another appearance. The scales of the thorax have almost all fallen off, and the blackish brown colour of the mesonotum especially in *lutescens* and *excrucians* appears; simultaneously the whole uniform tomentum of the abdomen of *O. lutescens* disappears, the yellow strongly shining chitin, often a little darker at the base of the segments, appears. The abdomen of *excrucians* and *annulipes* gets a rather similar aspect; the scales of the legs and proboscides are torn off; the legs are no more white banded but uniform yellow and only reminiscenses of the whitish rings appear; this more especially holds good with regard to *O. lutescens* and *annulipes.* It will therefore be understood that at this time of the year it is impossible to distinguish the three species from each other. — As the three species were unquestionably distinguishable from each other in the larva stage, and were conspicuously different when newly hatched as imagines, I was inclined to regard them as three species, but was unable to determine them. After having sent them to Dr. Edwards I was interested to hear, partly that the separation of the three species was correct, and partly that my material contained the two above-named species *O. lutescens* and *O. excrucians.* He wrote to me that he had arrived at the same result as I, that the three species in the female sex are almost indistinguishable from each other later on in the year, after the abdomen has been filled with blood and enormously distended, the females of the three species having lost most of their hair-coating.

The best distinguishable species is *O. lutescens* with its uniform ochraceous, tomentum of the abdomen and the dark mesonotum; also *annulipes* with its red tomentum, consisting of upright standing hairs is easily recognizable for a long time in the summer; but in very many cases *O. annulipes* takes the intermediate stage between *O. excrucians* and *cantans,* and the three species are then very difficult to determine. As far as I can see, the male genitalia do not help very much, the structure of the side pieces and clasp-filaments is almost the same in the four species, and only the structure of the harpagos (basal appendages) differs a little in the four species; they are long and strap-shaped in *O. annulipes*; in the other three species they are provided with a large, membranous expansion near the tip, and this expansion has a somewhat different appearance from species to species.

The two species *O. cantans* and *annulipes* have always been difficult to separate from each other; roughly speaking the two species differ from each other by *O. cantans* being more greyish-dark, *O. annulipes* more yellowish-red; but with regard to the colour most probably every possible intermediate stage may be found. *O. annulipes* is a more robust species than *O. cantans,* and this species may occur in pond-races of only very small sizes (from five to six mm.); this I have never seen with regard to *O. annulipes.* It may be added that *O. cantans* is a forest mosquito par excellence, *O. annulipes* only found on the large fens and moors; moreover *O. cantans* appears at a somewhat earlier date than *annulipes,* and is troublesome at an earlier time of the year than this last-named species.

Also as larvæ the four species are difficult to distinguish from each other; the best characteristics are the following: In *O. cantans* the sipho is much shorter than in the other above-named species; it does not reach more than about three times its own width at base; those of the others about four times. Among the other three species *annulipes* is distinguishable by means of the pecten, the two last spines not being detached from the others, and provided with lateral thorns like these. The two other larvæ, those of *O. lutescens* and *excrucians* are difficult to distinguish from each other; I refer to the descriptions given above. — It will be seen that whereas it is difficult to distinguish *O. lutescens* and *excrucians* as larvæ from each other, the difficulty is not so great with regard to the imagines; otherwise *annulipes* and *cantans* are easily recognizable as larvæ, whereas as imagines it is often impossible to recognize them.

8. **O. detritus** (Haliday).

Tab. VII.

Description. Female. Proboscis moderate, cylindrical uniform, dark brown almost black, sprinkled with white scales especially near the base. Palpi black with many whitish scales and some black setæ. Antennæ filiform, the joints subequal, rugose pilose, black, sprinkled with whitish scales; second joint thicker, but scarcely longer than third, pale; tori subspherical with a cup-shaped excavation, luteous, darker within, outwardly sprinkled with many white scales, hairs of whirls black. Clypeus rounded prominent, black, nude. Eyes black. Occiput black, covered with lanceolate, curved, creamy scales; on the sides broader; generally an ill-defined lateral black spot; bristles on the occiput and along margin of eyes black, those between the eyes yellow.

Prothoracic lobes elliptical, remote dorsally, black, clothed with narrow white scales and dark bristles. Mesonotum black with a monotonous coating of yellowish brown or reddish hairs, without distinct brighter or darker lines; scutellum trilobate, black, each lobe with a group of bright bristles. Postnotum elliptical, prominent, blackish, nude; pleuræ dark brown, coxæ luteous, both covered with patches of elliptical, flat, white scales.

Abdomen subcylindrical, tapering posteriorly; dorsal vestiture with broad white basal bands, tending to expansion in the middle line; seventh segment almost yellowish white; sprinkling of the darker parts of the abdomen with numerous white scales; venter yellowish-white with a median series of three dark spots and with two other more inconspicuous dark spots in each apical corner of each segment. Wings rather broad, hyaline, petiole of second marginal cell and second posterior cell shorter than their cells; basal cross-vein distant less than its own length from anterior cross-vein; scales black, but with numerous white scales scattered over all the veins, especially over the subcostal vein which may be almost pure white.

Legs moderately long and slender, dark, brightest below, no conspicuous knee-spots; covered with numerous white scales, especially conspicuous upon hind tibia and tarsi.

Size 5·5 mm.

Male: Palpi and proboscis, black; end of long joint swollen, black, sprinkled with white hairs. Abdomen broadest on sixth to seventh segment; coloration similar to the female; lateral ciliation long, abundant, pale; wings narrower than in the female; stem of the fork-cells longer.

Size 6·5 mm.

Male genitalia: Side pieces almost three times longer than wide, tapering distally; apical lobe well developed with some few, rather short hairs. Clasp filaments slender, slightly expanded in the middle and bearing a long articulated terminal spine; a few extra large bristles at proximal end of the basal lobe; stem of harpago long, blade strap-shaped, not much shorter than stem.

Larva: Head rounded, wider than long, a notch at insertion of antennæ; front margin arcuate. Antennæ short, antennal tuft small, only with from five to seven hairs inserted below the middle of antenna; on apex four hairs, two long, and a digit. Anteantennal tuft multiple; lower frontal tuft consisting of two or three hairs, upper of one. Eyes large.

Thorax subquadratic angled at hair-tufts, hair-formula of frontal border 311144113; in tuft four two long and two short hairs. Lateral hairs in multiple tufts and some single strong hairs. Abdominal segments rather broad, the first of them shorter than the last. Lateral hairs on the first two segments four or three, on the others, two; subdorsal hairs in double tufts. Tufts of eighth segment in common arrangement; lateral comb consisting of about twenty-five scales, arranged in a triangular area; scales blunt, without any peculiar, developed median tooth. Sipho rather short, not fully three times longer than broad, tapering at apex. At basal third a pecten consisting of about twenty thorns, all in line and with from five to six teeth of unequal length at base; a tuft of hairs between end of pecten and apex.

Anal segment longer than wide; the dorsal plate subquadratic, not covering the two thirds of the segment; dorsal tuft large, two very long stiff hairs beneath; ventral brush consisting of about fifteen rays, every ray carrying from seven to nine hairs. Before the barred area two or three free tufts; Anal gills four, extremely short, bud-shaped, equal, almost isodiametric.

Lateral tufts of labrum short but dense; the inner part with a crown of comb-hairs; palatum large, covered with long soft hairs. Mandibles quadrangular with two strong spines before the collar; a row of short cilia from a collar. About ten thorn-like bristles from margin, the last very strong, curved; dentition five, strong, blunt thorns and one longer, more acute; long cilia below thorns. Process below indistinctly furcate with strong hair-tufts on tips and a group of hairs at base. Maxillæ elliptical, at apex a brush of very long hairs; a seta near the apex; near the inner margin a coating of long soft hairs; an inconspicuous row of thorn-like bristles along the margin; palpe well developed with four or five apical digits. Mentum triangular with rather large median tooth and about 13 small teeth on each side.

Biology. This peculiar mosquito, easily recognizable by the white scales scattered over the wings, abdomen, and legs, I have for a long time vainly searched for in our country. It has been described as *Culex salinus* Ficalbi (1896 p. 29) from Italy, from the Mediterranean (see Lang 1920 p. 89), and from England where it seems to be abundant, more especially in the South of England. It is a brackish water species with sea-side habitat; it has very often been found with the larvæ of *O. caspius* and *O. curriei.*

During the regular exploration of the island Amager I always expected that the species would occur sooner or later, but till the last part of August 1920 we never found the species there; nor did all simultaneous exploration of the sea coasts along Roskilde Fjord and various fjords on the east side of Jutland, and the brackish water pools in the southern parts of Lolland and Falster, ever disclose the species. Finally, only a few months (on $^{20}/_{\text{VII}}$ 1920) before the work was sent to press, I found the species abundant in pools on the shores of Guldborgsund, which separates the two islands Lolland and Falster; the pools were often filled with the brackish sea water and contained numerous larvæ and pupæ. When hatched the pupæ all gave *O. caspius*, and I supposed that the larvæ would give the same; then suddenly another mosquito with unbanded legs appeared in my cultures, and these were now more thoroughly studied. I then saw that the larvæ really did not belong to *O. caspius*, having all blunt scales and more than one hair in the frontal tufts. Isolated they soon gave the above-named mosquito; a very short examination then showed that the wings and legs were sprinkled with white scales and that the abdomen on the underside possessed a series of black spots. The species was then determined as *O. detritus* (Haliday); in the latter part of August samples brought me from Amager and Roskilde Fjord all contained numerous larvæ of *O. detritus*, and many specimens were hatched in the laboratory. It seems that the species in our country has only one generation, the imagines appearing very late; owing to this it had nearly been overlooked.

Lang (1920 p. 89) supposed that *O. detritus* winters as a larva or an egg (in my localities almost certainly as egg) and that the species at least is double brooded "for larvæ and emerging flies have been taken in September".

Geographical distribution: *O. detritus* has hitherto only been found in Italy and England.

9. **O. communis** (De Geer).

Tab. VIII.

Description. Female. Very similar to *O. punctor* (Kirby), but the scales of head and thorax are darker brown, and the coating of the mesonotum more homogeneous, the blackish brown stripe being less conspicuous and often almost obsolete. The scales on the lateral parts of the thorax are more greyish than those of *O. punctor*.

The abdominal bands are pure white, not creamy, forming straight lines without any contraction in the middle line even on the apical segments. Underside of abdomen usually all white. Femora darker than in *O. punctor*. Tibiæ and tarsi with more numerous pale scales.

Size 6 mm.

Male. Palpi entirely black; mesonotum covered with an almost homogeneous greyish-brown tomentum. Abdomen and legs as in female. Genitalia: Side pieces more than twice as long as wide; outer edge straight; apical lobe rather well developed with only a few long hairs at tip; basal lobe well developed with long hairs; clasp-filaments slender, slightly expanded in the middle, bearing a long articulated terminal spine. Stem of harpagones very long, columnar; terminal filament hardly more than half as long as stem, slender and bearing two ridges. Size 6·5 mm.

Larva: Head rounded; wider than long, a notch at insertion of antennæ; front margin arcuate. Antennæ short, antennal tuft small, with only a few hairs; on apex three hairs and a short digit. Anteantennal tuft multiple; lower and upper frontal tuft both consisting of one hair, or lower of two, upper of one hair. Eyes large. Thorax subquadratic angled at hair-tufts; hair formula of frontal border 3131441313. In tuft 4 two hairs shorter than the others. Lateral hairs in multiple tufts and some single strong hairs. Abdominal segments rather broad, the first of them much shorter than the last. Lateral hairs on the first segment four, on the second three, on the third to seventh two. On fourth to seventh segments subdorsal hairs in double or triple tufts. Tufts of eighth segment in common arrangement; lateral comb consisting of about forty to fifty scales, arranged in rows occupying a large triangular area; scales blunt with many almost equally long apical teeth. Sipho short, straight, tapering at apex only a little more than double as long as wide rarely three times longer than wide. At basal third a pecten consisting of about twenty thorns all in line, and most of them with from 1 to 4 teeth of unequal length at base; a tuft of hairs between end of pecten and apex.

Anal segment longer than wide; the dorsal plate subquadratic, covering the two thirds of the segment; dorsal tuft large, two very long stiff hairs beneath. Ventral brush consisting of about 17 rays, every ray carrying from five to seven hairs. Before the barred area about six free hair-tufts; a lateral tuft with two hairs. Anal gills rather long, acute, equal. Lateral tufts of labrum short, but dense; the inner part with a crown of comb-hairs; palatum large, covered with long, soft hairs. Mandibles quadrangular with two strong spines before the collar; a row of short cilia from a collar. About twelve thorn-like bristles from margin. Dentition: four or five strong teeth, before them two short, acute thorns; long cilia below thorns. Process below distinctly furcate with strong hair-tufts on both tips; a group of hairs at base. Maxillæ very broad, obtuse at front, at apex a brush of long hairs, a seta near the apex, beneath the brush; near the inner margin a coating of soft hairs, an inconspicuous row of thorns along the margin. Palpe well developed with four apical digits. Mentum triangular with median tooth and about 14 small teeth on each side.

Colour commonly greyish or brown, the head almost black.

Biology. Even in January, when the lakes are covered with thick ice, and the landscape white with the snow, we are, on bright frosty days, able to feel the heating power of the sun. If then on such a day, we examine the south exposed borders of small ponds, lying in the beech-forest but in bright sunshine we shall see that there is often a little stripe of water between the borders of the pond and the ice edge; if the frost is severe, the stripe will disappear a few hours after sunset, but will be formed again the next day if the weather is fine. By means of a thermometer we are further able to ascertain the peculiar fact that the temperature in this stripe of water, only few inches from the ice edge, at the brightest hour of the day, may rise to 7—10° C.; sometimes I have even found 17° C. In this stripe of water we find very many hibernating organs of the freshwater fauna: Statoblasts, resting eggs, turions of water plants (*Stratiotes, Myriophyllum* etc.); besides we also find a great part of the freshwater fauna which has hibernated under the ice and now, in the water stripe, get the first feeling of approaching spring. (Larvæ of *Odonata*, of *Ephemeridæ* etc.; many small *Mollusca, Crustacea* etc.). The enjoyment is but short; at four or five o'clock the temperature at the south exposed borders of the ponds falls again, often below zero; but the above-named temp. has been enough to hatch many of the hibernating organs, swept in autumn by the wind on to the borders of the ponds, where they have been frozen in the ice in November—December. This is the case with many Cladocera, and I suppose also with the eggs of Phyllopoda. Simultaneously with them some insect eggs, which have hibernated with them are hatched; among these eggs we shall in this connection especially pay attention to the eggs of *O. communis.*

It is a rather common fact, at all events for my district of exploration, to find in January the borders of the partly ice-covered ponds teeming with newly-hatched *Culex*-larvæ; all the larvæ still carry their egg tooth; they are hatched on a sunny day from twelwe to three o'clock, but run the risk of not meeting this temperature again for months. In the winter of 1918—1919 the ponds thawed in the first days of January and were open till 22/I; the larvæ were observed in these three weeks. In this period the air-temperature never rose above 2° C.; we had only very few sunny days, and the hours in which the temperature in ponds was above one or two degrees, were certainly very few. By 22/I the ponds were frozen again, and did not thaw before the first days of April. Examining the same ponds again, we still find the borders of the ponds teeming with very small newly-hatched mosquito larvæ. All are almost of the same size, a few have passed the first ecdysis. From material taken into my laboratory on 13/I and wintered here at low temperatures, near zero, we learn that the larvæ do not grow at these temperatures. I therefore suppose that a great part of these larvæ found in the ponds in the first days of April, which look as if they were newly-hatched, are really about three months old. In animals of such a small and delicate structure, the need for atmospherical air is by no means as high as for larger ones which, for a long time of their life, are covered with a much thicker cuticula; the respiratory conditions for cutaneous respiration in these ponds are also much better at low temperatures than at higher. In early spring, immediately after the melting of the ice, all our small ponds in our woods, the bottom of which is covered with decaying leaves, teem with mosquito larvæ; at that period in most of the explored localities these almost all belong to one single species, the most common of all our mosquitoes *O. communis*. In the three years 1917—1919 the ponds thawed at different times, in 1917 from $^{5}/\text{IV}$ to $^{25}/\text{IV}$, in 1918 already in the last days of March, and in 1919 $^{1}/\text{IV}$. Nevertheless *C. communis* was hatched as imago almost at the same time all three years, in 1917 about $^{6}/\text{V}$, in 1918 about $^{15}/\text{V}$, and in 1919 about $^{10}/\text{V}$. In 1920 the temporary ponds were open already by $^{15}/\text{II}$ and then contained huge masses of halfgrown larvæ of *O. communis*. In a mild period in the first half of April they pupated; then a very cold period came, tp. of air hardly ever more than five to seven dg., and the development was great retarded. The ponds were often visited; a layer of living pupæ covered the surface but imagines did not appear before $^{10}/\text{V}$. I got the impression that an enormous amount of pupæ were destroyed by larvæ of *Dytiscs*, by *Phryganids* (*Phryganea minor*) by *Hydrometridæ* and *Notonecta*.

At the beginning of the period we often find newly-hatched and halfgrown or even fullgrown larvæ among each other; side by side we further find ponds in one of which all larvæ are fullgrown, whereas in the other many larvæ are almost of the same size; the pupation takes place almost on the same day, or at any rate in the same week. Further it is very interesting to see, that the hatching of imagines in the different ponds, but in the same latitude, almost everywhere in the last part of the period takes place simultaneously; in North Seeland hundreds of forest ponds have sent out their *O. nemorosus* material almost in the same week, and in the years 1917—1920 this always lay between $^{6}/\text{V}$ and $^{15}/\text{V}$.

The different development at the beginning of the period is intelligible, because heavy showers suddenly raise the watermark line in the ponds, carrying a new border of eggs outwards, giving them conditions for development. But also the peculiar fact that, in spite of the different time for hatching from eggs, all larvæ are ready to pupate simultaneously, is intelligible. For it must be remembered that these latest hatched larvæ grow up under much higher temperatures and much better conditions for rapid nutriment than those hatched in winter in ice and snow. From my observations in my numerous cultures in my laboratory I can show that I am always able to control the rapidity with which I wish the development of the larvæ to take place. Kept at temperatures between 0 and 5 degrees, the development lasts about four months; kept at 15—20 degrees it is finished in at fortnight; at low temperatures the water in my aquaria is very limpid and undoubtedly poor in organic matter; at higher temperatures the sides of the aquaria are covered with algæ, and the water contains numerous Infusoria.

On the other hand we often find ponds where life conditions for the mosquito-larvæ are so difficult that they highly influence the development.

On an excursion in Gripskov 15/IV 1919 I found many ponds with almost fullgrown *O. communis* larvæ; a single pond lying in thick forest, and never getting a single sunbeam, was still ice-covered; in the free stripe of water near the border were many newly hatched *O. communis* larvæ, hatched almost a fortnight later

Textfig. 8. Pond in Store Dyrehave. *O. communis, rusticus, cantans.*

than in all ponds in the neighbourhood. The cold influenced the size of the imagines, this being only half of the normal.

Of two of my Mochlonyx-ponds one lies free on the top of a hill, without forest and fully exposed to the sun; the other lies in a deep hole, overshadowed by willows and hardly ever sun-lit; the first is very shallow, has never more than about one or two decim. water and dries up in May, the other is about one m. deep, and dries up three or four weeks later; on sunny days the tp. in the former is about 10 degrees above that of the latter. In 1919 the imagines were hatched already on 6/V in the first pond, and the whole vegetation was covered with numerous *O. communis*; a few days later, the pond was almost quite dry. In the second pond the pupæ did not arrive before 26/V then the pond was covered with a thick layer of millions of pupæ, and not before 29/V were the pupæ hatched.

I have often observed that the whole bulk of larvæ, when the pond is almost dried up, are metamorphosed into pupæ in the course of very few days and often probably in the course of a few hours; in these very small water reservoirs, black with the pupæ, often lying in layers over each other, the temperature rises in the sunshine to about 28° C.; the pupæ-stage lasting only one or two days.

Further I have observed ponds which had a good deal of water in 1918, and from which enormous masses of *O. communis* were then hatched, but were dried up in 1919 during the whole of spring, and only in July got a decim. of water in the deepest holes of the bottom. These holes were often formed by the cattle plodding in the mud. In these very small water reservoirs a small part of the enormous egg masses which covered the whole bottom was hatched; in the course of only eight or ten days, by the drying power of the sunshine, in our hottest summer-months, the whole metamorphosis was finished; at last the little water-mass was packed with pupæ, these being so numerous that they lay in layers over each other, pressed together to suffocation; the whole mass is in a constant circulation, the deepest layer always trying to reach the surface. In the greyish dried up surface of the pond these small holes shone black from the masses of black pupæ.

The huge masses of larvæ in the last stage as well as the pupæ are of course extremely good as food for many lower animals. Whereas the pupæ of Chironomidæ when they come up to the surface from the great depths of the lakes are a welcome prey to the dikeswallows, I do not know of any insect-eating bird which has learned to catch its food in the ponds teeming with mosquito larvæ or pupæ; at all events I have never disturbed our singing birds on the drying mosquito-ponds; for the blackbird, which comes in late autumn and winter to the same ponds to search for the larvæ of Trichoptera, the mosquito larvæ are probably too small. On the other hand, the surfaces of these ponds, near the hatching time of the mosquitoes, are covered by pondscaters which dig their huge proboscis into the fat forepart of the pupæ. As most of the pondscaters are wingless, we must admire the speed with which they are able to find these small and often sheltered ponds. But also different Dytiscidæ more especially of the genera *Colymbetes* and *Rhantus* as larvæ prey almost exclusively upon *O. communis*-larvæ; the eggs are laid in early spring, and it is interesting to see how these larvæ in their development keep time, so to speak, with the mosquito larvæ; they are hatched as larvæ at the same time as these and they are ready to pupate a little after the mosquito larvæ have metamorphosed into pupæ. It is very interesting to find these ponds which, a few days before, have delivered the whole mass of mosquitoes to another element, teeming with black and white coloured Dytiscid-larvæ. Another fat morcel would have been desirable before pupation, but such a one cannot now be obtained, the mosquitoes all being out of their reach; now they have only one prey upon which to satisfy their hunger, viz. their own comrades. This is exactly what happens, woe to the larva which, when the mosquitoes have left the pond, has not passed the second ecdysis; it will unquestionably be devoured by more vigorous comrades.

As always in the Culicidæ, the males appear a few days before the females; during the first days the vegetation round the ponds is covered with males; then they disappear and we next find them in large dancing swarms in the glades and on the wind-protected edges of the wood. Especially if the weather is cold, we do not suffer from *O. communis* till a fortnight after ecclosion (see later); then suddenly comes the week, when the lust of blood awakes in the millions of mosquitoes hatched in May from the numerous woodland ponds. In the vast forests of North-Seeland I have observed how the swarms in May are restricted to the very ponds in which they are hatched; but later on, especially in the middle of June, the swarms are fused together and, everywhere in the forest, horses as well as men are attacked. As an exclusive forest mosquito it hardly ever goes out of the forest; according to my experience, the attack is always worst in the biggest and darkest part; here in the deep shade the attack on a sunny day at noon is just as severe as in the evening. In late spring and early summer man and cattle are almost exclusively injured by this single species.

The mighty attack of *O. communis* lasts only two or three weeks; before the end of July other species displace it, but even in September, though rarely, we are subject to its sting.

When, in July, the female is going to deposit her eggs, she commonly finds only quite dried up ponds everywhere; where, in spring, bright little mirrors of water broke the monotonous green carpet only greyish-brown spots surrounded by or quite overgrown with Cyperaceæ etc. are found on the forestground.

For three years I vainly tried to see the process of egglaying. Not until the summer of 1919 on $^{3}/_{\text{VII}}$ did I have an opportunity to observe it in one of the wholly dried up *Mochlonyx*-ponds. The females were sitting under the dry leaves; here, as many times before, I had placed myself on one of the Carex-tufts eagerly observing every grass-stem and every leaf, hoping that here I should see something of the process. Once after having turned over the withered leaves, I found, in a layer of leaves below those rolled up by the sun, some mosquitoes which slowly flew away. Looking at these leaves with a lens I found them sprinkled with the well-known black mosquito eggs. Later on, leaves which were cleaned were brought into the laboratory and placed in a vessel together with several females; the next day I found the same black eggs scattered over the bottom under the leaves. Therefore we can now take it for granted that this species probably, like all our other *Ochlerotatus*-species, lay their eggs on dry earth and singly. I interpret the life-cyclus of *O. communis* as follows:

The eggs are hatched in midwinter or in very early spring; many of them do not hatch before April; owing to the rising tp. the latest hatched overtake the first, and in the two first weeks of May the mosquitoes are hatched. The mating process takes place shortly after hatching, but the craving for blood does not appear before June, often not till the latter part of June. The eggs are laid singly and often in the same pools in which the imagines are hatched, but these pools are now dry, and the eggs are deposited upon dry bottom from July—August to December—January and do not hatch before a freezing period; the males probably die off shortly after the mating process; the number of males I have seen after June being very limited. In some ponds, and more especially in rainy summers, larvæ may be found after June, but the number is always very limited and has no great significance, neither for the species nor for man.

O. communis has as a rule not more than one generation. In the very rainy summer of 1919 many of the ponds were never dried up, and a good many had plenty of water almost the whole of the summer. Of course we should now expect that a new generation would be hatched, but this, as far as I can see, is not the case. — In these ponds I have really found *O. communis*-larvæ in the months of July—August; but the number was always small, and I never found those vast swarms of larvæ and pupæ which coloured the ponds black in spring. The 21st of July was the last day I found *O. nemorosus* larvæ; to these lately hatched *O. communis* larvæ, I refer most of those imagines which torment us in August and September. Even on 12/IX a single *O. communis* stung me in the Royal Park at Hillerød. In autumn when the small ponds are filled again, as a rule we find no *O. communis*-larvæ; here and there I have seen a few, and once I got a pupa which metamorphosed into imago 11/XII in one of the aquaria.

I am inclined to regard all these larvæ which appear after the great hatching period in spring, not as belonging to a new, second generation, but to the same generation as those which were hatched in spring. I suppose they derive from eggs, which have had a rather unfortunate situation, which the water has reached too late, or which have been buried too deep under the remains of the decaying vegetation. I do not think that we have to do with a new generation, hatched from eggs laid in summer, whilst only very few larvæ are hatched, and whilst the same ponds in which these larvæ are hatched, teem with larvæ the next year.

It may be added that more than once I have observed ponds which had water till June in 1917 and which were hatching-places for swarms of mosquitoes about 7/V; in 1918 the very same ponds did not get any water and were dry the whole year. In 1919 in April the ponds got water again and now teemed with larvæ in May; I suppose that these larvæ belong to eggs which have preserved their vitality from 1917.

That *O. communis* really can have two generations in a year, we shall see from the following fact.

On an excursion 25/X 1918 through the forest Store Dyrehave near Hillerød I found many small ponds filled with water; heavy showers during the last fortnight had given so much water that the bottom in the hollows could not take up more. To my great astonishment in two of them I found enormous masses of black, almost fullgrown mosquito larvæ. The ponds were overshadowed by high spruce firs, the bottom of the ponds were covered with spruce-needles; the depth of the water was only about a decim., and the area of the pond about fifty yards.

In regard to its short sipho and its black colour it differed very much from *C. morsitans*, the only mosquito larva which was common at this season; a closer examination of the sipho further showed that it could not be *O. rusticus*; that the larva would only be that of *O. communis* did not occur to me. It was therefore to be expected that the larva must be a new one. In the time from 15/x to 15/xi the ponds were often visited. The temperature fell from seven to two degrees; at that constantly sinking temperature, and in a pond which never got a single of the really very few sunbeams of the season, these larvæ reached their maximum size; at the water temperature of 2° C. the larvæ metamorphosed into pupæ. At an air-temperature of only 4° C. and a water temperature of 2° C. I saw the imagines in nature come out of the pupæ, very slowly fly a few yards and settle themselves on the cushions of *Sphagnum* near the borders of the pond. The males appeared first, a few days later the females. By 15/xi came a short frost-period; the ponds were ice-covered, and all the pupæ in the pond were killed. In December the ponds thawed again, but not a single larva or pupa could now be detected. In the time from 15/x to 15/xi I visited many similar forest ponds lying in forest of spruce firs, and I often found the same larvæ in these ponds; these were always in very cold localities where the damp autumn-fogs hung under the spruces almost the whole day. Though I especially paid attention to that point, I could never see the mating process; but opening the *Sphagnum* cushions near the ponds, I found the female sitting there very indolent and half sleeping. The larvæ had all blunt scales in the comb and one single hair in the upper and lower frontal tuft. The colour of the larvæ and pupæ was black as tar, but apart from this colour they were indistinguishable from the typical *O. communis* larvæ. The next spring, in the first part of April, when the ponds were still partly covered with ice, I examined the locality and found the water teeming with minute larvæ. By 8/v they contained enormous masses of larvæ and pupæ, on 14/v the pupæ were hatched.

If now we compare the imagines from the autumn of 1918 with those from the spring of 1919 and 1920 we shall see that the first-named are larger, darker and more hairy; a closer examination will however show that tenable differences between the two groups of imagines hatched in autumn and spring do not occur; both belong to the same species, our common *O. communis*; I do not think that the imagines have hibernated; most probably they have died off, imagines in spring deriving from eggs which have not been hatched in autumn.

For a time I thought that in the autumn-generation I had had *O. nigripes* Zett. before me. This was more especially the case because only a few kilometers from my localities STAEGER (1839 p. 553) in the Royal Deer park near Copenhagen has indicated that he has found *O. nigripes*. Owing to the peculiar fact that the larvæ metamorphosed at temperatures between 4° and 2° C. and that the imagines appeared at the same temperature, in this tract, which was quite extraordinary and unique for a mosquito of our fauna I saw a phenomenon which strengthened my supposition. After having sent the specimens to Prof. SIMON BENGTSON in Lund and asked him to compare them with the specimens of *O. nigripes* in the collection of Zetterstedt, he kindly told me that a very similar specimen was caught in Scania and was determined as *O. nigripes* but differed from this by a brighter colour and in not being so hairy. In a small preliminary paper the specimens were then described as *O. nigripes*. Later on I learned that this determination was wrong. The Royal Museum of Copenhagen possessed mosquito larvæ from Greenland, from where we have hitherto only got one single mosquito species: *C. nigripes*; they were kindly given me by Inspector LUNDBECK and will be described in the following; it will then be seen that the two larvæ differ very much from each other.

It seems therefore that *O. communis* in our country really can have two generations and that the late autumn generation differs a little especially with regard to colour from the spring generation.

As described in the anatomical chapter the larvæ have very short flabellæ; and are very well equipped with comb-hairs. Nevertheless they are not bottom-feeders, but live mainly in the surface of the ponds, hanging down from it by means of the flaps of the sipho. In this attitude the ecdysis takes place too, also the last one from larva to pupa. The larva often hung down in such countless numbers from sunlit surfaces of the forest ponds that they almost touched each other. The millions of flabellæ, all in activity about a centimeter under the surface, must produce an uninterrupted water current, lifting a deeper water layer upwards to the surface. The flabellæ of *O. communis* being very small, they act in quite a different way to the large flabellæ of *Culiceta morsitans*. Whilst the flabellæ of the last-named species strike about 100 to 130 strokes a minute by summer temperatures, the flabellæ of *O. communis* strike with such an enormous rapidity that it is quite impossible to count the number of strokes. Besides, the larva has also another method of using the flabellæ, and according to my view this is more significant when the organ is to be used for gathering nutriment. We see that there are always certain larvæ which, when kept in aquaria, constantly hold the apex of the sipho in the surface, suddenly bend the head upwards and now press also the flabellæ against it. Immediately after the bending of the corpus in a bow, the whole body begins to describe a circle round the sipho which is held quite still; during the circular movement the flabellæ are pressed against the surface and used as brushes which clean the underside of the surface of all adherent particles.

Geographical distribution: The species has been so confused with *O. punctor* (Kirby) that it is almost impossible to determine its range with certainty. Most probably it is the most common forest mosquito with unbanded legs in North and Central Europe.

10. **O. nigripes** (Zetterstedt).

Tab. IX.

Larva: Head rounded; wider than long, a notch at insertion of antennæ; front margin arcuate. Antennæ short; antennal tuft small, with only a few hairs; on apex four hairs, one long, and a digit. Anteantennal tuft multiple; lower and upper frontal tuft both consisting of one single feeble hair. Eyes large. Thorax subquadratic, angled at hair-tufts; hair-formula of frontal border: 3231441323; hair one after tuft four very short. Lateral hairs in multiple tufts and some single strong hairs. Abdominal segments broad; the first of them much shorter than the last. Lateral hairs on the first segment four; on the second three, on the third to seventh two. On fourth to seventh segment subdorsal hairs single in two series. Tufts of eighth segment in common arrangement; lateral comb consisting of about twenty scales arranged over a little triangular area; scales formed as sharp strong thorns without any lateral thorns or hairs. Sipho short, straight, tapering at front only about two and a half times longer than broad. Pecten long consisting of about fifteen thorns; the last of them out of line at greater distance from each other; most of them with a short basal tooth. A tuft of hairs between end of pecten and apex. Anal segment broader than long ringed by the dorsal plate; dorsal tuft rather feeble but with two strong hairs; ventral brush consisting of about eighteen rays, every ray carrying from seven to ten hairs; no hair-tufts before the barred area; anal gills extremely long, acute and equal.

Lateral tufts of labrum short but dense; the inner part with a crown of comb-hairs; palatum large, covered with long soft hairs. Mandibles quadrangular with two strong spines, before collar a row of rather long cilia from a collar. About eight thorn-like bristles from margin. Dentition: four acute teeth, before them a long acute thorn; long cilia below thorns; Process below indistinctly furcate with hair-tufts on both tips, a group of hairs at base. Maxillæ very broad, almost quadratic with a brush of rather short hairs at apex and a seta; near the inner edge a coating of long soft hairs; stronger dense haircovering along margin. Palpe thick, high with four small digits at apex. Mentum triangular with inconspicuous apical tooth and many small almost equal lateral ones.

Geographical distribution: Greenland; most probably circumpolar.

11. **O. punctor** (Kirby).

O. sylvæ Theobald.

Tab. X.

Description: Imago: Very similar to *O. communis.* Scales of head and thorax mostly yellowish-brown, brighter than in *O. communis.* Thorax with a more or less commonly well-defined median stripe of dark brown scales on mesonotum. The white bands of abdomen with a creamy tinge, not white as in *O. communis*; most of the bands at least them on segments 5—7 contracted or even interrupted in the middle so that the bands are almost changed into creamy, yellowish, triangular spots. Venter with a more or less well-defined dark median line not all white as in *O. communis*. Femora yellowish white, without dark scales scattered over the light parts; tibiæ and tarsi dark, with scarcely any light scales; in *O. communis* tarsi have several numerous pale scales. Length 5.5—6.5 mm.

I have never seen the male; according to indications kindly sent me by Mr. Edwards the male genitalia of *O. punctor* differ very much from those of *O. communis*. The side pieces have only a rather faintly developed apical lobe, with many short hairs; clasp-filaments with some hairs (three) along the outer edge; a large densely haired basal lobe; blade of harpags not much shorter than the stem. See also Lang (1920 Fig. 64).

Larva. Head rounded, wider than long; a notch at insertion of antennæ; front margin strongly arcuate. Antennæ short, only slightly tapering at front; antennal tuft nearer to the base of the antennæ; consisting only of a few hairs. At apex, three short hairs and one or two digits; colour yellowish-brown, not brighter at base. Antennal tuft multiple, upper and lower frontal tuft both consisting of two strong hairs. Eyes large, triangular. Thorax subquadratic angled at hair-tufts. Hair formula of frontal border 3121441213; tuft one after tuft four only consisting of one or two very small hairs, the other hairs of frontal border all being strong. Lateral hairs in multiple tufts and some single strong hairs. Abdominal segments rather broad, the first of them shorter than the others; lateral hairs on the first two segments three, on the third to seventh two. On fourth to seventh segments two series of single, subdorsal hairs. Tufts of eighth segment in common arrangement; comb consisting of about twenty-five scales, occupying a triangular area; the scales are very long, acute with a strong very acute median tooth and a few shorter ones. Sipho short, straight, tapering at apex, three times longer than broad, often a little more. A pecten consisting of about twenty thorns, all in line and most of them with from three to four teeth at base. A tuft of hair between end of pecten and basis.

Anal segment almost as long as broad, ringed by a plate; dorsal tuft rather feeble, with two very strong, long hairs beneath. Ventral brush consisting of about from twelve to fourteen rays, every ray carrying from six to seven hairs. Before the barred area about five free hairtufts, a lateral tuft with one hair. Anal gills moderate, acute, equal.

Lateral tufts of labrum short, dense, the inner part with a crown of comb-hairs; palatum covered with short, stiff hairs. Mandibles quadrangular, with two strong spines before the collar, a row of short cilia before collar. About fourteen thorn-like bristles from margin; the last strong. Dentition: four strong teeth, before them one acute thorn, serrated; long cilia below the thorns. Process below distinctly furcate with strong hair-tufts on both tips, a group of hairs at base. Maxillæ broad, obtuse, at apex a brush of long hairs and a seta near the apex below the brush; the whole inner part of the maxillæ covered with a coarse coating of long soft hairs. Palpe well developed with three or four digits. Mentum triangular with a rather small, median tooth and from thirteen to fourteen small lateral teeth.

Colour deep grey, often almost black.

Biology: Of *O. punctor*, in the above-named sense, I have only seen one single specimen, brought me by Mr. Kryger from Tisvilde-forest, near the shores of the Kattegat. I immediately saw that this specimen differed very much from all our other forest mosquitoes belonging to this group. Especially the restriction in the middle of the abdominal bands was very conspicuous. Later on Mr. Edwards corroborated my supposition, writing to me "that this was the first undoubted specimen he had got from Denmark"; all the other related specimens belonged either to *O. communis* or *O. prodotes*; I have never found the larva; the specimens used for the table derive from Mr. Edwards' collection.

The real geographical distribution of the species is quite unknown.

12. **O. prodotes** (Dyar).

Tab. XI.

Description. Female: Proboscis moderate, cylindrical, uniform, black. Palpi short, about one fifth as long as proboscis, black with few, whitish scales intermixed; setæ moderate, bristley. Antennæ filiform, the joints subequal, rugose, pilose, black with some whitish scales, second joint longer and thicker than third, pale at base; tori subspherical with a cup-shaped excavation, luteous, darker within; hairs of whorls black. Clypeus rounded, prominent, black, nude. Eyes black. Occiput black; scales on vertex lanceolate, curved yellowish wbite, on sides broad milky-white throughout, now and then an ill-defined lateral black patch; bristles on the occiput and along margin of eyes black, those projecting between the eyes pale.

Prothoracic lobes elliptical, remote dorsally, black, clothed with narrow white scales and dark bristles. Mesonotum black with a coating of brown hairs commonly spread over the whole mesonotum and without wellmarked blackish lines. Scutellum trilobate black, each lobe with a group of brown bristles. Postnotum elliptical, prominent blackish nude. Pleuræ brown, coxæ luteous, clothed with patches of elliptical flat, white scales and rows of pale bristles.

Abdomen subcylindrical, tapering posteriorly; dorsal vestiture black with broad white basal segmental bands which in the middle have a rusty colour; first segment almost white; venter whitish, scales with small black segmental medio-apical spots; cerci black.

Wings rather broad, hyaline; petiole of second marginal cell shorter than its cell, that of second posterior cell slightly longer than its cell; basal cross-vein distant almost its own length from anterior cross-vein; scales blackish-brown, the outstanding ones broadly linear. Halteres whitish, with yellowish knobs.

Legs moderately long and slender; femora yellowish-white; brightest below, darker above, a black ring before tip; tibiæ with dirty-white scales below, bronzy black above with a few white scales intermixed, tips black; tarsi almost black; the basal joint beneath with scattered white scales; terminal joints entirely black. Claw formula 1.1—1.1—1.1.

Length: Body about 5.5 mm.

Male: Proboscis slender, rather long, straight, black. Palpi almost of the length of proboscis, perhaps a little longer; end of long joint swollen dirty-white; the first long joint yellow, black at apex; the second yellow, black at base, the last two joints black with long black hairs with silky luster. Coloration similar to the female. Abdomen elongate, broadest on sixth and seventh segments, narrowest at third; white basal bands almost as in female, but first segment more black; lateral ciliation long, abundant, pale yellowish brown. Wings narrower than in female; stems of the fork-cells longer; vestiture less abundant. Claw formula 2.1—2.1—1.1.

Length: Body about 6 mm. wing 5 mm.

Male genitalia. Side pieces almost three times longer than wide; apical lobe well-developed, with some few rather short hairs. Clasp-filaments slender, slightly expanded in the middle and bearing a long articulated terminal spine. Stem of harpagones very long, columnar; blade broad in middle, bearing only one median ridge.

Larva: Head rounded, strongly vaulted, wider than long with a slight notch at insertion of antennæ; front margin feebly arcuate; antennæ short, thin, black, from base to apex slightly spinose, with the small antennal tuft (four hairs) inserted almost in the middle of the antennæ. Anteantennal tuft only triple; lower and upper frontal tuft consisting of only one hair. Medially and laterally are three areas with a remarkable warble structure.

Thorax subquadratic, angled at hair tufts; hair formula of frontal border most probably 3131221313, one of the hairs in tuft two, strong, the other feeble and short. Lateral hairs in multiple tufts, and some single strong hairs.

Abdominal segments rather broad, the first of them shorter than the last. Lateral hairs on the first and second segments triple; on the third to seventh double. Tuft of eighth segment in common arrangement; lateral comb consisting of about twenty-five scales, arranged triangularly in two or three rows, the scales end in a single strong spine, furnished at its base with two other shorter spines and with the basal part fringed by numerous small hairs or bristles. Sipho almost three times longer than broad, tapering at apex; pecten consisting of about twenty thorns, furnished at base with three or four lateral teeth; between the tuft situated almost in the middle of the sipho and the apex two single thorns, without teeth and with much wider distance between than the teeth of pecten; a single short thorn dorsally near the apex of the sipho. — As fig. 6b indicates, the free thorns are inserted unsymmetrically, and their place differs from individual to individual; one side may also have a thorn more than the other. Anal segment almost as long as wide; the dorsal plate subquadratic, covering most of the segment; dorsal tuft rather small with two very long stiff hairs beneath. Ventral brush consisting of about from ten to twelve rays, carrying from four to six rather short hairs; before barred area three or four free tufts; a lateral tuft with one single hair. Anal gills short, equal, acute.

Lateral tufts of labrum extremely short, the inner part with short comb-hairs; palatum feebly developed with short hairs.

Mandibles quadrangular with two curved spines before the collar; a row of rather short cilia from a collar; about seven to ten thorn-like bristles from margin; dentition five, almost equally strong teeth and before them a strong tooth; long cilia below thorns; process below very indistinctly furcate with hairs on both tips and a group of hairs at base.

Maxillæ of remarkable form, broader than long, on apex a brush of long hairs, which was commonly spread out as a flattened crown over the maxilla, all the hairs lying in the same plane but with the hairs turning towards the inner surface of the maxilla much longer than on the outer edge; near the inner margin a thick and coarse coating of short soft hairs; inconspicuous thorns along the margin. Palpi remarkably well-developed, almost cylindrical, furnished with four digits at apex.

Mentum triangular with middle tooth feebly developed and thirteen teeth along the borders.

Biology. From one of the *Hydrophantes* ponds in Hestehave near Hillerød *O. excrucians* and *communis* were hatched in 1919 in huge numbers. Among the *O. communis* material a good many were characterized by brighter bands, rusty in the middle on the abdomen, and almost white, long joint in the palpi of the male. I regarded them as an aberrant form of *O. communis*, but sent them to Mr. Edwards who kindly told me that according to his opinion they were *O. prodotes* Dyar.

On examining my larva material from the *Hydroplantes*-pond I found a few specimens of a highly characteristic larva, hitherto overlooked by me. Next year, just after the ice had melted very many of these larvæ were found and later on hatched in my aquaria. Having found the species in this single pond I searched for the larvæ in a great number of ponds near Hillerød, but found the species only in a few of them and always in small numbers. On the other hand, on an excursion in April to the many ponds on the Eremitage-plain in the Royal Deer Park about 15 kilom. from Copenhagen, almost all the ponds teemed with *O. prodotes* larvæ, and in more than one of the ponds I only found this very same species.

The species is hatched very early before *O. communis* and *O. nemorosus*. On examining the ponds in the latter part of April and first days of May the ponds contained huge masses of larvæ of these two species but not a single *O. prodotes*-larva. It is owing to this fact that I have overlooked the species in 1917—1919. As far as I have hitherto observed, it seems that the species prefers temporary ponds on plains, not overshadowed by trees, or ponds lying on the outskirts of forests; I have never found them in the temporary pools in the deepest parts of the woods, overshadowed by trees and only rarely touched by the sunbeams, localities where *O. communis* preponderate.

The species has unquestionably only one generation in the course of the year, lying almost the whole year as eggs; all ponds in which the species is found are commonly dry from June to March. The eggs according to Dyar (1920 p. 10) have a rather characteristic appearance being "thickly fusiform, rounded, one side flattened, the ante-micropylar end more pointed than the other".

Geographical distribution: *O. prodotes* has hitherto only been found in North America. Its range "is to the north along the higher mountains of the Rockies into the Yukon Valley, where it is the second species in abundance". (DYAR 1920 p. 9). In U. S. A. it is indicated as a "high altitude species".

13. **O. rusticus** (Rossi).

Aëdes diversus. Theob.

Tab. XII.

Description. Female: Proboscis moderate, subcylindrical, flattened, uniform, black, covered with scattered yellowish-white scales; nearest the apex and labellæ black; setæ minute, black, curved, those on the labellæ more prominently outstanding. Palpi stout, rather long, about one-fourth of the proboscis; vestiture of black scales with many pale ones; setæ few, long, black. Antennæ with the joints subequal, rugose, pilose, black; second joint somewhat thickened, tori subspherical with a cup-shaped excavation outwards, covered with small, broad whitish scales, on the inner side black. Clypeus shortly conical, prominent, convex, black, nude. Eyes bronzy black. Occiput covered with dense, narrow, yellowish-brown scales on the vertex and many forked upright ones, a large patch of golden brown ones on each side close to the eyes; bristles along margin of eyes black.

Prothoracic lobes elliptical, well separated, black, covered with yellowish-white scales and many long, black bristles. Mesonotum black with a dark, very small middle line, two broad median dark lines and two small lateral dark lines behind; between these lines stripes of yellowish-brown scales. Scutellum trilobate, black, clothed with narrow, curved brown scales, each lobe with a large group of long, yellowish-brown hairs.

Postnotum convex, black, nude. Pleuræ black, coxæ black, clothed with narrow, elliptical, flat yellowish-white scales and short pale bristles.

Abdomen flattened, broad, the posterior segments tapered; dorsal vestiture of blackish-brown scales, each segment with a basal band of creamy white scales, which spread out in the middle, forming together a more or less conspicuous whitish middle line, and on the sides, where they form triangular creamy spots; the seventh segment almost white with two dark spots; posterior borders with pale golden bristles. Venter almost entirely clothed with pale creamy scales.

Wings large, veins covered with dark brown scales and pale lateral ones; first submarginal cell much longer and narrower than second posterior cell, its stem slightly shorter than the cell; stem of the second posterior cell shorter than the cell, the forks of which widely diverge; supernumerary and mid cross-vein in a straight line; the posterior cross-vein about half its own length distant from the mid cross-vein; fringe brown, halteres ochraceous, with pale scales on the knob.

Legs: Femora creamy-yellow, especially beneath, with some dark scales above;

darkest at apex; knee spots yellow, large, distinct; tibiæ darker, yellow beneath; metatarsi and tarsi blackish-brown, hind metatarsi not so long as the tibiæ; ungues equal. Formula 1.1—1.1—1.1.

Length 7 mm.

Male: Proboscis slender, straight black violet. Palpi exceeding the proboscis about the length of the last joint; end of long joint and the last two joints thickened, the long joint coated above with greyish scales; this and the two last joints bearing long greyish hairs. Antennæ plumose, the last two joints long and slender, black with white rings; hairs of whorls long, dense, black with greyish lustre. Coloration of head and thorax similar to that of the female, but the dark lines of the mesothorax more obsolete; coloration of abdomen similar to the female, but the expansion of the bands in the middle line often rather inconspicuous. Lateral hairs very long, dense and yellow. Wings narrower than in the female, stems of the fork cells longer. Legs as in female. Claws on the fore and midlegs unequal; on the forelegs the large ones with two teeth, the smaller with only one; on the midlegs both claws with two teeth; the inner tooth of the smaller one small; the large claw strongly curved and highly developed; claws of hindlegs equal and with only one tooth.

Male Genitalia: Side pieces with parallel curved outer and inner edges, about thrice as long as wide, slender; the whole side piece being narrow, forming the arc of a circle; Clasp-filament long, slender, curved not swollen medianly, with a long articulated terminal curved spine; apical lobe of ventral flap indistinct, distal part of basal lobe prolonged into a narrow arm-like projection with an expanded hand-like end; tuft at the base of the basal lobe with extremely long bristles extending along the ventral flap as a fringe of very long hairs. Harpes slender, rather long, margins narrowly revolute. Harpagones with a stout thick curved columnar base with small setæ on inner side; distal joint spatulate. Unci approximate, revolute, forming an indistinct basal cylinder; basal appendages stout and prominent, bearing a row of stout setæ at tip.

This very characteristic species, in the female sex easily recognizable by the white middle line on the abdomen, in the male sex by the genitalia, and in the larva by the characters of the sipho, is probably rather common at all events in North Seeland.

Larva. Head rounded, wider than long, narrowed before eyes; a notch at insertion of antennæ; front margin arcuate. Antennæ extremely short, straight, spinose; antennal tuft small, inserted almost in the middle of the antennæ; at the apex two small hairs a long hair and a digit; anteantennal tuft multiple, lower frontal tuft triple, upper double; epistome with a very characteristic coloration of the head integument. Eyes well-developed.

Thorax much wider than long, rounded; hair formula of frontal border* 5141331415 or 4131331314; hair 1 after median tuft 3 short, lateral hairs highly developed; most of them in large multiple tufts, some of them single.

Abdomen moderate, the first segments much shorter than the last; lateral hair-tufts on segments one and two multiple, on segments three to six double; a pair of subdorsal hairs on segments one to six, largest on segments four to six. Hairs of segment eight in normal arrangement. Lateral comb consisting of about 15 scales, triangularly arranged in two irregular rows; each scale with a broad spatulate base and a very strong median thorn, two shorter lateral thorns and many shorter ones bordering the spatulated part. Sipho straight, a little more than three times longer than wide; pecten at basal third highly developed, consisting of about fifteen to twenty strong dark spines, the first of them without lateral thorns, the others with one or two. The pecten reaches to the hair-tuft; between it and apex two or three strong spines with large distance between each other; dorsal to the pecten and about halfway along it a small hair. On the opposite side of the sipho four pairs of hair-tufts, more or less conspicuosly double, arranged in two lines. Anal segment much longer than wide, almost covered by the dorsal plate. Dorsal tuft well-developed with two very long, stiff hairs. Ventral brush in the barred area consisting of nine rays each with from six to eight hairs; before barred area three or four free tufts. Anal gills very short, broad, almost equal.

Lateral tufts of labrum short, a crown of comb-bristles nearest to the palatum which is covered with long, soft hairs. Mandibles quadrangular, four stout spines before collar, a row of long cilia from a collar; about ten spines from margin; dentition very strong: four teeth, the first of them strongest, between them and the marginal spines two strong spines; below the teeth a series of bristles. Process below but slightly furcate, with strong hairs at apex; a group of hairs at base. Maxillæ of very remarkable form, almost wider than long, divided by a suture with a large hair-tuft on the broad, oblique apex and a spine near it; coating of soft hairs on both sides of suture; longest on the inner surface; no spines at inner margin; palpe high, almost as high as maxilla; at the apex five conical digits. Mentum broad, triangular with curved sides; a median tooth and 10—12 rather large teeth on each side. Colour greyish, dark, often almost black with yellow head.

The species has been described by Theobald from England (1901 p. 73) and refound by Edwards (1912 p. 219). It has also been found by Goethgebour (1910 p. 84) in Belgium and by Eckstein at Strassbourg (1910 p. 67). The larva has been shortly described by Eckstein (1919 p. 293). The species is new to our fauna. In accordance with my observation Goethgebour remarks que "l'éspèce est la plus précose dans nos environs. Je n'ai plus revu l'éspèce a partir de la mi-juin".

Biology. In November—December 1918 I found, in two ponds near Hillerød, together with *C. morsitans* a huge, fullgrown, almost black mosquito-larva which I immediately saw must give a species hitherto unknown to me; in the ponds the larvæ were always rare; and that year I found them only in the two above-named ponds, lying near each other in the forest at the mainroad between Copenhagen and Hillerød. Though the ponds were only about two hundred yards in circuit and were only a few decim. deep, and though I used my net for about an hour, I could only get a few larvæ. In December the ponds were frozen over, but on 21/I, after a long period of thaw, they were half free from ice. Then I again captured some few larvæ, two of them were held in aquarium, but died during the winter. In the last days of January the ponds were ice-covered again and did not thaw before 5/IV 1919; at this date, when the pond was still ice-covered, I got eleven larvæ under the ice on one of the borders; they were all fullgrown and in the following days (till 16/IV) on three excursions I caught all in all about twenty larvæ.

On a journey to Suserup I got very many larvæ in the same pond in which *C. lutescens* was hatched, undoubtedly belonging to the same species. Further, on

Textfig. 9. Pond in Store Dyrehave. *O. cantans, rusticus, C. morsitans.*

excursions to a little forest near Suserup, Arnehave, I found a pond which was almost exclusively inhabited by this larva; here it was present in thousands of specimens. All these finds were made in the time from 17/IV to 21/IV. In the time from 1/V to 3/V there were no changes to note, but on 3/V I saw the first pupæ, and before 15/V all were hatched. On 6/V the first imago appeared in my cages; on 12/V the last. By 21/V the ponds near Hillerød were both dry, by 7/VI all those at Suserup; however, in the ponds where *O. lutescens* was hatched, and which were now covered with grass, I found numerous specimens deep down in the grass. After July the first I have never seen a single specimen, neither at Hillerød nor at Suserup. Probably we have to do with a rather rare and early flying species. Its life-history may be summed up as follows: The imagines are hatched in May and may problyba lay their eggs on the dried bottom of forest ponds, rarely in ponds in meadows, without trees around. The eggs are hatched in autumn when the ponds get water again. Before winter they are full grown, and as such they winter, living under the ice exactly like *C. morsitans.* In the first days of May they pupate, and the mosquitoes appear in the first part of the same month. In the aquaria they almost always lie upon the bottom and only rarely come to the surface; with their short flabellæ they brush the bottom and gather their food in this way. If there are water plants in the aquarium, I have seen them follow the leaves and stems, go round the leaves, holding the axis of the body in a very acute angle to the leaf, simultaneously pressing the flabellæ against the leaf and slowly move forward cleaning it from adherent particles. It looks rather peculiar to see the larva without any clinging or grasping organs slowly slide over the under side of the leaves, using the flabellæ simultaneously as an organ for nutriment and for movement. But in another respect, too, the larvæ are peculiar. More than the other, hitherto observed mosquito larvæ they stand still in the water layers; without reaching either the surface or the bottom, the larvæ, always standing perpendicular, first ascend a little and then slowly sink downwards then swim a little actively and horizontally and then again stand perpendicular for slow ascent or descent. I have tried to see, if an air-bubble would appear on the apex of the sipho during these movements and probably alter its size, but I have never seen anything of that kind. When I had different species of mosquito larvæ in the vessels, I was always able to distinguish the larva of *O. rusticus* from other mosquito larvæ owing to this power of suspension in the water layers below the surface.

Though I have rather often found the larva in the neighbourhood in Hillerød I have hardly ever seen the imago in Nature. In 1920 (26/v) when I was on an excursion upon Amager to my astonishment I was attacked by enormous masses of *O. rusticus.* Often more than twenty were sitting upon my clothes, trying to get blood; they stung vigorously. The attack began at about seven o'clock and was unaltered, when I left the place at half part eight. The specimens were larger than those I have hatched from the forest ponds; their hatching ponds I did not succeed in finding. — Collections from the first days in June did not show a single *O. rusticus*; at that time immense numbers of *O. lutescens* appeared, which had just begun to sting by 26/v.

Geographical distribution: The species has hitherto only been recorded from Italy, Macedonia and England.

14. **O. diantæus** (Howard, Dyar and Knab).

Tab. XIII.

Description. Female: Proboscis moderately long, curved, labellæ conically tapered, vestiture black, but with many intermixed greyish scales; labellæ black. Palpi short; only about one-sixth as long as proboscis; vestiture black, some white scales at apex. Antennæ filiform; the joints subequal, rugose, pilose; second joint enlarged, bright; the others black, with grey scales and outstanding greyish hairs;

tori subspherical with cup-shaped apical excavation, bright brown with a patch of brighter scales on innerside, hairs of whirls sparse black. — Clypeus roundedly prominent, nude, black; eyes black. Occiput black with narrow curved, pale-ochraceous scales on vertex, and broader whitish ones on the sides; setæ along margin of eyes black; those projecting forward between the eyes black.

Prothoracic lobes elliptical, remote dorsally, black, clothed with yellowish-white scales and black bristles. Mesonotum black, clothed with narrow curved pale bronzy scales; with a broad middleline black, formed by two black lines fused together but separated by an extremely small line only indicated by a series of few long bristles; sideways two shorter, more or less conspicuous black lines. The remainder of the thorax covered by a coating of yellowish-white hairs. Scutellum brown, with creamy scales and dark brown border bristles, metanotum chestnut brown; pleuræ black, but almost covered by numerous patches of almost snow-white scales.

Abdomen subcylindrical, flattening, tapering posteriorly; dorsal vestiture of black scales with basal creamy almost snow-white bands, narrow, almost disappearing in the middle line but laterally widening in white spots; the underside banded by bands of very broad, white scales; posterior borders edged by yellowish-grey hairs.

Wings with the veins clothed with yellowish-brown scales; those of the costal and subcostal vein black; first marginal cell longer and a little narrower than second posterior cell; stem a little shorter than the cell; stem of the second posterior cell longer than the cell; supernumerary and midcross-veins forming a slight obtuse angle with one another; posterior cross-vein about twice its own length from the midcross-vein; fringe brown. Halteres grey with fuscuous, greyish bordered knob.

Legs with coxæ covered by snow-white scales; underside of all femora yellowish-white, on the upperside black, but at base all round yellowish-white; knees bronzy; hindfemora in their half length almost white. Tibiæ and tarsi black. Claw formula 1.1—1.1—1.1.

Length: body about 5.5 mm.

Male: Proboscis long, slender, haired at tip, straight, black. Palpi slightly exceeding the proboscis in length, blunt at apices; vestiture almost black but in some lighting showing a slight greyish tomentum; end of long joint and last two joints slightly enlarged with dense, moderately long black hairs. Antennæ plumose; the last two joints long and slender, pilose black; the other joints short, pale with blackish rings; hairs of whorls long, black with greyish silky luster. Occiput black, clothed with narrow, curved, creamy-yellow scales above; the sides with broad flat, dull white scales; nape with many short, upright, forked, creamy-yellow scales; a row of long, black bristles along margin of eyes; those projecting forward between eyes pale, yellow.

Prothoracic lobes elliptical, remote dorsally, brownish, clothed with narrow curved creamy-yellow scales and with few black bristles. Mesonotum clothed with rather coarse, narrow curved, creamy-yellow scales; two narrow submedian lines of brownish-black scales, which are smaller and denser; scutellum and posterior portion of mesonotum denuted. Postnotum nude, deep brown. Pleuræ almost black, coxæ luteous; clothed with patches of flat white scales; the prothoracic epimera with narrow curved, creamy-yellow scales.

Abdomen elongate, depressed; dorsal vestiture black with narrow, yellowish-white basal segmental bands, obsolete centrally; venter whitish scaled, the segments with apical median black spots; lateral ciliation moderately long and abundant, brownish.

Wings narrow, hyaline; stems of second marginal and second posterior cells longer than their cells; basal cross-vein its own length distant from anterior cross-vein; vestiture sooty brown, with a few pale scales intermixed, rather sparse, outstanding scales linear.

Legs rather long and slender; vestiture sooty brown, the femora pale, especially beneath to near apices; fore femora palest; knees pale; tarsi dark but hind tarsi a little brighter than the others. Claw formula 1.1—1.1—1.1.

Length: Body about 6 mm.

Genitalia: Side-pieces nearly three times as long as wide, rounded at tip; apical lobe roundedly prominent, without basal prolongation; basal lobe digitate, appressed, with a side-piece bearing two stout apical setæ. A group of dense hairs arising at origin of apical lobe. Clasp-filament long, slender, with two small setæ towards tip arising from slight notches; a long articulated terminal spine. Harpes elliptical, concave, inner margin thickened and revolute; tip pointed and outcurved. Harpagones with a long stem, its basal and larger portion thick, angular and bearing a few setæ, apical portion slender, with a broad terminal filament which is expanded at tip, the angles of the expansion pointed. Unci approximated revolute, forming a basal cylinder. Basal appendages approximate, bearing several short, stout setæ.

Larva. Head rounded, much wider than long, narrowed before eyes, a notch at insertion of antennæ; front margin arcuate. Antennæ very long, longer than the head, straight, not or only slightly curved, thorned; antennal tuft with few hairs inserted almost in the middle of the antenna; terminal portion slender, carrying two hairs near the tip and two thorn-like hairs on apex. Anteantennal tuft with five hairs; lower frontal tuft with four or five hairs, upper triple. Eyes large.

Thorax rounded, angled at hair-tufts; hair formula of frontal border 121114411121. The median tuft of four hairs consisting of one very long hair and three small ones. The next hair nearest 4 exceedingly small. Lateral hairs long, a few single, most most of them in multiple tufts.

Abdomen rather broad, the first segments much smaller than segment six and seven; lateral hairs on first two segments triple, double on third to fifth, single on sixth. No subdorsal tufts. Eighth segment with tufts in common arrangement. Lateral comb consisting of about twelve scales, arranged in an arcuate row, each scale spatulated at base ending in a long, acute spine with smaller spines at its base and many small spines or hairs bordering the spatulate part. Sipho rather short, tapering at apex, only two and a half times longer than broad, a pecten at basal third consisting of about 13 thorns, the last two single, at great distances from each other; the others with three or four lateral thorns; a large hair-tuft. Anal segment longer than wide, dorsal plate square, only reaching halfway down the sides; dorsal tuft well developed with two very long stiff hairs. Ventral brush consisting of thirteen rays in the barred area and before it three or four free rays; every ray carries from seven to ten hairs; anal gills long acute equal.

Lateral tufts of labrum well developed, no comb-hairs near palatum; palatum covered with long soft hairs. Mandibles quadrangular, two stout spines before the collar; a row of long cilia from collar; about ten spines from margin; dentition four

Textfig. 10. Pond in Stenholtsvang. *Aëdes cinereus; Ochlerotatus cantans; communis, prodotes, rusticus, diantæus, Culicella morsitans.*

to five strong teeth and between them and the row of cilia three long thorns, the last very long and acute; five strong ciliated hairs below the teeth, process below furcate with strong hair-tufts on both tips, a group of hair at base. Maxillæ elongate, tips conically rounded, divided by a suture; at the apex a large brush of long soft hairs, a strong seta near the apex below the brush. Between the suture and inner margin a coarse coating of short, soft hairs. No spines at margin. Palpes well developed with five little apical digits. Mentum triangular with arcuated sides, the median tooth but small and with about eleven teeth on each side. Colour of the body red brown with bright yellow head and golden brushes on labrum.

Biology: I have found this peculiar mosquito only in one locality in the little bog of Stenholtsvang near Hillerød. In the same sample 23/v 1919, in which I found the larva of *A. cinereus* I found, among the numerous *O. cantans* larvæ, a remarkable red brown larva with very long antennæ, almost as long as those of *C. morsitans* but almost straight, not elegantly curved as in this species. — I immediately saw that I had to do with a new species for our country. In the time from 25/v to 5/vi the pond was visited almost every day; the larva was rare, and I never got more than about fifty specimens; they were hatched in my cages before 5/vi. By 5/vi the pond was almost dried up and got only very little water till October; practically it was dry. In the time from 20/vi to 1/vii and later on in August I have often tried to catch the imago among the vegetation which covered the dry bottom. It was always in vain. I had quite given up finding the imago in Nature, when suddenly on 29/ix 1919 I found it in another part of Grib forest. Dredging in the northern part of Griblake my assistent and I were suddenly attacked by mosquitoes. The boat was about thirty meters from land; it was fine sunshine and almost calm where the boat was. I had an opportunity to catch some of them; they undoubtedly all belonged to the same easily recognizable species.

In the winter 1919—20 up to June 1920 the pond was visited regularly; it was open from February and contained enormous quantities of *O. communis* till about 20th May. On 5/v the first halfgrown *O. diantæus* larvæ appeared in the samples; by 25/v all were pupæ; the larvæ were much rarer in 1920 than in 1919; I found only about thirty, which were hatched; among them were only two males.

For the present we must register this species among the forest mosquitoes, hatched in spring in ponds which are commonly laid dry in June; they winter as eggs and probably do not possess more than one generation. The late occurrence on 29/ix is remarkable.

Geographical distribution: The species has hitherto only been found in America. New Hampshire (H. D. K. 1917 p. 758). Only the male has hitherto been known. The species has been determined by Dr. Edwards. The description of the female is new; that of the male has been worked out in accordance with that of Howard, Dyar and Knab; the description of the remarkable male genitalia has been quoted verbatim.

15. **O. sticticus** (Meig.) var. **concinnus** Steph.

Description. Female: Proboscis rather long, uniform, labellæ conically tapered; vestiture black, labellæ grey; setæ small, black. Palpi short, not one fifth as long as proboscis, black, no brighter scales at tip. Antennæ long, the joints subequal, rugose, pilose, black, second joint a little larger; hairs of whorls rather short, sparse; tori subspherical with a cup-shaped apical excavation, black with a few greyish-white scales on the inner side. Clypeus rounded, triangular blackish nude. Occiput black, clothed with coarse narrow, curved yellowish-white scales, margin of eyes and the cheeks white, scales on lower part of sides flat; many slender, erect forked black scales; setæ along margin of eyes rather short, black.

Prothoracic lobes elliptical, remote dorsally with narrow yellowish scales and many black setæ. Mesonotum black, covered with golden yellowish or bright reddish brown scales and with creamy ones at the sides; over the roots of the wings tufts of golden brown bristles; scutellum deep brown, almost black, trilobate, clothed with pale scales and each lobe with a tuft of golden-brown bristles. Postnotum black, pleuræ dark brown with patches of pale scales.

Abdomen densely black scaled with clear white basal bands, not or only little contracted in the middle line not forming distinct broad lateral patches; posterior borders with clear pale golden bristles; venter white and black scaled.

Wings with brown, almost black scaled veins; first sub-marginal cell considerably narrower and longer than second posterior cell; petiole of first submarginal cell as long as the cell, that of second posterior cell a little longer; basal cross-vein very close to the anterior cross-vein. Halteres with ochraceous stem; knob fuscous with grey scales. Legs unbanded; coxæ brown with white scales; femora and tibiæ densely covered above with greyish white scales; knee spots white, apices of femora before the spots deep black; hind tibia with a very characteristic white stripe on the outer side. Claw formula 1.1—1.1—1.1. Length of body about four mm.

I have never seen either male or larva; the last-named is unknown.

The species was brought me by Mr. KRYGER who caught it in the western part of Jutland at Linding near Varde. He has only caught three specimens, which I determined as *Ochlerotatus nigrina* (Eckstein). Mr. EDWARDS has been kind enough to verify the determination. He refers it to *O. sticticus* Mg. var. *concinnus* Steph. and gives the following synonymy. *O. sticticus* = *sylvæ* Theobald = *dorsovittatus* Villeneuve = ? *nigrinus* Eckstein. — The best distinguishing feature is the white stripe on the outer side of hind tibiæ. See further p. 96.

Geographical distribution: *O. sticticus* Meigen var. *concinnus* Steph. seems to be rare everywhere; Mr. EDWARDS states that it has hitherto been found in England, Scotland, France, Germany and Siberia.

Genus III. *Finlaya.*

1. **Finlayia geniculata** (Olivier).

Culex lateralis Meigen.

Tab. XIV.

Description. Female: Proboscis rather long uniform, labellæ rather long, tapering at tip, vestiture black without pale scales intermixed. Palpi about one-sixth the length of proboscis, black without white hairs at apex. Antennæ filiform, vestiture black; second joint scarcely thicker than the following; tori globose with a cup-shaped apical excavation and white hairs on the inner side; hairs of whirles black, long. Clypeus rounded, triangular, blackish, nude. Eyes black. Head black, with creamy spindle-shaped scales in the middle and forming a row behind, pure white ones at the sides; a pale patch just in front projecting between the eyes.

Prothoracic lobes elliptical, remote dorsally. Mesonotum black, covered with bright bronzy or snow-white scales; two median black stripes as long as the thorax, separated from one another by a white line; laterally two other black stripes, half as long and also separated from them by a white line; scutellum trilobate, black, bordered by lines, the median line being forked; long golden hairs on the borders of the midlobe and on the lateral lobes; post-notum deep black; pleuræ black with eight or nine distinct large patches of snow-white scales.

Abdomen violet black, covered with dusty black scales and long golden hairs from the posterior border of each segment. Each segment with lateral snow-white spots, most prominent when the mosquito is observed laterally; on the dorsal side they never form bands; venter with broad white bands.

Wings with the veins covered by long lateral black-brown scales, truncated at the apex; those along the costa and base of the first long vein black; first submarginal cell a little longer and narrower than the second posterior cell, its stem about equal to half the length of the cell; stem of the second posterior cell nearly equal to the length of the cell; basal cross-vein not twice its own length distant from the anterior cross-vein; fringe dark brown; basal lobe of wing with a fringe of flat, black scales and no bristles near the base of the first long vein.

Legs black, coxæ covered with snow-white scales; bases of the femora and the ventral surface for about half their length white; knees snow-white. Tibiæ and metatarsi black; hind metatarsus about two-thirds the length of the hind tibia. Ungues of the female, on the forelegs uninserrated, on the other simple; on the male unequal on fore- and middlelegs, on the forelegs the small ungues uninserrated, the large biserrated; so also on the middle legs, but the inner tooth indistinct; the outer on both claws remarkably rod-like and broader at apex; those of the hindlegs simple.

Length of body 5 mm.

M a l e: Proboscis longer in male than in female; palpi black almost of the same length as the proboscis. Antennæ black; but with white bands upon every segment; the white parts of the thorax more distinct; the white spots of the abdomen larger; the last segment almost snow-white. The ventral surface of the legs white to a greater extent than in the female. With regard to ungues see under ♀.

Length of body 5.5 mm.

L a r v a. Head rounded; almost isodiametric; hind angles rounded; sides arcuate and front margin highly arcuate. Antennæ small, cylindrical, only slightly tapering at front, smooth without any spinosity. Antennal tuft consisting only of one single hair, inserted almost in the middle of the antenna. Two hairs and two attenuated digits at apex. Eyes small, the stripe of integument between the eyes often indistinct or obsolete. Anteantennal tuft often only with two or three hairs; upper frontal tuft with two hairs, lower with one single hair; between the upper frontal tuft a small tuft of about six hairs and a similar one over the eyes.

Thorax rounded, slightly angled at hair-tufts; hair formula at frontal border

21022012. Between 2 and 0 a very small hair-tuft. Lateral hairs long, many single, the others in multiple tufts. Two series of smaller tufts with one single or a few hairs between the median and posterior tufts.

Abdomen rather broad; lateral hairs on first two segments triple, double on third to sixth; short hair-tufts at the base of the lateral hairs. On the dorsal side of the segments three pair of tufts, one pair at the anterior and posterior border of each segment, and a greater pair almost in the middle of the segment; this tuft always consists of four hairs commonly arranged rectangularly to each other; the other hair-tufts mainly triple or with four hairs, the arrangement of these hair-tufts is very regular, the tufts forming three series over the dorsal surface of the abdomen; on the ventral side only the median tufts present, those of the anterior and posterior border being absent. Seventh segment with some more irregular distribution of the tufts and without lateral hairs. Hairs of eighth segment in common arrangement. Lateral comb consisting of about twelve scales arranged in an arcuate, single row, each scale having a rather narrow base and terminated by a long strong spine; on both sides fringed with a long series of weaker ones or very fine hairs. Air-tube moderate, almost one and a half times as long as eighth segment, tapering at the apex, three times longer than broad: pecten short, with 10—12 teeth, every tooth broad, flattened, yellowish-brown with white apices; at the base furnished with a series of dark, short spines; a single hair-tuft of five hairs at some distance from the pecten and a single hair on the opposite side. Anal segment very short, a little wider than long; the plate small, not quite encircling the whole segment; dorsal tuft consisting of about eight to ten hairs of rather different length. The ventral brush very remarkable, only feebly developed, consisting of but seven rays, each ray carrying two or three hairs; before the brush two or three free tufts; lateral tuft highly developed with three strong hairs. Anal gills of unequal size; the two large ones almost twice as long as the anal segment, the two others only half as long, all broad, flattened, obtuse.

Lateral tufts of labrum short but dense; the inner part with a little crown of comb-hairs; palatum well-developed, covered with soft hairs. — Mandible quadrangular, two stout spines before the collar, a row of cilia from a collar, about seven to ten spines from inner margin; dentition four strong teeth, preceded by two serrated filaments, one much stronger than the other; a strong spine before these filaments. Four hairs within; process below slightly furcate, with strong hair-tufts; a group of long hairs at base. Maxillæ narrowly elongate, tips conically rounded, divided by a suture; at the apex an elegant large brush of long hairs; a seta near the apex beyond the brush. Along the suture, between it and the inner margin, a coarse coating of short, soft hairs. No spines at margin, but the whole space between it and the coating of short soft hairs covered with short, strong spines, especially in the part nearest to the apex; palpus well-developed with five small apical digits. Mentum triangular, straight sides, a large central tooth and from ten to eleven small teeth on each side. The whole body pilose.

Colour commonly white with almost black head and sipho; the tracheal trunks very wide and flattened.

Systematical remarks. When I first found the species and tried to determine it, I felt quite sure that I had found *Finlaya geniculata* (Olivier) = *C. lateralis* Meigen; and even now after having studied the whole literature with regard to this and allied species I do not think that there can be any doubt upon that point; I cannot find any real discrepancy between Meigens' description and the Danish specimens. Theobald too supposes that he has found the species again; as his description is not however in full accordance with my specimens, I have given a new one. It will be seen that my specimens do not agree with Theobalds with regard to the drawing of the thorax, but are in accordance with Meigens' description; further that there is some discrepancy in the description of the wing between Theobald and me.

In this connection it is however necessary to take into consideration two other species *Culex sticticus* Meig. and *C. ornatus* (Hoffmanseg) Meigen.

C. sticticus is similar to *C. lateralis*, but differs from it in having the white lateral spots on the abdomen united in bands; the legs are brown, the hind tibia with a white stripe on the outer side. The species was later adopted by Schiner (II p. 629) by Ficalby (1896 p. 120) lastly by Schneider (1914 p. 41); this author maintains, that *stictica* is a good species and states that it is to be found in the neighbourhood of Bonn. On the other hand Theobald (1901 p. 80) refers the species to *C. nemorosus* and so does Blanchard (1905 p. 393). Having got the specimens with white bands from Jutland I am quite sure that *sticticus* really is a good species, to which most probably *O. nigrinus* (Eckstein) may be referred. (See page 93) Eckstein (1918 p. 67) maintains that the specimens of *C. lateralis* Meigen belong to *ornata*. This view I cannot adopt.

C. ornatus (Hoffmgg.) Meigen has always been a very doubtful species, and it is now very difficult to understand what the earlier authors really meant by this species; the type-species does not exist anywhere any longer, In Staeger's collection at the Royal Museum, Copenhagen, there are some species labelled as *C. ornatus* Meig. A closer examination has shown that there cannot probably be any doubt that what Staeger has determined as *C. ornatus* Meigen has really been *Finlaya geniculata* Olivier, (= *C. lateralis* Meig.). In Theobald's translation Meigen has described *C. ornatus* as follows: "Thorax whitish, with two black streaks; abdomen fuscous with basal white bands; legs blackish, with a white knee spot; proboscis blackish-brown; antennæ dark brown in the ♂ with brown hairs; palpi of the ♂ blackish-brown, with long hairs and three whitish spots; thorax yellowish white with two converging blackish stripes and two others further behind; pleuræ blackish-brown, with white spots and marks. Abdomen blackish-brown with white basal bands. Legs brown with the coxæ dull yellow; femora dark brown, knee spots white, tibiæ and tarsi dark brown. Wings with brown scales. Length 3 lines". Theobald has never seen the species, but indicates that it resembles *C. lateralis* from which it can at once be distinguished by the abdominal bands. It is stated to have been found in Germany (MEIGEN, GRÜNBERG 1909 p. 88), SCHNEIDER (1914 p. 42); Scandinavia (ZETTERSTEDT 1850 p. 3459), Denmark (STAEGER 1838 p. 553), Holland VAN DER WULP), Austria (SCHINER), Russia (GIMMERTHAL), England (STEPHENS, VERREIL; EDWARDS 1912 p. 220; LANG 1920 p. 97).

ECKSTEIN, too, (1919 p. 66) has recently tried to elucidate the question but in my opinion without success. He maintains that the species "in den Wäldern um Strassburg nicht sehr häufig ist", and says that the species is characterized by its "glänzed silberweissen Schuppenringen an allen Knien, wodurch *C. ornatus* leicht und mit Sicherkeit, namentlich frische Exemplare von ähnlichen Arten (*C. lateralis* = *F. geniculata*), *nemorosa* and *nigrina* unterschieden werden kann". He maintains that the authors after Meigen have determined the true *ornatus* as *lateralis* "sonst würde man nicht von scharfen, weissen Knieflecken lesen können". As MEIGEN (1818 p. 5) however writes with regard to *lateralis*: "Knie blass" it is in my opinion questionable whether he is really right.

As far as I can see ECKSTEIN has described as *O. ornatus* what is really *Finlaya geniculata* (= *C. lateralis* Meig.); as his description, more especially of the female, is however rather insufficient, this cannot be established from his description of the imagines alone; on the other hand, if this description is combined with that of the larva and the statements relating to the habitat, as far as I can see, there can be no doubt upon that point.

ECKSTEIN (1918 p. 66) says that the larva lives "in den manchmal recht kleinen Wasseransamlungen in hohlen Bäumer zusammen mit solchen von *A. nigripes*. Die Eier werden einzeln wenige Zentim. oberhalb des Wasserspiegels an dem feuchten Mulm u. s. w. abgelegt". GALLI VALERIO and ROCHAZ DE JONGH (1912 p. 224) as well as MARTINI (1915 p. 585) have also found the *C. ornatus*-larva in tree-holes. This is just the place where I have found my *F. geniculata* (= *C. lateralis*) larva. As North of the Alps we have hitherto never found other Culicin-larva in tree-holes than this one[1], I suppose that ECKSTEIN and I have really found the same larva. We have only determined the species in different ways, he as *O. ornatus*, I as *Finlaya geniculata O.* (= *C. lateralis* Mg.). That this is really the case, will be clear if we compare the description of the larva of *O. ornatus* by ECKSTEIN (1919 I p. 291) with my description of *F. geniculata*. He describes this larva as follows. "Die Larve fällt sofort durch die auffallend starke Beborstung des Körpes, insbesondere des Abdomens auf. Jedes Abdominalsegment trägt nämlich mehrere aus 6—9 meist aus 7 starren Borsten bestehende Borstenbüschel. Das Atemrohr is kurz gedrungen, nicht ganz 2 mal so lang als sein Durchmesser an der Basis, ziemlich dunkel gefärbt. Der Dornkamm unterscheidet sich von den anderen Stechmückenlarven ohne weiteres dadurch, dass die Dornen nicht wie bei jenen von der Basis zur Spitze des Atemrohres allmählig an Grösse zunehmen, sondern dass neben den

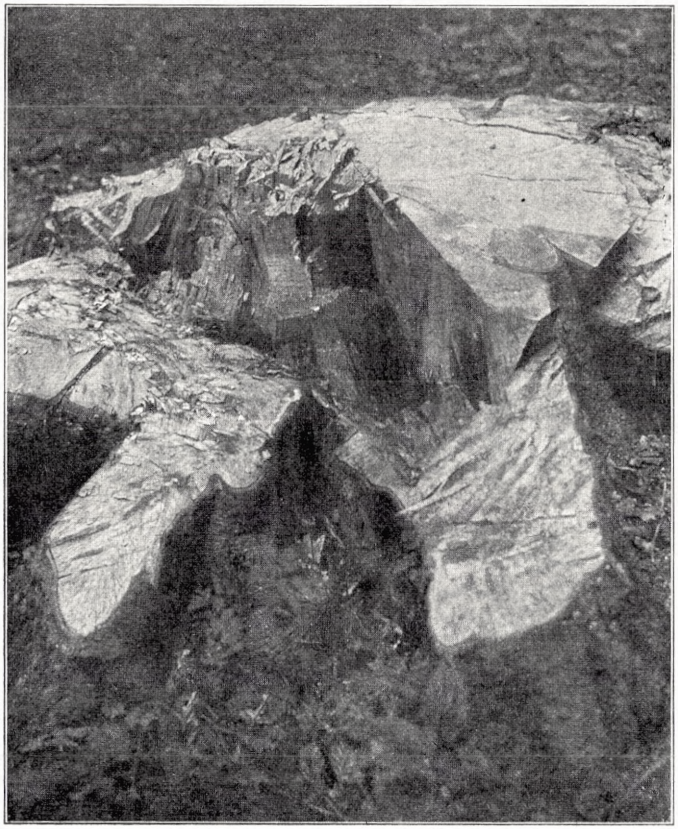
[1] Apart from the remarkable discovery of the larva of *Onthopodomyia albionensis* Mac Gregor and *Stegomyia fasciata* (Fabricius) from the same tree-hole in Epping Forest.

basalen sehr kleinen ohne vermittelnde Bindeglieder sehr grosze stehen. Alle haben kleine Zähnchen; meist sind 4 kleine und 9—12 grosse Dornen vorhanden. Das Haarbüschel des Atemrohres steht etwa in seiner Mitte. Am 8 Segment befinden sich etwa 25 in zwei Reihen stehende lange lanzetförmige in einer Spitze auslaufende Striegelborsten". There are some discrepancies between these two descriptions. Eckstein says that the hair-tuft on the sipho "steht etwa in seiner Mitte"; this is in accordance with my description, but his own figure (Fig. 10) shows it at the base. Further his statement: "dasz die Dornen nicht allmählich an Grösse zunehmen, sondern dasz neben den basalen sehr kleinen ohne vermittelnde Bindeglieder sehr grosse stehen" is not in accordance with those of my *Finlaya geniculata* larva. Further my larvæ have in the comb only 12 scales arranged in one series.

The mosquito which Eckstein has described as *O. lateralis* (Meigen) has, as far as I can see, not hitherto been found in Denmark. The descriptions of the female and more especially of the larva are so insufficient, that it will be very difficult to determine them; in the description of the male genitalia he has pointed out some characters, by means of which it seems that his *O. lateralis* (Meigen) can really be separated from his *O. ornata* (Meigen) (1920 p. 237). Most probably he is therefore right, when he says (1918 p. 67) that: "*lateralis* ist eine Art für sich, und ebenso *ornata* und *nemorosa*".

Biology. More than twenty years ago, when on an excursion to Jægerspris, near the fjord of Roskilde, I found some mosquito larvæ in a little hole of an old oak; I supposed that the locality for these larvæ was rather peculiar, the quantity of water not being 1/4 Ltr., black, brown and of an extremely nasty odour. Yet I did not then thoroughly study the larva. Later on, when I read the work of Howard, Dyar and Knab, with the description of all the remarkable mosquito larvæ found in tree-holes, in the small volumina of water, among the leaves of Bromeliaceæ and other tropical plants, I remembered my observation of more than twenty years ago. Having mentioned it to Dr. Th. Mortensen, he told me that he, too, had found mosquito larvæ in the holes of old trees in North Seeland. Dr. Mortensen, who at that time was my guest at the Freshwater Biological Laboratory at Tjustruplake, explored the forest near the laboratory with me. In the course of July we then found about thirty holes with mosquito larvæ. On the meadow before the laboratory more than hundreds of plants of *Angelica silvestris* were growing. As this plant is provided with the greatest sheaths found in our flora, and more than any other Danish plant is able to hold the rainwater in the sheaths for about a week, I supposed that mosquito larvæ might also be found here. The plants were regularly observed; in the collections of water were found great quantities of Infusoria and some Rotifers, but never mosquito larvæ. It must be supposed that our flora of herbaceous plants is unable to retain rainwater long enough for mosquito larvæ to live in.

The tree-holes are mostly to be found near the ground where the roots branch off from the trunks, but I have also found them some meters from the ground, where the trunk is cleft in large branches; many of these holes are never filled with rainwater because it immediately sinks down into the ground, or into the decaying wood; in very dry summers the holes hold no water or only very small quantities. In some of them, more especially those in which the bottom itself is of wood, and not part of the ground, the rainwater can be retained for months, more especially when a little rain now and then can replace the loss by evaporation. In these holes the bottom is almost always covered with decaying vegetation, more especially leaves, which in its deepest layer form a black humus. The water is dark-brown and of an extremely foul odour, smells strongly of hydrosulphuric acid; the volumina of water are often less than a deciliter, and never more than from three to four liters. In autumn the holes are filled with leaves; from December to May the contents of the holes can with more accuracy be described as moist leaves, than as clear water; for more than three months the whole mass is frozen into a brown ice; at the bottom of the holes I have however almost always found a layer of frost-free, black humus. The temperature of the water is remarkably constant during the whole summer and always rather low; even on hot days, where the ponds have temperatures of about twenty-five Celsius, the holes rarely have more than about twelve degrees, and probably never more than fifteen. This is due to the fact that the water in the tree-holes hardly ever receives a single sunbeam. Though the water has a disagreeable smell, it is commonly clear, and most closely resembles fresh urine. The bad smell is strongest when the bottom is stirred up. What certainly contributes to the bad quality of the water is the huge mass of drowned animals which first cover the surface of the water and later on sink to the bottom and decompose. Every heavy shower carries large quantities of animal-



Textfig. 11. Hole in a trunk. *Finlaya geniculata* and *Anopheles nigripes*.

cules into the holes with the streams running down the trunks and passing through the huge carpets of tree-mosses. Often the surfaces are covered with thick layers of large *Podura* which later on form a decomposing mass on the bottom. Some grashoppers f. i. *Meconema varium*, *Carabidæ*, *Oniscidæ*, which here, curiously enough, meet with a few living *Asellus aquatius* but especially many snails f. i. *Limax* o. a., are swept down into the holes and drowned.

In dry summers f. i. 1918 the holes contain no water from the first days of August to October; in the course of the autumn the holes were filled, but in December they froze and were frozen till the last days of March. To aquatic animals in the free-swimming stage the holes are only habitable for about four months, but in these four months long periods of drought may intervene, and the holes may be laid dry for weeks and even months.

Curiously enough, these rather unpleasant localities contain a crowd of animalcules which have here found a home and are adjusted to the remarkable conditions these holes can offer their habitants. Now and then the water contains infusoria in countless numbers, the animalcules forming stripes and clouds in the water; also many rotifers are common, more especially those of the *Philodinidæ*, probably swept down from the mosses on the trunks; yet it is much more remarkable that *Copepoda* and *Ostracoda* are very common, the former in the water itself, the latter on the bottom, living on the decaying leaves; the Ostracoda more especially are common; the species hitherto found are *Cyclops bisetosus* Rehberg, *Cyclops pulchellus* Koch, *Candona compressa* Brady. I beg Dr. Sven Ekman Upsala to accept my best thanks for the determination. Once I found a few *Asellus aquaticus* in a single hole. In the upper layer of the bottom are found many hitherto undetermined Nematoda, in the lower, various Oligochæta. The greatest and most interesting contingent is yielded by the Insects.

Very frequent are the larvæ of different *Chironomidæ*, further of *Ceratopogon* and *Eristalis* (rattle snakes). These larvæ, especially, may be present in great numbers; common are also the larvæ of *Helodes* sp.

Amid this company we also find the mosquito larvæ which, when hatched, give the beautiful mosquito *Finlaya geniculata* hitherto unknown in our country and the larva of *Anopheles nigripes*, mentioned later on. The number of larvæ of *F. geniculata* found in the holes is always very restricted; often I have only found two or three, commonly about ten, in spring however I have often found fifty and only once about eighty; the larvæ are extremely slow and sluggish, difficult to observe in Nature, always seeking back into the darkest parts of the small water volumina or between the leaves; in my aquaria they only rarely come to the surface to breathe, they lie on the bottom or search the bottom for food. When there, they only move forward slowly; the body is commonly held obliquely, and the very short flabellæ are in constant motion, brushing off the surface of the bottom; the description and drawings show that the larva differs very much from all other Danish mosquito larvæ; the antennæ are extremely short; the eyes rather small, the anal segment of a rather peculiar form and the swimming-brush more reduced than in any other of our Danish mosquito larvæ; of the anal gills two are extremely large and broad, and the hair-covering of the body, more especially that of the abdomen, unusually highly developed; further, the colour of the larva is greyish-white and the whole larva semitransparent. Finally the tracheæ are remarkably broad, flattened. Many of these peculiarities may also be pointed out in many of the tropical mosquito larvæ living under similar conditions; this more especially holds good for the equipment of hair-bristles, which are often more luxurious in tropical species, further with regard to the small eyes, the slight development of the anal brushes, of which the ventral one may be wholly absent, and the large broad trachea gills. There is an easily comprehensible connection between the small eyes, the slight development of the swimming-fan and the conditions under which the larvæ live; on the other hand the luxurious development of bristles, and more especially that of the large anal gills, is difficult to understand. It must be taken for granted that respiratory conditions on the bottom of these holes are extremely bad; it is therefore difficult to comprehend how the cutaneous respiration, taking place either through the cutis of the abdomen or through that of the anal gills, can help the larva to any considerable extent.

Having found the larvæ in the forest of Suserup, where the summer laboratory is, later on I found the larva in the neighbourhood of Hillerød, by Dragsholm, by Tidsvilde (North Sealand near the coast of Kattegat). The imagines have never been found in Nature itself; all the specimens in my collection derive from my aquaria; the imago is of course extremely rare and probably very difficult to detect. In such a little wood as that of Suserup every single tree has been observed; the wood does not possess more than twenty breeding localities; if there are only hatched about thirty-forty mosquitoes in every hole, it is intelligible that the imago must be rare and almost impossible to detect. I have further observed that spiders almost always weave their webs over the holes; the webs standing only a few centimeters from the surface, almost every flying animal leaving the surface must be caught by the webs.

Having had the holes under regular observation for about two years, I feel quite sure that we have only one or two generations the whole year round. In 1918 many of the holes were ice-covered during the last days of March; they were filled with water during the first days of April and in the time from April the first to about April the fifteenth very many larvæ in the first stage were found in the holes. In the first weeks of May many of the holes were almost dried up; the larvæ only grew very slowly, lying between the moist leaves at the bottom of the holes, but without any water to swim in. In the latter part of June the holes got some water and the larvæ grew more quickly, but no pupæ were observed before the first days of July; in the course of July all the pupæ were hatched, owing to the extremely rainy summer the holes almost always held water. From the last days of July no larvæ could be observed in the holes. In 1919 and 1920 I found a few halfgrown larvæ in several holes in October—November. In December the holes were frozen, and when they thawed in 1919 in March and in 1920 in February, they never contained larvæ; I take it for granted that the larvæ from the autumn have died out in the course of the winter. In 1920 the holes which were ice-covered in February contained no larvæ before the first days of April; they were filled with water till June, but no pupæ appeared before this month. In August 1920 I saw the only sign of a second generation. A large beech was cut down in May; in the stump was formed a hole, and this hole was filled with water in the first part of July; during the last days of July I found almost fullgrown larvæ which were pupæ in the middle of August and have most probably given a second generation in the latter part of the same month. During the whole summer I found larvæ of very different size; at a first glance one would think that this must be interpreted as if the mosquito had many generations in the course of the year. I do not think this is the case; in our country the different sizes of the larvæ must in my opinion be referred to eggs which have arrived at their natural hatching conditions at different times of the year.

When the imagines were hatched in my cages, they stung immediately; they had great difficulty in piercing the skin and often tried from ten to twenty times before they got blood. I had hoped that these gorged imagines would lay eggs in the vessels placed in the cages, but this did not occur.

The eggs are laid in July—August and are to be found on the sides of the holes, commonly a little above the water rim. Most probably the eggs are laid at different times and by different females; under specially favourable conditions e. g. in wet summers, in which the eggs are reached by the water rim at a very early date, it may possibly occur that some of these eggs are hatched in the very summer in which they are laid, but I feel quite sure that the main part hibernate as eggs, and are not hatched before the next year, commonly in March—April.

Lang (1920 p. 96) agrees with me with regard to the number of generations; he maintains, as I, that there is most probably only one generation, and that the larvæ grow slowly. That this is not always the case, Eckstein (1919 p. 101), has tried to show starting from very careful observations; it seems that he has proved that more than one generation can be hatched in the course of the summer; the number depends upon the number of rainy periods; the first generation takes 36 days from hatching of egg to imago, the last only 10. I feel convinced that this is not the case in our country. Whilst in Germany, in the time from 24/III to 23/V, five series of eggs can be hatched, in Denmark no imagines appear before June; further the high temperatures in tree-holes (21—24° C.), mentioned by Eckstein, have never been found in our country, the temperature most probably never exceeding about 15 degrees.

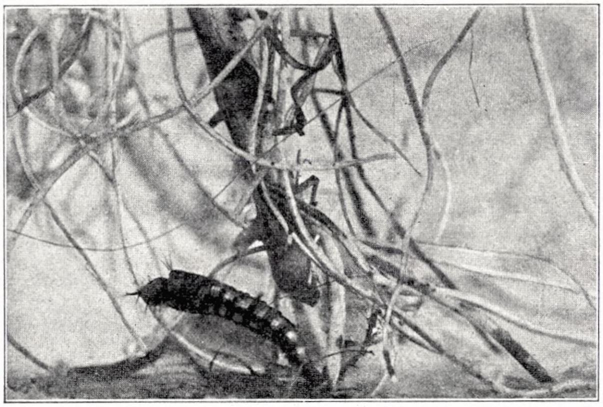
Geographical distribution: Most probably *Finlayia geniculata* is widely spread over the whole of Europe; it is unknown from Scandinavia, rare in our country and most probably has a more southerly range.

Genus IV. *Tæniorhynchus.*

1. **Tæniorhynchus Richardi** (Ficalbi).

Tab. XV—XVI.

Description. Female: Proboscis moderate; labellæ moderate; vestiture of broad scales blackish-brown with many black and a few yellowish scales; labellæ bright ferruginous, setæ small, black; yellow on the labellæ. Palpi brown, about a fifth as long as the proboscis, with many outstanding bristles and creamy-yellow scales. Antennæ filiform, moderate, blackish-brown, joints at shaft subequal, rather short, densely clothed with silvery hairs; second joint a little thicker, ferruginous; tori globose, brownish with an inconspicuous group of flat white scales on inner side; hairs of whirls sparse, dark. Eyes black. Clypeus broad; rounded, almost black, nude. Occiput brown, clothed with narrow, curved, pale scales and numerous forked black ones; numerous blackish and pale brown bristles projecting at vertex.



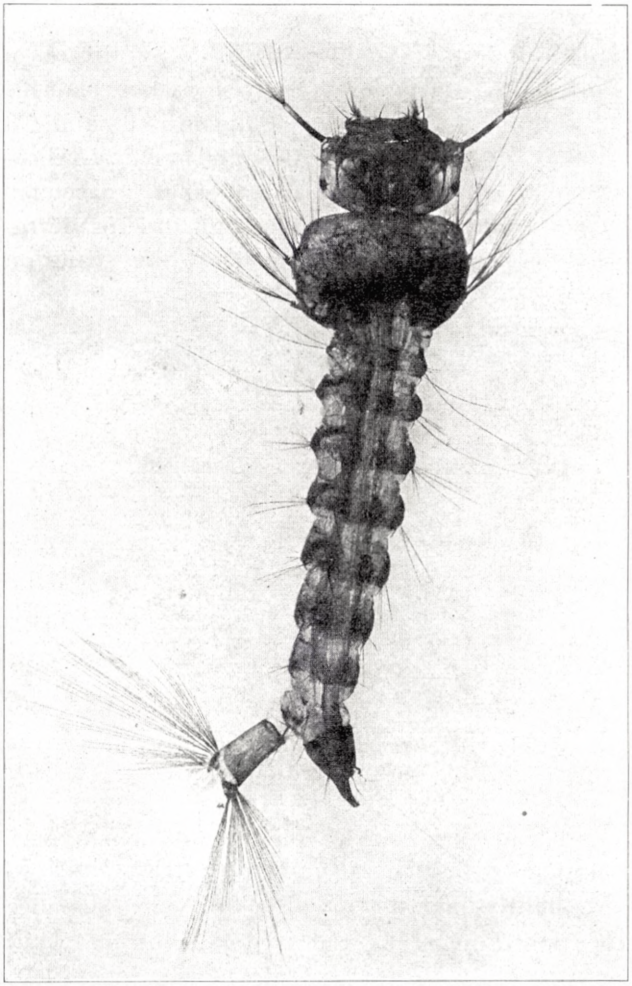
Textfig. 12. *Tæniorhynchus Richardi*. Larva living; with the sipho pierced into the root.

Prothoracic lobes small remote, similar to mesonotum. Mesonotum chestnut-brown with scattered golden scales, more or less distinctly arranged in rows, bristles black. Scutellum trilobate, clothed with narrow curved scales and bright, golden brown border-bristles. Postnotum elliptical, nude, clear, ochraceous brown; pleuræ and coxæ pale, yellowish-brown, with a few pale yellowish scales.

Abdomen subcylindrical, flattened, slightly tapering towards tip, when denuded dull ochraceous-brown, under certain conditions of light it is dark, shining, while in other cases it may be black. When covered with dusky scales it is almost black with now and then traces of apical bands. Five or six yellowish-white lateral, often rather inconspicuous spots. Numerous golden brown hairs along the sides and the hind margins.

Wings: The veins densely covered with rather broad, elongated oval, brown and light scales; besides there are a few scattered yellow scales, especially along the costal region; no long thin lateral scales. First submarginal cell almost as long as the second posterior cell; stem of the former about half the length of the cell; stem of the latter also about the same relative length; basal cross-vein only about once its own length apart from anterior cross-vein; halteres pale, ochraceous.

Legs: The coxæ yellowish, femora yellowish, the upward turning surface brown, the apex white, the white band not involving the tibia. Tibia brown with scattered black and dull yellow scales; metatarsi and tarsi yellowish, banded in the following manner: fore metatarsi and first two tarsi with traces of basal bands. On the midlegs the bands are more distinct; the bands on the hindlegs are broader and still more distinct, but there is no broad, pale median metatarsal band, such as THEOBALD states with regard to *T. Richardi*; ungues equal, simple. Claw formula 0.0—0.0—0.0.



Textfig. 13. *Tæniorhynchus Richardi.*

Length: Body about 5 mm.

Male: I have hitherto only found females and with regard to the description of the male refer the reader to THEOBALD (1901 p. 194).

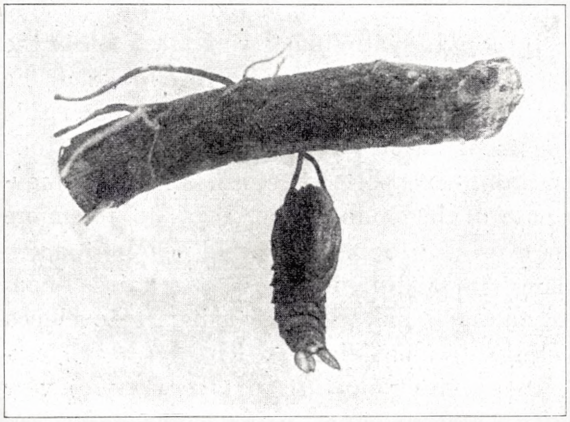
Larva: Head subquadrate, wider than long (5 : 3) antennæ long and slender; a large hair-tuft nearer the base than the apex, arising from a notch, terminal portion slender, flagellum like, very flexible and much drawn out, one of the terminal hairs situated not far beyond the tuft; dorsal hairs all in multiple groups; the anteantennal tuft large, multiple; lower frontal tuft absent; upper frontal tuft commonly with five hairs, between them four very small hair-tufts.

Thorax transverse, angled at hair-tufts. Hair formula for the frontal border of the thorax 531105501135, between 5 and 0 a small hair-tuft; lateral hairs long, a few of them single, most of them in multiple tufts; a few small tufts scattered over the dorsal side.

Abdominal segments rather broad, when the larva is fastened to the roots, almost inflated; the long lateral hairs double; dorsally and ventrally every segment provided with two series of hair-tufts, every segment carrying four tufts eighth segment without these hairs. Lateral comb of eighth segment with ten to twelve scales in a single, irregular row; each scale having a somewhat spatulated base and terminated by a stout spine, at the base of the latter on both sides a commonly smaller spine, followed by a series of still smaller weaker ones; hair-tuft behind the comb consisting of from three to four, long hairs. Air-tube about twice as long as wide; the basal part broad and strongly convex with black ring near base, the apical portion attenuated, consisting of thick lamellæ with a group of hooks at the tip and with stout teeth on one side mesially. It bears a hair-tuft on each side near the middle, and two pairs of filaments at base of apical projection; the one pair strongly curved, inserted upon two cushion-like parts of chitin and very movable. No pecten; two strong hairs at the base of the sipho. With regard to the more thorough description I refer to my paper (W-L. 1918 p. 277). Anal segment much longer than wide, ringed by a chitinous plate; dorsal tuft of many long hairs, divided into two small and two large groups on each side, no particularly developed long bristles; ventral brush great, consisting of about eight to ten rays, each carrying from eight to ten, very flexible bristles; either no tufts or a few (two) very feebly developed tufts before the ventral brush. Anal gills four, equal, slender and not as long as anal segment.

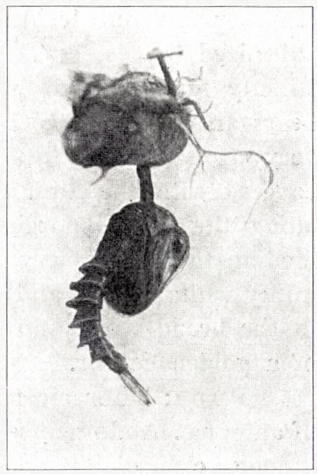
Mouth brushes very large, distinctly divided into two parts: the inner part without comb-bristles; palatum coated with a covering of rather short hairs. Mandibles remarkably high, three, long, curved thorn-like spines near the collar, a row a cilia from a collar and from inner margin a series of tubercles bearing rather long, curved but feeble setæ; dentition about four to five irregular dark highly chitinized thorns, one of them very long, acute and dagger-like; process below distinctly furcate, with hair-tufts on both furca. The maxillæ very large; the apex bears an elegant large brush of dense and long hairs and near the outer margin a very strong spine. Surface between the longitudinal suture and the inner margin covered with a coating of dense but short hairs; no particular fringe of long hairs along the inner margin; the palpus short. Mentum provided with a very large median tooth and very few (about six) but great lateral teeth. Colour of the larva milky-white; head and thorax of almost the same colour as the abdomen; sipho in the broad part yellowish, in the attenuated part almost black; most of the hairs of a golden colour.

Pupa: Thoracic mass subpyriform, rather large, indented behind the insertion of antennæ. Abdomen serrate, the segments largely expanded posteriorly; anal paddles oblong, cleaved at apex; the whole pupa quite hairless. No hairs on the cephalothorax; no fan-shaped dorsal tufts on first segment; no subdorsal hairs at the ends of the abdominal segment and no tufts on the angles. The most peculiar point in the structure of the pupa is the two airtubes; these are not as in other mosquito pupæ trumpet-shaped, but end in a long, sharp, thorn-like process of a very peculiar shape and structure. The tracheæ runs through the whole tube, ending at the apex in a minute, almost invisible aperture. The tube itself has in the different parts a very remarkable, highly specialised structure; in the part nearest to the cephalothorax the structure resembles that of a trachea, being striped transversely; where the tube attenuates, the transversal stripes cease and are succeeded by a more homogeneous structure with a very fine irregular rhomboidal stripening, resembling that of a common pupa tube. A little before the spot where the tube attenuates, passing into the accuminated part, there is a weak point, where the chitin is thin and where the apical part breaks off very easily. At the same spot a chitinous ring runs round the tube, on the inner side leaving a cleft open. Outside this ring the tube acuminates; the inner half has almost the same structure as that on the other side of the ring, but the outer part is formed quite differently. It has a broad fringe of long hairy excrescences and the utmost part, which is commonly corkscrew-shaped, and lying in another plane, has a hyaline transversally striped membrane on each side, which has inconspicuous saw-teeth along the edges. It is this extreme part which must be used as a piercing organ. The tracheal tube, which runs from the apical opening to the above-named chitinous ring, has a rather narrow lumen, being only one-third broader than the tube in this part; immediately behind the ring it expands to almost the whole width of the tube, but tapers again and now runs as a narrow tube through the whole air-tube.



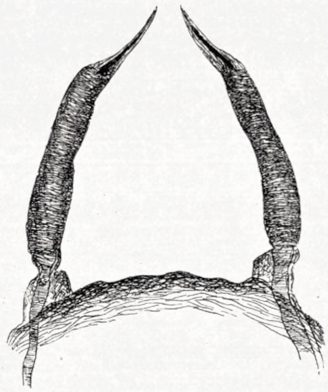
Textfig. 14. *Tæniorhynchus* pupa, frontally.

The tubes, which in the case of all other mosquito pupæ are directed outward and divergent, are convergent in the *Tæniorhynchus* pupæ (Fig. 16); the acuminated parts are laid against each other when pierced into the stem; it looks as if the two tubes only made one single hole when piercing; perhaps it is not quite improbable that the two acuminating parts act along each other when piercing and in this way saw a hole in the plant-tissue. At first I had the impression, that each tube is hollow only on its inner side, the two half pipes forming a common conduit when laid against each other; without section it is difficult to decide this question, but I suppose that the description, first given, is correct.



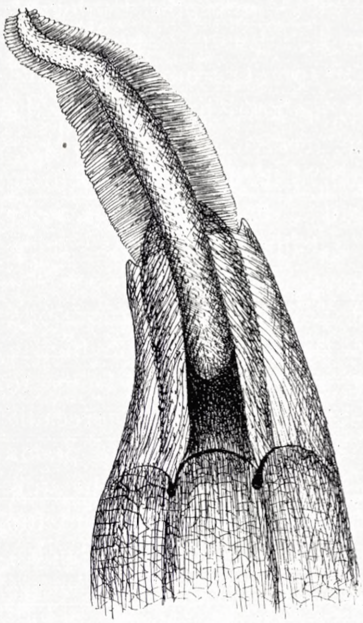
Textfig. 15. *Tæniorhynchus*-pupa, laterally.

S y s t e m a t i c a l a n d f a u n i s t i c r e m a r k s. As my specimens have not pale rings in the middle of the metatarsi, these being quite black, it is only with great hesitation that I refer my specimens to this species. As however I have never seen the male, I suppose that provisionally we had better refer them to the old well-known species.



Textfig. 16. *Tæniorhynchus* pupa. Cephalothorax with the two trumpets.

On an excursion in September 1914, to one of the little ponds near Donse in the north-eastern part of Seeland, a locality well known to botanists and zoologists, I was sitting in my boat near a sunlit, prominent point of the shore. Some plants were laid upon a tray, half filled with water. While searching for larvæ of *Coleoptera* my attention was now and again attracted by some large mosquito larvæ which crept over the bottom in a serpent-like manner, when the tray was shaken. It struck me that it was really a peculiar season to find fullgrown *Culex*-larvæ. I caught one of them and placed it in a high cylinder-jar. To my astonishment I saw that the animal was undoubtedly heavier than the water and that it sank slowly downwards and settled itself horizontally on the bottom. Moreover I saw that the animal did not at all swim like a common *Culex*-larva, but always swam horizontally; it was extremely sluggish and had a milky-white colour, very different from the brown colour characteristic of most of our Danish *Culex*-larvæ. I observed that the sipho was of a peculiar structure, but on using a lens with high power I immediately understood that I had made one of the most remarkable discoveries made in our freshwaters for a long time past.



Textfig. 17. *Tæniorhynchus* pupa. Apex of one of the trumpets; highly magnified.

Some weeks before, I had received a separate copy from Dyar and Knab (Entom. News 1910 p. 259) relating to a peculiar mosquito larva, *Mansonia perturbans*; the paper was cited in my work on Aquatic Insects (1915), then just in press. The larva is recognizable at a first glance on account of its very characteristic sipho which has been converted into a piercing organ by means of which the animal perforates living plant-tissues; the air in the air-spaces is used for respiration. The mode of life of the larva is therefore quite different from that of the other mosquito larvæ; it does not swim, but must really be regarded almost as a sedentary animal, sitting with the sipho bored into the plant-tissue, near the bottom, often at a depth of one-third of a meter (Textfigs. 12, Tab. 16 fig. 10).

In fact, the respiration takes place in quite the same manner as in the case of the *Donaciin* larvæ, the life of which has been so admirably studied by my friend Dr. AD. BØVING in almost the very same locality where the *Tæniorhynchus* larva was found.

Till 1914 the *Mansonia*-larvæ have only been found in America, and as I knew that the genus *Tæniorhynchus* (= *Mansonia*) has an almost entirely tropical distribution, it will be understood I could not have been more astonished even if I had drawn forth a representative of the Dipnoi from the mud of the Donse pond.

In the autumn of 1914 I made many excursions to Donse, and I found many larvæ. Frequently I had 30—40 larvæ in my aquaria, where I had ample opportunity of seeing the larvæ creeping between the roots and piercing their tubes into the plant-tissues. In one of the last pages of my paper on the Aquatic Insects I gave a microphoto of the larva fixed to a root, and some drawings of the tracheal system and the sipho.

The larva was rare; the greatest number I was able to procure after searching for 4—5 hours was 10—15. Strangely enough I could never find it in any other locality than where I had found it the first time. The vegetation was composed of *Acorus*, *Ranunculus lingua*, *Glyceria spectabilis* and *Typha angustifolia*. I have no impression that the larva preferred any of these plants to the others; if so it would probably be *Acorus*. In the aquaria the larva fastened itself to the most different plants and often sat for a fortnight or more fastened to the same spot. It was always restricted to very shallow water. I never found it deeper than $^1/_3$ meter. The best method to get the larvæ is to loosen the roots of the plants from the bottom and then to shake them in high cylinder jars. When the material has sunk to the bottom the larvæ will be found creeping slowly over the decaying material. More than once on examining the plants I saw the animals fixed in their normal position, trying to detach themselves when the plant was brought onboard. I have never found more than two or three on one plant. Altogether I have probably caught about 100 larvæ.

It was my intention to keep the larvæ during the winter in my laboratory, but in February they all died, probably because I had kept them at too high a temperature. As soon as the ice on the pond had melted I went again to Donse to procure fresh material. Behold, another great astonishment, though not so agreeable as when I found the larvæ. An enterprising man had bought the water in the ponds with the intention of establishing an electricity works at the little brook. The stillborn project supplied the country with electrical light for some months, and the water of the pond disappeared. Next year it was almost wholly dried up; not a single larva was to be found, the water having receded far beyond the zone where they lived. On summer evenings I lay in the grass, hoping that some mosquito, new to our fauna, would come and suck my blood. All was in vain. Neither in 1915 nor in 1916 did the water reach the zone where the larvæ were found in 1914. As long as the imago was not found, I did not like to publish my observations.

After many excursions in 1915—16 always without result, finally, in 1917, I had the good fortune to catch the imago. On an early day in July I was sitting some 100 yards from the pond where I first got the larva. After a heavy rain the mosquitoes stung vigorously. *O. communis* and *cantans* swarmed around me; then there arrived three specimens of a dark-coloured mosquito which immediately attracted my attention. I could not get more than the three specimens; but when these were more thoroughly examined later on, it was established that I had found the *Tæniorhynchus* for which I had waited patiently for three long years. The next day I had to leave for my new laboratory at Tjustrup, and when I returned, I found no more specimens. Still the animal could now be identified and the observations be published.

According to Giles (1900), Blanchard (1905) and Howard, Dyar and Knab (1912—17), the home of the genus *Tæniorhynchus* is almost entirely restricted to the tropical or subtropical countries. The main localities are Brazil, West-Africa, the neighbourhood of the great African lakes, India, China and West-Australia. According to Howard, Dyar and Knab North America possesses only two species *T. ochropus* Dyar and Knab and *T. perturbans* (Walker) Dyar. In about 1900 European dipterologists show that the genus also occurs in Europe, and that a single species lives far beyond the normal area of distribution. In 1896 Ficalbi describes a mosquito from Italy under the name of *Culex Richardii.* Theobald (1901 p. 194) refers the species to the genus *Tæniorhynchus* and remarks: "Ficalbi's *T. Richardii* comes in this genus in spite of the male ungues differing from those of Arribálzaga's species" (1901 p. 190). According to Theobald (1901 p. 197) a single specimen of this species was found in England near Sutton by Bradley and, probably, the species also occurs at Toronto (Canada); finally in 1903 (p. 269) Theobald states that the species "seems to be common in some parts of the Norfolk Broads, England."

Later on Edwards (1912 p. 261) has recorded the species from different parts of England, and Lang (1920 p. 99) mentions many other localities. Also Eckstein (1920 p. 232) has found the species "in den Wäldern bei Brumath (Unterelsass)"; Martini (1915 p. 605) at Danzig and Hamburg; most probably the species is more common than hitherto supposed. Just before this paper was going into print Prof. G. W. Müller, Greifswalde, wrote to me that he had found a peculiar pupa in that place the previous summer and sent me two drawings of the trumpets. The drawings prove that he has undoubtedly found a *Tæniorhynchus*-pupa and that he has interpreted the structure of the trumpets in the same way as I have. In 1919, simultaneously with my own paper relating to the *Tæniorhynchus* larva Edwards published a valuable paper on the same subject (1919 p. 83). In all main points we agree well. Edwards has seen the larvæ "when disturbed rise to the surface of the water and hang suspended there in the manner of an ordinary mosquito larva." I do not think that they ever do so in nature, but in 1919 and 1920 I have often seen the larva in my aquaria in this position when the roots were bad. As far as I can see we agree with regard to the morphology of the air-tube, the mode of affixion, and the large airsacks in the thorax.

With regard to the peculiar *Tæniorhynchus* pupa this is mainly known from American authors I. B. Smith (1908 p. 22) and Grossbeck (1908 p. 473), further Howard, Dyar and Knab (1917 p. 519) have especially studied that of *T. titillans,* Theobald (1903 p. 270) has figured that of *T. uniformis.* The pupa of the European species has not hitherto been thoroughly studied.

Additional biological remarks. With regard to the biology and anatomy I refer to my above-named paper; some new observations may now be added and compared with others derived from authors from last year.

In June 1918 my assistant mag. sci. L. Pedersen found the larva of *Tæniorhynchus Richardi* in a sheltered little creek in Funkedam near Hillerød. The locality was often visited, but also here the larva was rare, and I did not venture to disturb it too often. A more thorough examination was made on an area only a few square yards large. This spot was covered with submerged plants of *Sparganium* and *Scirpus*; the bottom round this was covered with *Fontinalis* and a few *Potamogeton natans.* Among the *Sparganium* I could get about twenty larvæ in one single catch, outside it only one or two. Taking the plants out with my hand I more than once got plants, on the roots of which I found the larvæ fastened. These plants were always *Sparganium.* Most of the larvæ were fullgrown, but curiously enough I got four minute larvæ, of not more than three to four mm. With the new living material in my laboratory I mainly tried to study the pupa and its life conditions.

In accordance with the above-given description of the pupa it may now be maintained that the most characteristic features in the anatomy of the hitherto known *Tæniorhynchus*-pupæ are that the trumpets do not diverge but converge, and that the trumpets are provided with a long, strong chitinized hook for insertion into the roots of the water plants. The two hooks meet each other, so that the two trumpets form a half-circle over the cephalothorax. Another remarkable structure is that the stellate hair tufts on the hinder part of the first abdominal segment are wanting. The paddles are cleft at apex.

From the structure of the trumpets we must suppose that the pupæ like the larvæ are fastened to the plants and for their respiration use the air in the intercellular spaces. As far as I know, no one has hitherto seen the pupa sitting with the trumpets pierced into the plant tissues. Further if it is right that the pupa, too, is attached to plants, the question arises how it is possible that the pupa can pierce the siphoes into the tissues. Finally we do not know if the pupa, when the last metamorphosis is going to take place, really leaves the plant and, like other mosquito pupæ, metamorphoses on the surface or finishes its metamorphosis fastened to the plant roots.

For two consecutive years (June, 1918 and 1919) I had about twenty fullgrown larvæ of *T. Richardi* in my aquaria; during both years five or six specimens metamorphosed into pupæ. I very often tried to observe the moment when the ecdysis took place, but I was always too late. Every time I found the fresh yellow pupa fastened to a root, and with the two siphos pierced into the plant. At all events it was now established as a fact that the pupæ like the larvæ are really fastened to the plants using the air in the plants for respiratory purposes.

I only wish to call attention to the almost incredible power of adaptation which the *Tæniorhynchus*-species presents. Like other mosquitoes they have the respiratory system formed in quite different ways as larvæ and as pupæ; as larva the tracheae open in an unpaired organ, the sipho, on the eighth segment; as pupæ in paired siphones "trumpets" on the forepart of the body, on the cephalothorax. If then the species in its two different stages as larva and pupa is to be adapted to use a special source for air-supply, it is able to modify, not only the unpaired sipho of the larva, but also the paired one of the pupa. One would be inclined to suppose that the problem of making a piercing organ out of two divergent, loosely attached appendices which, when used, were to act according to the new claims as an unpaired organ, would have been almost insoluble even to Nature. And still this problem has been solved and in the most elegant manner only by making the two siphones convergent and by laying the acuminating points against each other. I only regret very much that I have not been able to see how it is possible for the pupa to pierce the trumpets into the plant. From our knowledge of the structure of the pupa-body and the different mode of locomotion it possesses I am unable to understand how it is possible for the pupa to get the necessary support, which must be the condition sine qua non, if the pupa is to be able to pierce the trumpets into the roots of the waterplants. Any one who will try to force a needle into a root to which a *Tæniorhynchus*-pupa is fastened, will find that this demands no inconsiderable force. I have thought that the pupa might perhaps get some support in the larva skin, this being thrown off after the piercing process of the trumpets has been finished. But I do not possess any basis for this supposition.

When I touched the pupa with a needle, it struck out eagerly with the abdomen; I could take the whole plant out of water, the pupa was quite unable to loosen its hold. The first year all the pupæ died, attacked by *Mucoraceæ*; the next year three imagines were hatched, but sad to say, the ecdysis took place at a time when I was at my summer laboratory; as however I found the pupa-cases floating on the surface and the hooks of the siphos broken off, there can be no doubt that the pupæ, when the ecdysis is going to take place throw themselves away from the plants by means of the abdomen and rise to the surface. This is also in accordance with some observations made by Edwards just published (1919 p. 83). Although he has not found a living pupa, he is able to record that several specimens of *T. Richardi* were hatched in a pail which he had brought home full of pond water and sods of grass. "The empty pupul skins were found floating on the surface for the emergence of the adult. An examination of these skins showed that in every case the terminal portions of the breathing-tubes were missing; hence it must be inferred that they had been left behind in the roots." I can add that this supposition of Dr. Edwards is quite right; in every case I found pierced into the roots the pointed terminal portions of the breathing tubes; in the tubes there is a conspicuous predestinated zone of weakness, where the tubes break off; then the pupæ rise to the surface. Most likely their barbed structure, while facilitating their insertion, would prevent their being withdrawn. (Se also Edwards 1919 p. 83). It is only difficult to understand how without hairs the pupæ are able to be sufficiently supported by the surface film during the metamorphosis.

It is of some interest to remember that the *Tæniorhynchus* larvæ are probably not the only mosquito larvæ which make use of the air in the intercellular spaces of the plants. According to Howard, Dyar and Knab (1917 p. 894), the larvæ of the genus *Aëdeomyia* (*A. squamipennis* and *catasticta*) are to be found in shallow ponds covered with the water plant *Pistia* "from which they probably derive their supply of air although their habits have not been exactly determined". They do not come to the surface, but hide between the water plants. The sipho presents no peculiar structure, being shaped as the sipho of a common mosquito larva; only the tracheæ of the tube are said to be rudimentary. On the other hand, the antennæ have a very peculiar appearance in comparison with those of the other mosquito larvæ, being strongly curved, inflated. hollow, with a stout spinose digit on the tip. Howard, Dyar and Knab (1917 p. 898) suppose that these inflated antennæ may play some part in the respiratory process.

In 1916 Dette has made the supposition probable that a Tipulid-larva, *Trichosticta flavescens*, too, makes use of the air in the intercellular spaces of the plants.

How the peculiar method of respiration, especially with regard to the *Tæniorhynchus*-larva, has arisen it is difficult to understand. Further studies will probably acquaint us with larvæ in which the modus of respiration as well as the shape of the sipho represent the missing link.

For a long time I thought that we should have to study the tropics if we wanted to solve these questions, and that it would be almost unreasonable to expect that it would be possible to find the solution of the problem in a little pond in North Seeland, far away from the centre of the geographical distribution of the genus. Later observations from this last winter have somewhat altered my opinion upon that point.

In my aquaria I had some *Myriophyllum*, which were growing well. In the same aquaria there were a great many *C. morsitans* larvæ. One day in January I removed one of the aquaria into the bright sunshine and now observed the well-known fact that vertical series of air-bubbles from different spots of the plants rose to the surface. The numerous *C. morsitans* larvæ now fixed themselves to the plants. The position was always the same; the two strong curved setæ on the flaps of the sipho were pierced into the plant-tissue and the apex of the open air-tube was pressed against its cutis. The larvæ were hanging down from the plant, quite as a *Tæniorhynchus* larva. For more than twelve hours they did not rise to the surface and when brought into darkness and cold they hung down from the plants for weeks. The biological difference between the *C. morsitans* larva and the *Tæniorhynchus* larva is in one respect but slight, in another really very large. The *C. morsitans* larva sits with the hooks on the flaps pierced into the cutis of the plant and the apex of the sipho pressed against it; it is only a fraction of a millim. distant from the air-supply of the plant, but most probably it is never able to use it; still it is a question, whether it cannot make use of the air-bubbles which rise from the stem of the water plants in sunshine, from holes which may be pierced by the hooks for the sake of attachment, into the plants. The *Tæniorhynchus* larva sits with the flaps of the sipho which have been modified into a piercing organ and with the apex of the sipho directly pierced into the air spaces of the plant and is able to use this air for respiration. Still it is a question how much the *Tæniorhynchus* larvæ actually use of this air-supply in the water plants; for respiratory purposes it is, especially in winter, of a very bad quality. (Ege 1915 p. 183); perhaps this air is not their daily food at all, but is only used on certain more solemn occasions (f. i. during the ecdysis process) as the cutaneous respiration is of the greatest significance also for these larvæ. If so the difference in the mode of respiration between a *Tæniorhynchus* larva and a *C. morsitans* larva is not either by any means as great as should be expected at the first glance, the *Tæniorhynchus* larva being also mainly restricted to cutaneous respiration during winter. After this has been written it was of great interest to me to see that Lang (1920 p. 103) has had quite similar thoughts. With regard to the larva of *C. morsitans* he writes: "Evidently they shun the surface and may well be on the way to developping similar habits to *Tæniorhynchus*. Mr. Edwards suggests, that it is even possible that that genus may have been derived from *Culicella*." It has always been maintained that the sipho of the *Tæniorhynchus* larva lacks a pecten. In this connection I wish to direct attention to the possibility that the saw teeth in the *Tæniorhynchus* tube may really be the modified pecten. This supposition is weakened by the fact that the pecten in a normal larva sipho is situated on the opposite side to where it is situated in a *Tæniorhynchus* tube.

The life-cyclus of the species is probably as follows: The female deposits its hitherto almost unknown eggs in the course of the summer. In autumn the eggs are hatched. In September we mainly find very tiny larvæ on the roots. Before winter most of the larvæ are fullgrown and in this stage they winter. The pupation takes place in the latter part of May. Whether the imago winters we do not know but it is not probable that it should do so. How to explain the very small larvæ in spring I do not know; that the larvæ should be biennial would be quite exceptional. I am more inclined to think that the difficult life conditions render it necessary that not all eggs are hatched in autumn or rather, that not all larvæ are fastened under good conditions in autumn, so that the development is delayed and only part of them pass the last ecdysis before winter.

Geographical distribution: The species is described from Italy (FICALBI) later on found by EDWARDS in England, in Germany by MARTINI (1915 p. 585) and by G. W. MÜLLER.

The eggs of *Tæniorhynchus* have been described by different authors (see DYAR and KNAB 1910 p. 259). Further they have been thoroughly described by the said authors in a special paper (1916 p. 61). The following remarks are taken from that paper. The eggs of the three American species, *Mansonia fasciolatus*, Arrib. *arribálzagæ*, Theob., and *perturbans* Walk. do not differ very much in shape, arrangement, and manner of disposal from eggs of typical *Culex* species. The egg-boats float upon the surface of the water, one end usually resting against an aquatic plant; still there is some difference in the arrangement of the eggs of the three species. The eggs of *M. titillans* found by MOORE, are of quite another type; they are placed on the under-surface of the leaves of *Pistia* and deposited in a mass, generally between the ribs of the leaves. They are attached to the leaves with their bases very closely crowded together and apparently kept by a cement secreted by the female. The number of eggs in a cluster exceeds 150. MOORE has observed directly that at least the abdomen was submerged when ovipositing. "The lower half of her abdomen was submerged and bent or curved back, the segment somewhat extended, and was being moved slowly from side to side; the eggs seeming to issue forth in rapid succession and to be as rapidly set up each in its place ...... air bubbles were entangled in the abdominal scales and on the leaf itself. According as the cluster enlarged in her direction she drew her abdomen more and more up so that when she finished at 6,35 not much more than the tip of it was curved under the leaf. When she first started more than half of her abdomen would have been under the water. The freshly laid cluster was white". DYAR and KNAB call attention to the fact that the abdomen of the female of *M. titillans* is unusually hairy, the hairs being well distributed and coarse. This is no doubt an adaptation, that by entangling air between the hairs prevents the body itself from becoming wet while immersed. MOORE supposes that the female, when at work on *Pistia*, really works in a globule of air, for, owing to the dense pilosity of the leaf, the under surface is simply aglow with air-bubbles, so that the leaf probably rests more on air than on water. The egg-shell of this species presents no special structure; it resembles that of most other *Culicidæ*.

In the same paper DYAR and KNAB describe another egg also forwarded to them by MOORE. The egg is furnished with a small neck from the upper edge of which four pairs of horns project upon very short stalks; these horns appear to consist of solid chitin and taper into a sharp point. Later on, MOORE found the species which laid these eggs; it was described as a new species, *M. humeralis* Dyar and Knab. These eggs are of interest because they resemble the eggs of *Nepa* and *Ranatra*; as well known, these water-bugs pierce their eggs into half decaying plant material, and the crown of spines round the tip of the eggs is commonly regarded as a respiratory organ. DYAR and KNAB also regarded the spines of the egg of *Mansonia* as in some way connected with the problem of air-supply.

The eggs of *T. Richardii* are unknown; most probably they are laid in the manner of the genus *Culex* in eggboats. ECKSTEIN (1919 p. 288) writes; "Es ist mir gelungen *T. Richardii* aus den Eiern zu züchten", giving no description of the eggs; he refers to a future paper.

Genus V. *Theobaldia.*

Tab. XVII.

1. **Theobaldia annulata** (Schrank).

Imago. This mosquito is recognizable at a first glance from all other Danish Culicinæ by its spotted wings, a characteristic it shares with *T. glaphyropterus* which has not hitherto been found in this country. It is the largest of all our mosquitoes; its large size, its spotted wings, the white banded legs make it one of our most conspicuous and also one of our most beautiful species.

Larva. Head rounded, rather small, wider than long, a notch at insertion of antennæ, front margin arcuate. Antennæ very short rather thick, tapering at front spinose, tuft small, only consisting of about five to seven hairs, inserted directly without notch on the antennæ and below middle. Near the apex two hairs, on the apex itself three hairs and a digit. Anteantennal tuft multiple; lower frontal tuft with six hairs, upper with one very long, and two shorter ones. Eyes large; a remarkably well developed tuft in the notch between the eyes and antenna; a characteristic coloration of the head integument (see fig. 1).

Thorax subquadratic, angled at hair-tufts. Hair formula of frontal border 341144441143; I have also found 341145541143; the median tuft consist of one long and three or four very short hairs; the next tuft of four hairs always short. Lateral hairs in multiple tufts and some single strong hairs.

Abdominal segments broad, the first of them much shorter than the last. Lateral hairs on the first segment multiple, on the third triple, on the third to sixth double; subdorsal hairs on third to sixth segment double; between them and the lateral hairs a single hair; the eighth segment with tufts in common arrangement, the upper double; lateral comb consisting of about forty scales arranged in rows, occupying a triangular area; the scales are long, spatulated with a feathered base without median thorn. Sipho rather short, straight, slightly tapering at apex. A short pecten consisting of about ten, short, feeble thorns, without any or with very indistinct teeth at base; then a series of about twenty long, soft, flexible hairs.

No tuft of hairs between apex and end of pecten, but a large tuft at the basis of the pecten. Anal segment broader than long, ringed by a plate. Dorsal tuft consisting of a rather compact tuft of rather long, soft hairs, two very long stiff hairs and some others much softer and almost equally long. Ventral brush large, consisting of about 17 rays; on the barred area every ray carrying from 14 to 16 hairs; before the barred area five short tufts; a lateral tuft with three short hairs. Anal gills moderate, equal, acute.

Lateral tufts of labrum short, dense; the inner part consisting of comb-hairs, arranged as a crown around the palatum, covered with soft hairs. Mouth-parts highly remarkable. Mandibles quadrangular with three strong spines before the collar; a row of remarkably short cilia from a collar; a row of very strong spines from margin; most of these spines dentated, furnished with strong thorns. Dentition: a broad dark plate formed as the forelimb of a talpa with six almost equal teeth; a series of bristles below; process below distinctly furcate with strong hair-tufts on both tips; a group of hairs at base. Maxillæ broader than long, almost without suture; no apex and no tuft of long hairs upon it; fore and inner margin furnished with a coarse covering of very short, soft hairs; a few hairs near the palpe; a short bristle on the foremargin. The palpe well-developed with a few digits. Mentum triangular, borders almost straight; median tooth small, about twenty equal teeth on each side. Colour commonly greyish.

The larva has been described and figured by Meinert (1886 p. 376). Owing to his description of the sipho and pecten I must suppose that he really has seen the larva, but with regard to the description as well as the figures, especially relating to the bristles of the head and anal segment, there are such great differences between his and my statements, that I have often supposed that he has unfortunately used a larva of another species to describe these details. Of the frontal tufts, the lower so characteristic with its one long and two short hairs, is, according to his description, the most feebly developed with three bristles; the habitus figure has only one single very long bristle, and the more specialized figure (2) has a very short tuft with three hairs, one of which is really longer than the others; the arrangement of the tufts differs greatly in the habitus figures from the more detailed figure (Fig. 2). On the mandibles (Fig. 7—8) he has correctly indicated that the spines of the inner border are dentated, and the figure of the characteristic broad maxilla (Fig. 6) is correct. He has further seen that the species has comb-hairs in the flabellæ. On the other hand the dorsal brush of the anal segment is quite different from what I have found; the two long bristles are wanting, and the division in two parts is only problematically indicated in the figure.

Schneider (1914 p. 44) has a more correct figure of the two last segments (Fig. 4). With Eckstein's statement (1919 p. 290) that the pecten consists of "7 mehrzähnigen Dornen" I do not agree well.

Biology. The biology of *T. annulata* is rather remarkable. If in winter we examine the deep frostless cellars of our houses, we find among the numerous *C. pipiens* a few much larger ones, highly characteristic because of their spotted wings and white ringed tarsi. This is *T. annulata*, the largest of all our mosquitoes. I have never found it in great numbers; yet it is by no means rare.

In December 1918 I took twenty imagines and placed them in a little shed, where the temperature in the nights often fell below zero; most of them died but some hibernated.

Hitherto we have taken it for granted that the mosquito only hibernates in houses, cellars and sheds; but this is undoubtedly not correct. In 1916 on one of the last days in April, I was examining an old hollow beech and to my astonishment saw that many *T. annulata* were sitting in the bright sunshine on the wind-sheltered part of the trunk. I prodded the hollow part of the trunk with a walking stick and the mosquitoes rushed out of the trunk like smoke; all were females, which undoubtedly had their winter-quarters there. When I passed the same old beech late in Oktober 1919, I again saw many imagines of the same species but now males as well as females, sitting and flying round the entrance to the hollow part of the trunk; no doubt they were seeking their winter quarters there. I lost the opportunity to see the egg-rafts and the egglaying processes, but in July—August I found the large greyish larvæ among the swarms of *C. pipiens* larvæ; they were hatched in Cement-reservoirs in dairy-farms and in cow-houses in farm yards; the number is always rather small, perhaps about one *T. annulata* to a hundred *C. pipiens*. They are found as larvæ and pupæ much later than *C. pipiens* (till 20/x 1918). This is in accordance with the fact that the imagines fly remarkably late; and that I have often found the imagines sitting out of doors the last days of October, behind shutters, below veranda-staircases etc. I suppose that the imagines pair before winter and then die out; in spring I have never seen a single male. The development by no means always takes place in our houses; I have found them together with larvæ of *C. pipiens*, in ditches mainly consisting of urine near gates sheltered by old oaks below which the cattle regularly sought shade against the burning sun. But, apart from these unsavory localities, I have also found them in great numbers in a little pond covered with *Lemna* but with very decaying mud in the bottom. This pond has been under regular observation for three years, 1918—20, but *T. annulata* was only to be found in 1918.

The pond was visited for *O. cantans* from April to June in 1918 and during that time I did not get a single *T. annulata*. When I visited the pond 10/VII to search for the rare larva of *Rana agilis* living in the same pond, I was rather astonished to see that the pond now contained a great many grey, halfgrown larvæ, which later on gave *T. annulata*. The larvæ were not hatched before the middle of August. I always found small and large larvæ among each other, and I got the impression that the egg-laying took place at all events in September; curiously enough I could never find the egg-rafts. Also in ponds near Hillerød have I found *T. annulata* larvæ in September—October; one of them had clear brown peaty-water; they lived here till 12/x, when the pupæ appeared, giving imagines in my laboratory on 17/x.

From these observations we are able to ascertain that *T. annulata* is hatched in the cement-reservoirs indoors, as well as in ponds in Nature itself. I am inclined to interpret the above-named facts in the following way. In our country *T. annulata* has two generations. The hibernating generation appears in September—October, hibernates in our houses, and lays its eggs indoors in stables etc.; from these eggs appear the summer generation, which disappears from our dwellings and lays its eggs mainly in natural ponds; most probably this generation has several broods, the egg-rafts being not all laid simultaneously, the males die off after the mating process but the females from all these broods return to our cellars and hibernate there.

The biology has never been more thoroughly studied. All authors agree with regard to the remarkably high susceptibility to domestication, breeding places in Nature not being found hitherto. THEOBALD (1901 p. 335) states that both ♂ and ♀ hibernate but this has never been ascertained. I have observed this species in many localities of hibernation but I have never seen a single male in winter or early spring. With regard to the nourishment I refer to the following chapter.

Geographical distribution: According to THEOBALD (1901 p. 334) it is common throughout Europe, from Scandinavia to Italy; it also occurs in India, at 5000 feet above sea level. OSTEN-SACKEN states that it is also said to occur in North America, but by HOWARD, DYAR and KNAB (1915 p. 496) the American species are regarded as another species (*Culiseta Dugesi*).

Genus VI. *Culicella.*

1. **Culicella morsitans** (Theobald).

Tab. XVIII—XIX.

Description. Female. Proboscis long, uniform, pale near base, labellæ conically tapered almost black with some few bronzy yellow scales; palpi short; almost black, apex yellowish-white. Antennæ brown, joints subequal, rugose, pilose, second joint slightly enlarged, hairs of whorls rather long, spinose; tori subspherical, bright ferrugineous. Occiput dark brown covered with yellowish-white scales denser towards the sides; margins of eyes white scaled; many slender erect forked black scales; setæ along margin of eyes curved, black.

Prothoracic lobes elliptical, remote dorsally with narrow yellow scales and many black setæ; mesonotum brown, with a median and two shorter curved lateral, rather indistinct and varying lines of bright bronzy-brown or creamy scales, which are also found on the sides of the mesonotum. Scutellum trilobate, brown, clothed with narrow curved shining yellow scales: each lobe with a large group of brown bristles; postnotum pale, clear chestnut brown pruinose, nude; pleuræ brown, covered with spots of creamy almost snow-white scales.

Abdomen subcylindrical, depressed, truncate at tip; dusky brown, covered with fuscuous scales and with basal creamy yellow bands; their posterior borders edged with pale hairs; venter covered with pale yellow scales.

Legs long, slender, dark, almost black; coxæ, bases and ventral surfaces of the femora more pallid; knee spots snow-white, tibiæ black, apices of the tibiæ yellow, base of all tarsal joints narrowly banded, all the bands are very narrow, broadest on the hind tarsi. Ungues of all legs equal and simple. Claw formula 0.0—0.0—0.0. Length of body 6.5—7.5 mm.

Wings unspotted, with veins covered with long, thin, black, lateral scales and a dark fringe; both fork cells long and about the same width; second marginal cell a little longer than the second posterior cell; base of the second posterior perhaps a little nearer the base of the wing than that of the second marginal cell; petiole of the second posterior about as long as that of the former cell; basal cross-vein about the same length as the anterior cross-vein, but not its own length distant from it. Halteres with a pale stem and fuscous knob.

Male. Proboscis straight, uniform, brown, almost black at apex. Palpi longer than proboscis. First joint of palpi in the first basal third part white; then a small black stripe; again a white stripe and lastly black at apex; second joint white at base, otherwise black; third joint white at base and black at apex, slightly spatulate and truncated, the two last joints with black hairs. Antennæ plumose, banded black and white; hairs long, dense black. Occiput black with a hairless line down the centre; clothed with pale creamy curved scales on each side; flat creamy white ones at the sides, but commonly with no brownish lines between these and the curved ones, long brown upright forked ones, dotted about and golden hairs projecting forward.

Mesonotum chestnut brown, with three rather distinct lines of yellowish golden scales as long as the thorax and two other more distinct bright yellowish, only half as long as the former ones, bordered by black scales; long black hairs scattered over the whole thorax and over the roots of the wings; scutellum brown, trilobate, with tufts of long black hairs at the border.

Abdomen blackish brown, covered with brown scales, each segment, except the first, with a basal band of creamy-white scales, broader on the last segment; posterior borders of the segments with long golden hairs and the sides with long brown hairs.

Legs with the coxæ brown; femora at the base and beneath grey, at the upper side dark brown; knee spots white; tibiæ dark, covered with dusky brown scales, apex bright yellow. All the basal joints with creamy white apices, but without white bands at base; hind metatarsus about two thirds the length of the tibia; metatarsus of the front legs distinctly longer than the remaining four joints together; ungues of fore and midlegs unequal; the larger one with two, the smaller with one tooth; hind ones of moderate size equal and simple. Claw formula 2.1—2.1—0.0. Length 7.5—8 mm.

Wings long; the veins clothed with yellowish-brown scales, the lateral scales mostly long; second marginal cell narrower; but about the same length as the second posterior cell; its stem only three-fourths of the cell; its base a little nearer the apex of the wing than the base of the second posterior cell; petiole of the latter as long as the cell and almost as long as the stem of the second marginal cell; the basal cross-vein about its own length distant from the anterior cross-vein; fringe brown with pale reflexions along the inner border towards the base. Halteres ochraceous-brown with a slightly fuscuous knob, stem elongated and thin.

Larva: Head subquadratic, almost twice as wide as long, a notch at insertion of antennæ; front margin almost straight, slightly arcuate. Antennæ very long, longer than head, elegantly curved, covered with spines, especially between antennal tuft and head; the part of the antenna between the head and tuft ivory coloured, the narrower part brown; tuft very large, inserted near the apex, consisting of more than twenty five very long feathered hairs; the terminal portion slender, carrying two long hairs before apex, on apex itself one long and one short hair; between them a short digit. Anteantennal tuft almost in line with the frontal hairs multiple; lower frontal tuft with four hairs, upper double; the points of insertion of the hair-tufts forming a curved line over the epistome. Eyes large.

Thorax subquadratic, angled at hair-tufts; hair formula of frontal border 231124421132. Lateral hairs in large multiple tufts some single, strong hairs.

Abdominal segments rather narrow, lateral hairs on first two segments multiple, single on third to seventh; subdorsal tufts double on third to seventh segment. Tufts of eighth segment in common arrangement, but all remarkably feebly developed. Lateral comb consisting of a great many, about a hundred scales, arranged in rows occupying a large triangular area; each scale with spatulated base and elegantly feathered broad tip. Sipho straight, extremely long, 6—7 times longer than broad; a tuft of five hairs at base; the pecten extremely short, consisting of only about six to eigth thorns, all broad obliquely feathered, no tuft of hairs between pecten and apex. Anal segment longer than wide; ringed by a dorsal plate; dorsal tuft in two parts, the upper part consisting of a tuft of many, rather short hairs, the lower of 6—8 hairs. unequal, two very long. Ventral brush in the barred area consisting of 12 rays, each carrying about twelve hairs; before the barred area about six detached hair-tufts. No lateral tufts. Anal gills long, acute, equal.

Lateral tufts of labrum very large, distinctly separated in two parts the inner part without any comb-bristles, palatum large, covered with short, soft hairs. — Mandibles quadrangular, with four strong spines before the collar; a row of long cilia from a collar; about 10 scales from margin, but no distinct spines: dentition: five teeth, two of them strong, before them a very long, arcuate thin thorn. Long cilia below the teeth; process below distinctly furcate, with strong hair-tufts on both tips; a group of hairs at base. Maxillæ elliptical, tips conically rounded; at apex a large brush of long, soft hairs. No spines at margin. Palpus well-developed with five little apical digits. Mentum high triangular, the median tooth large, with 10 or 11 teeth on each side.

Colour of the body brown or green, brushes on labrum golden.

Systematical remarks: From the description above it will be understood that there are same distinct differences between Theobald's species *C. morsitans* and the Danish specimens. The greatest variations are to be found in the white bands on the palpi of the male, in the banding of the legs, further there are some smaller differences with regard to the nervature of the wings. Otherwise there is full accordance between Theobald's description and the Danish specimens. Among all other Danish mosquito larvæ the larva of *C. morsitans* is distinguishable at the first glance owing to the antennæ, the sipho and the structure of pecten and comb. It has already been described by MEIJERE (1911 p. 138), EDWARDS (1912 p. 261) and later by SCHNEIDER (1914 p. 35) and ECKSTEIN (1919 p. 288); it is perhaps one of our most remarkable mosquito larvæ.

Most probably the species is widely spread over the whole of Europe but it is not very common in our country.

I have hatched many hundreds of this species in my laboratory, especially from larvæ which have hibernated in my aquaria, most of them there gave imagines in April; in nature they did not hatch before the latter part of May. Later on in the course of the summer I gathered several flying specimens. Between these specimens hatched in my laboratory in April—May and those gathered in summer, there were rather conspicuous differences. Those from April were smaller, only about 6.5 mm, of a more brown colour, and with the bright scales almost white; those from May and later were much larger, about 8 mm, almost as large as *C. annulatus* and much darker.

For a long time I thought that I had more than one species in the material. As according to MEIJERE himself (1911 p. 142) and EDWARDS (1912 p. 262) *C. fumipennis* Stephens is said to resemble *T. morsitans* very much, I particularly thought, that this species was concealed in the material. More especially some specimens found in August 1918 in an old house in the park at Dragsholm Castle differed very much from the true *C. morsitans* owing to their more yellowish colour. Unfortunately all these specimens were old; the hair-coating of the thorax was almost wanting, and that of the abdomen was inconspicuous; all the specimens were females. Mr. EDWARDS has been kind enough to look over my whole material, and maintains that all specimens may be referred to the single species *C. morsitans*. This view is strengthened by the fact that in the large larva material I have never been able to find more than one larva type. According to MEIJERE and EDWARDS the two species are easily distinguishable in the larva stage, *C. fumipennis* having five to six spines beyond the pecten. I have never found larvæ with siphones of this structure in Denmark. As the species however is found in Holland (MEIJERE) in Scotland (EDWARDS 1912 p. 262) England (LANG 1920 p. 104) and in Germany (ECKSTEIN 1919 p. 289) I suppose that further explorations will also reveal this species in our country. LANG (1920 p. 104) maintains that the two species are almost indistinguishable from each other as imagines. He maintains that it "would be of great interest to determine .... if these two species always bred true, and that they were not one species with a dimorphic larva".

Biology. *C. morsitans* has been studied regularly for more than three years in a great many ponds, more especially those of Stenholtsvang, the Strødam ponds, those of Grønholthegn; the Mochlonyx ponds, those of Store Dyrehave, of Gripsø, of Hestehave and of Suserup. To these many regular observations I can add many accidental ones, gathered on excursions often undertaken for quite different purposes. In almost all localities the life history of the mosquito is on the whole the same.

When the ponds in the time from about 15/IX to 15/X get the first insignificant volumina of stagnant water, the first *Culicin* larvæ which appear are those of *C. morsitans.* The quantity of water, in which the eggs are hatched, is often extremely small, only some few liters; the height of the water is so inconspicuous, that the larvæ are unable to swim, living the first days of their life as creeping animals, winding themselves over the diatom-covered withered, yellow grasses which cover the bottom of the ponds. As the water rises during the autumn, and the waterline reaches eggs lying above the first waterline, new eggs are hatched. If heavy showers fill the little water basin in the course of a few days, almost all the eggs are hatched simultaneously, and the larvæ are almost all of the same size during the growth. If the filling of the basin takes place slowly through a long time, egg portion after egg portion is seized by the water line and it then happens that newly hatched larvæ are found with fullgrown ones.

In the time from about 1/X to about 1/XII the larvæ grow up, pass the three ecdysis-stages and are commonly fullgrown before the ponds are covered with ice. During the whole autumn the *C. morsitans* larva is the most common of all our mosquito larvæ, and in most of the ponds it is the only one occurring at that time of the year.

It often happens, as in 1919, that a little rain in the beginning of October fills the water basins; in the course of a few days the *C. morsitans* larvæ are hatched. They grew up to the second ecdysis, then in November we got a period of frost, and the pond froze to the bottom; then the whole larva material died out; when the ponds were thawed again in the latter part of November, not a single larva could be found. Then when snow and rain in December had filled the water basin to the brim, new lots of eggs were hatched, and new larvæ appeared. As many of these mosquito ponds are extremely shallow, it often occurs that a good many freeze to the bottom; in this case all the *C. morsitans* larvæ died and when in early spring the basins were again filled with water and snow, other mosquito larvæ especially *O. communis* took the place of *C. morsitans.* Then we had an opportunity to observe the very peculiar phenomenon that these ponds, when freezing, are filled with thousands of *C. morsitans* larvæ; whereas, when again thawed up, they only contain those of *O. communis.* This was more especially the case in the winter of 1918 with almost all the ponds in North Seeland; in a mild winter f. i. in 1920, when the covering of ice was but slight and the ponds open in February, the wintering of larvæ is a much more common phenomenon. But whether the winter is severe or mild, it is a rule that in April—May we hardly ever find the larvæ of *C. morsitans* in the larva swarms of *O. communis*; undoubtedly very many of the *C. morsitans* larvæ die out during the winter; and this is, I suppose, the principal reason, why the imago is comparatively rare in our country and much rarer than the larva. But the peculiar circumstance that we hardly ever find the larvæ in the swarms of *O. communis*, though they are by no means rare in the ponds, is caused by the fact that the larvæ of *C. morsitans* conceal themselves between the decaying leaves and only rarely come to the surface. This is in accordance with observations made by Eckstein (1918 p. 533), and Lang (1920 p. 102). In my aquaria the imagines from larvæ taken into the laboratory in December, appeared already in the two first weeks of April; I therefore thought that this would also be the case in Nature. It therefore astonished me extremely to find that in the last days of the hatching period of *O. communis* black and much larger pupæ appeared from which later on *C. morsitans* were hatched. A more thorough study of my temperature observations this year and new observations next year showed, firstly, that these ponds were all filled with water during the winter and further, that the larva of *C. morsitans* in spring as in winter hardly ever came to the surface, but lived near the bottom or were hanging down from the plants. If this is a general rule, the life as larva of this species may be remarkably long, lasting from the last fortnight of September to the last half of May; in the five last months, as far as I know, that larva does not moult. That the pupæ in May really derive from hibernating larvæ and not from a new spring generation I regard as certain, the pond in April—May being under regular observation almost every week.

I therefore feel sure that *C. morsitans* in our latitudes has only one generation; laid as eggs in the summer months, living as larvæ from September to May, as pupæ only a few days, and then from June to autumn as imagines, the latter dying out before autumn.

As imago the mosquito, as stated above, is rather rare; this is the case at all events in North Seeland. I have taken it from June to the middle of August, but always only in small quantities; in July the mosquitoes where filled with eggs. I suppose that the egg-laying process took place in July—August; the eggs were laid upon wholly dry soil, the ponds where the larvæ appear in September all being dried up during the summer months. As a female in a vessel without water, but with the bottom covered by dried leaves, had laid her eggs singly or in small batches, I take it for granted that the females also in Nature throw their eggs singly or perhaps in small lots between dried leaves and withered grasses on the spots where they were hatched in spring, and which will again get water in autumn.

As the mosquito lives as larva at very different temperatures, from about 15—20° C. in May and September and near zero in winter, we have an excellent opportunity to study the different manner of life at different temperatures. As regards respiration there is a great difference between the behaviour of the larva in autumn and winter and in spring. Like most of our other mosquitoes *C. morsitans* is supported by the surface film in the autumn and like other Culicin-larvæ breathes atmospherical air. When winter comes as the temperatures falls, the larvæ disappear from the surface and fasten themselves to the water plants or to the sides of the aquaria. They are also to be found at the bottom of the water, lying on the dorsal side, supported by the apex of the sipho and the long hairs of the head. At temperatures near zero it can be observed that the larvæ, often for more than a fortnight, never alter their position; this is also the case if the surface of the aquaria is covered with a slight layer of ice. The larvæ never or only at rare intervals seek the surface; they only satisfy their respiratory claims by means of cutaneous respiration; the anal gills are spread out, and the large flabellæ maintain the water currents.

In these hibernating larvæ it is interesting to observe how the number of strokes with the flabellæ quite automatically increases or diminishes with the rising and falling temperatures. At a temperature of 3° C. all larvæ had the flabellæ drawn in; at a temperature of 5 to 6° C. the number of strokes per minute was 30, at temperatures between 14 and 20° C. the number of strokes increased to 114 and when the sunbeams fell directly upon the larvæ, to 136. As the water in winter is extremely clear and contains very little detritus or animalcules, the larvæ get extremely little food by means of the flabellæ. In the winter-larvæ we therefore also observe very few swallowing movements, easily observed under the binoculary aquarium microscope in autumn or spring. During the winter the flabellæ therefore serve mostly for respiratory purposes.

More than any other of our mosquito larvæ the larvæ of *C. morsitans* live upon suspended detritus and plancton; only rarely we see the larvæ brush off the plants from the bottom; the flabellæ are not suited for that, being quite destitute of comb-hairs. In autumn we find the large larvæ hanging down from the surface; the head is held almost horizontally; in large elegant curves the antennæ project from the head, and the large antennal tufts form beautiful wheels on both sides of the head; the large flabellæ are almost always in activity striking in summer 120 to 140 strokes a minute and offering an excellent opportunity to study the feeding processes and other phenomena connected with them. I refer the reader to pag. 16—19.

The larvæ are fastened to the substratum by means of two curved hooks on the flaps of the closing apparatus of the sipho; this is sufficient when the substratum consists of small twigs or leaves; on the sides of the aquaria the hooks do not yield the necessary hold, the manner of attachment is then commonly another. It may be observed that the larvæ often swim round with a little air-bubble at the apex of the sipho; when the larvæ arrive at the sides of the aquaria this bubble is drawn in, and they are then glued to the aquaria by means of the diminished space and the pressure of the air.

Undoubtedly the green waterplants are of the greatest significance to the larvæ during the winter. In shallow, slowly running brooks, with the bottom covered with carpets of *Callitriche* and other green water plants, I have observed that the plants carry hundreds of *C. morsitans* larvæ, even where the ice covers the surface of the water, and the plants are partly frozen in the ice. In sunshine little air-bubbles rise from the plants, and it is possible that this air too, caught and drawn in by the sipho, is used by the larvæ. I have never directly observed this phenomenon, but the supposition is rather obvious, because these air-bubbles play a prominent part in the respiration of many other insects in winter, more especially Dytiscids.

Geographical distribution: It is very difficult to clear up the range, of *C. morsitans*. LANG (1920 p. 103) designates it as a mainly British species, which is further found in Ghent, France, Holland and Macedonia.

Genus VII. *Culex*.

1. **C. pipiens** Linné.

Tab. XX.

Imago. This species may be regarded as our only, true house mosquito the temperate zone of the old world. It is introduced into North America in from Europe and according to HOWARD, DYAR and KNAB (p. 366), has there conquered the northern cities, breeding in various receptacles containing water. In America it is usually rare or absent in the rural districts, being largely replaced by *C. restuans*.

Taken in the widest sense the species is easily recognizable from all other Danish species and most probably from all species of Northern Europe, by its extremely long and narrow second marginal cell, the fork of which is at least seven times as long as the stem and much longer than the second posterior cell. Also the brick-red or reddish-brown colour of the mesonotum, unique in our mosquito fauna, makes it easily recognizable. In the domesticated and most common form the mesonotum has generally three lines of black bristles, but especially in older specimens they are inconspicuous or obsolete. Also the flaxen-yellow bands of the abdominal segments dorsally and the same colour of the venter helps to distinguish this species from the whole of the other mosquito fauna.

Formerly we have here in Europe described very many species, which now are all referred to this very same species *C. pipiens* Linné (*C. vulgaris* Linné, *C. alpinus* Linné, *C. agilis* Bigot, *C. ciliaris* Linné, *C. communis* de Geer, *C. rufus* Meigen, *C. phytophagus* Ficalbi, *C. domesticus* German). As most of these species, owing to the descriptions, are irrecognizable, this method was most probably the most correct. On the other hand I feel quite sure that *C. pipiens*, as we now regard it, is really a collective species, which further explorations will dissolve into several smaller ones. This more especially holds good if we also take the larvæ into consideration, which differ much more from each other than the imagines do. The larva of the main-form may be described as follows:

Larva: Head rather large; subquadrate, a little broader than long; sides bulging; a notch at insertion of antennæ; front margin arcuate. Antennæ long, highly arcuate; basal thirds rather thick, spinose; apical part slender, a large tuft inserted remarkably near the apex; two long setæ before apex; on apex itself a long seta, a short one and a small digit. Anteantennal tuft, lower and upper frontal tuft all multiple, number of hairs in the two last-named tufts generally five and generally inserted over each other, the six tufts commonly not lying in an arcuated line; two small single hairs, between upper frontal tufts. Eyes rather large. Thorax rounded, wider than long. Hair formula of frontal border 221123321122. Hairs in 3 very long, reaching far beyond the brushes when extended; lateral hairs single and in tufts.

Anterior abdominal segments short, posterior ones elongated; lateral tufts of first two segments multiple, two hairs on third to sixth. Subdorsal hairs in the domesticated races double on third to sixth segment. Airtube very long, about five times longer than wide; pecten consisting of about ten teeth, short, only on basal third, single tooth oblique, triangular, feather-like, with from five to seven branches. Hair-tuft of air-tube with four or five hairs. Between the hair-tuft and apex four tufts double, the one of them out of line. Comb of eighth segment consisting of numerous scales in a triangular patch, the single scale with feathered tip; hairs of eighth segment in common arrangement. Anal segment a little longer than broad, ringed by a plate. Dorsal hair-tuft feebly developed, consisting only of from six to seven unequally long hairs; a single lateral hair; ventral brush well-developed, confined to the barred area, without free tufts before it. The brush consists of about 10—12 rays, every ray carrying about five to seven hairs.

Lateral tufts of the labellum very large distinctly divided in two parts, but the inner part without comb-bristles; palatum covered with rather short hairs. Mandible quadrangular, three stout spines before the collar and some short hairs arising from their base; a row of long cilia from a collar; outer margin with about ten scales bearing short hair-tufts. Dentition: three teeth on a process, the first of them very large; a long serrated tooth before; process below undivided with a few hairs; angle below sharp; a group of hairs within and a row at base. Maxilla high, conical, divided by a suture. At the apex a tuft of very long, feathered hairs; along the suture a series of shortening hairs. Inner half between suture and inner margin with sharply defined series of long soft hairs; inner margin itself furnished with a series of long stiff bristles; the outer half with a spot covered with soft hairs and a short spine near apex. Palpe moderate, four terminal digits rather long. Mental plate high with straight sides and triangular apex; a large central tooth and from nine to eleven teeth on each side; the first three small and densely crowded. Colour commonly greyish-brown, often almost milky-white.

Biology. Of all our European mosquitoes, this is the most domesticated species. In some regards it is the best studied; it is on this mosquito, that Reaumur has written his classical memoir and its life-history has been used as a model of all other European mosquitoes. Its anatomy is better studied than is the case with most of the other mosquitoes. I refer more especially to the papers on the genital organs by Lomen (1904 p. 567); Heimann (1913 p. 1); Kulagin (1901 p. 578); Kopfbau (Kulagin 1905 p. 285). Of course we know the developmental stage for this mosquito better than for all other larvæ; if however we will try to describe the life-history of the species in our country as well as elsewhere, it will be apparent that this is still quite impossible. According to my experience it is the most troublesome species to study; as far as I can see, here lies a special problem which cannot be solved together with the life-history of all our other mosquitoes. The following remarks may be regarded as points of support for such a future, more thorough, examination.

In November I have often found the females in numbers in summer houses arbours etc., but during winter they commonly disappear from localities of this nature. The females hibernate in deep sheltered, frost less cellars; hitherto, as far as I know, we have never in winter found the mosquitoes in Nature. As long as the temperature is above zero, the mosquitoes are able to fly when a light is brought near them; they hang down from walls and ceilings often in such huge masses that these are covered with them; the hibernating localities in our houses must always be dark, rather moist; and without any draught at all; it is not necessary that they are frostless; if the temperature falls below zero, they fly deeper into the cellars; during severe winters they often retreat to places of such a sheltered nature that it is difficult to find them.

Now and then they may also be found in localities where we should not expect to find them. In an old, almost put down farm of which only the walls and the chimney were left, in Dcbr. I found the chimney on its inside wholly covered with a greyish layer of *C. pipiens*, intermixed with a few *T. annulata*. The temperature has undoubtedly been below zero. It was very interesting to observe the behaviour of these mosquitoes. They were wholly immovable; they sat as glued to the walls; if they are taken off, they lie lifeless in the hand on the dorsal side. With regard to thigmotropical phenomena see WEISS (1913 p. 36). If mosquitoes are taken in from the deep dark cellars, brought into the light and kept at temperatures about 15° C., they almost always die; probably owing to want of food. Most probably they are not able to keep their metabolism at a point a slow as necessary, if food supply is to be wholly denied. The hibernating mosquitoes are all extremely fat; with regard to this point and to the blood sucking habits I refer to the following. That it is only the females, which hibernate, that the males die out before winter, and that the hibernating females are impregnated may all be regarded as established facts.

On a beautifull sunny day in May all the mosquitoes leave the hibernating localities in swarms; on 3/v, a day with bright sunshine, I was told that all the mosquitoes left my cellar as a cloud; the next day I could not find a single one. We do not know where they fly; it is most probable that they fly out to get blood, not being able to ripen their eggs without blood nutriment. Nevertheless we do not hear anything of attacks of *C. pipiens* in our country, and I myself have suffered no attack from this species in early spring; most probably it satisfies its lust for blood upon poultry, perhaps upon cattle. In June the eggboats are laid in cisterns, water barrels etc. and the larvæ appear; the females do not deposit all their eggs in one single batch, but in three or four, and between these batches there passes some time of varying length; most probably blood-nutriment is necessary or desirable between every deposition; we therefore find larvæ in the cisterns in all stages of development. With regard to the enormous amount of eggs which may be deposited, in some localities, I refer the reader to a valuable paper by GLASER (1917 p. 531).

It is very difficult to make clear how many generations are produced in the course of a summer. The common opinion is that the number of generations is very large; I for my part regard this supposition as quite wrong. I do not think that it exceeds three or rarely four; SPEISER (1908 p. 395) has arrived at a similar result, he indicates two or three generations, but every one of these generations has most probably from two to four broods. The cisterns teem with larvæ and pupæ till about the middle of September; then all the larvæ are almost of the same size i. e. no more eggs are deposited. On 15/X the cisterns still contain pupæ, but from the first days of November all the broods disappear. These indications are in accordance with those from Strassbourg (ECKSTEIN 1919_1 p. 95). He maintains that five generations may be the rule in a year. Here however the females appear in Nature already by 20/III Tp. 11° C. Eggs were found on 7/IV; in the first part of May the first generation appears. In our country the first generation does not appear before the middle of June. At Strassbourg the development from egg to imago takes three weeks in April, in summer only two. With regard to the influence of temperature on the life cycle of *C. pipiens* see also KRAMER (1915 p. 874). That the power of propagation may be regarded as extremely high is pointed out by many authors: GLASER (1917 p. 531); DAVIS (1906 p. 368). When in German literature from recent years we read about the enormous amounts of *C. pipiens* females wintering iu houses, we may also conclude that our climatic conditions are by no means able to produce such enormous *C. pipiens* swarms; though I have examined numerous cellars I have never seen them in such incredible numbers as indicated in literature.

It has often been pointed out that *C. pipiens* breeds in water of extremely nasty condition, and my own experience is in accordance with this; often they are found in localities where we should not expect to find mosquito larvæ f. i. 66 feet below ground (MAC GREGOR 1916 p. 142). See also MANOLOFF (1910 p. 52). I suppose that a more thorough exploration will clear up the questions relating to broods and generations. When it has not been done here, it is partly as indicated on p. 127 because it could not be cleared up simultaneously with the other explorations, partly also from another cause. It is rather difficult in our country to find farms where the explorations can be carried out in the course of some years; mosquito larvæ in the drinking water of the cattle and in the cooling-water of the dairies are with some reason regarded as inexcusable and must be combated when found. More than once I have found the water barrels cleaned, when some weeks later I came back, all further observations on this spot being then almost useless.

Also in our country the water barrels and cisterns in the cow-stables are by no means the only known breeding places for *C. pipiens*. In the so-called settlement gardens near the large towns, almost every garden has its barrel filled with drainage-water. If in August we study this water, we shall find millions of mosquito larvæ and almost always *C. pipiens* larvæ in them. But also in the dunghill pools, where the sides of the pools are real dunghills, we often find the brown, nasty fluid almost filled with mosquito larvæ; they may here stand so thick that the larvæ almost touch each other; curiously enough the huge masses of larvæ do not seem to appear before August. On calm days such pools are often covered with a green or reddish foam, originating from *Euglena* or other *Flagellata*. If so, it seems as if all larvæ in the course of a few days die off, the foam probably preventing respiration, atmospherical air for larvæ living under such conditions being a conditio sine qua non. I have often found the borders of the pond covered with a brown line of egg-boats. A more thorough exploration of how many times a year this line appears, may probably give some information with regard to the number of broods and generations. It is especially owing to the study of this line that I suppose that the number of generations in the course of the summer is but small; the examination is however rather difficult because geese and ducks have often consumed almost the whole stock in the course of a few hours.

But even all these localities lying near the human dwellings are by no means the only spots where this species may be found.

On examining clear, grassy ponds, which contain water the whole year round, I have in August 1918 and 1919 near the border of the pond found very small mosquito larvæ, often in great numbers. All in all these larvæ have all shown the systematic characteristics of *C. pipiens*; still the whole exterior was different; they were much smaller, of a more delicate structure, white or translucent.

These larvæ never appeared before the latter part of July, but at that time they were common enough; they were pupæ in the first part of August and imagines a little later. At the first glance these imagines did not resemble those from the cisterns etc. in our dwellings; they were much smaller, and of much more delicate structure. More thoroughly studied it was however quite impossible to find characters which distinguished them from the real *C. pipiens*. In August—September I often found these small races in Nature, more especially over the ponds where they were hatched; in our houses, on the other hand, I never saw them. In the latter part of August the larvæ disappeared from the ponds, and from the first days of September the imagines disappeared.

I confess that the life-history of *C. pipiens* is dim and obscure. More especially we do not know what are the relations between the larvæ and imagines in Nature and those of our dwellings, farms etc. As *C. pipiens* hibernates in our houses and the first generation is undoubtedly hatched here, I have thought that the generations following were divided into some stocks which remained as house dwellers and others which flew out in search of breeding places in Nature itself. Nevertheless if this was the correct explanation, it is extremely difficult to understand that the racial stamp could really be preserved in this way. On the other hand the total absence of real characteristics which might keep the forest-races apart from the house races; the coincidence of the hatching of the summer generation of the house race and its occurrence in the open air on the one side and the appearance of the larvæ of the forest races on the other suggests that there must be some connection between these phenomena. I think it rather probable that here we have to do with one of those rather rare examples of species, which just now are in status nascendi where new species arise. Some of these races are already now of remarkably stabile nature. I allude especially to the peculiar yellow very delicate little mosquito *C. ciliaris* and to *C. nigritulus* mentioned in the following pages.

2. **C. ciliaris** Linné.

It is with great hesitation and mainly from a biological point of view, that I, in contradiction to all other authors from recent years, again separate *C. ciliaris* Linné from *C. pipiens,* to which it has been referred as a synonym. Created by Linné, it was regarded as good species by Zetterstedt, Schiener, Van der Wulfp and Walker. Blanchard, Theobald and all later authors regard *C. ciliaris* as a synonym for *C. pipiens.*

It was separated from *C. pipiens* owing to its smaller size, its ferruginous thorax and yellowish-ferruginous abdomen. In the structure of the wings, legs and claws there are no differences from the true *C. pipiens.*

Every year in the latter part of August and through the whole of September a slender, very delicate mosquito arrives in the Royal Gardens at Frederiksborg. Its head quarters are always in the well-known several hundred years old box-hedges, from which it can be driven out even in October, when a walking-stick is pushed in among the foliage. I have only seen the species here, explored all the ponds in the vicinity, but have not been able to find the larvæ. I have therefore never hatched the imagines, and do not know the hair and scale coating of them when newly hatched.

The mosquito is of a yellowish, faintly brown colour, but the hair and scale coating always feebly developed; mesonotum is covered with a ferruginous uniform coating; the abdomen has almost no scales, appears either unbanded or with faintly developed basal bands almost only developed in the middle line; besides there are no differences from the true *C. pipiens.*

I am unable to understand why the box-hedges should year after year, always in the same month of the year, September, be a centre of attraction to denuded *C. pipiens*-forms. Further, as it must be remembered, that during the whole of September I find both males and females in great numbers, and that the specimens all differ from the true *C. pipiens* in the much brighter more ferruginous colour and much smaller size, I cannot see better, but that for the present it must be separated as a species differing from *C. pipiens.*

Geographical distribution: *C. ciliaris* has been recorded from Germany, Austria, Holland and England.

C. nigritulus Theobald non Zett.

Pl. XXI.

Extremely small mosquitoes only 3—3.5 mm. in length, dark with greyish-brown thorax, without any reddish tint. Abdomen dark, dusky brown with rather distinct pale basal bands, widest in the middle. Venter dusky, not yellow. Legs brown, rather dark. Claw formula of female 0.0—0.0—0.0; of male 1.1—1.1—0.0; those of fore and mid legs unequal. — First submarginal cell longer and narrower than second posterior cell, but only about one-fourth longer; knees faintly yellow not bright white.

Theobald (1901 p. 140) has referred some extremely small gnats found in England to Zetterstedt's *C. nigritulus*. He says that it looks very distinct from *C. pipiens*, „but when one comes to examine them, however, the structural differences seem very slight''. Edwards (1912 p. 263) maintains that these small gnats are certainly not *C. nigritulus* Zett., which he regards as a synonym of *Aëdes cinereus* Mg. I suppose that Edwards is quite right in this last supposition. As Edwards however further says "At first sight this variety appears to be totally distinct from C. pipiens, as it is much smaller and darker, the thorax being without any reddish tint. No external structural differences are however observable, and after carefully comparing the larvæ of this and typical C. pipiens I could find no differences whatever" I do not agree with Mr. Edwards.

Having found the larvæ in great numbers in August in a little pond in Arnehave near Tjustrup I have hatched many of these delicate creatures. The pond was very shallow, covered with vegetation; the larvæ were always to be found in the waterrim; they were extremely small, and the pupæ much smaller than any mosquito pupæ I have seen. Unfortunately a large *Crabro* had one morning eaten all my needled specimens, put them in her nest holes and used them as food for her young ones. No more specimens were hatched and in the two following years the pond contained no water, and I have never seen the species again. The above given description is only based upon my provisional notes.

As will be seen by the description of the larvæ these differ very much from the true *C. pipiens* larvæ, but undoubtedly belong to the *pipiens* group. Owing to the fact that these small mosquitoes never enter houses (already stated by Theobald 1901 p. 141), and to the very conspicuous differences in the larva, I do not refer them to *C. pipiens* and suppose it is best to refer my specimens to *C. nigritulus* Theob.

Larva: Head very large, subquadratic, almost rectangular broader than long; a notch at insertion of antennæ; front margin slightly arcuate. Antennæ very long, highly arcuate, basal two thirds thickened, spinose; apical third very slender, a very large tuft, much nearer to the apex than to the base; two long setæ before tip; a long terminal seta, a short one and a small digit on a pedestal. Anteantennal tufts and lower and upper frontal tufts almost at line. Anteantennal tuft always, lower frontal tuft often multiple, or with four or five hairs, upper generally with four hairs; between them two single feeble hairs. Eyes large.

Thorax rounded, much wider than long. Hair formula of frontal border 221123321122. All hairs especially 33 very long, reaching beyond the brushes when extended; lateral hairs single and in tufts.

Anterior abdominal segments very short, posterior ones elongated. Lateral tufts of first two segments with four to five hairs; two or three hairs on third to sixth segment. Subdorsal hairs on third to seventh segment in tufts of four to five, often in stellate arrangement with angles of 90°. Eighth segment with hairs in ordinary arrangement. Air-tube extremely long, six or seven times longer than broad; pecten short, restricted to basal fifth, consisting of about ten teeth; single tooth short, not so broad as in *pipiens* and only furnished with two, rarely three, branches. Hair-tuft of air tube double or triple. Between hair-tuft and apex four tufts double, often two out of line. Lateral comb of eighth segment consisting of numerous scales in a triangular patch; single scale extremely long more than four times longer than broad with feathered tip; restricted after the spatulated part. Anal segment much longer than broad, ringed by a plate. Dorsal hair-tuft with a few short and two very long bristles; ventral brush well developed, confined to the barred area without free tufts before. It consists of about 10—12 rays, every ray carrying from five to seven hairs.

Gills extremely long, narrow, acute often twice as long as anal segment.

Mouth brushes very large, distinctly divided into two parts, the inner part without comb-bristles; palatum coated with rather short hairs. Mandibles quadrangular, three spines before the collar; a row of long cilia from a collar; outer margin with about ten scales; bearing short hair-tufts; dentition: from three to four teeth on a process, the first of them very long; a long serrated tooth before; process below undivided with a few hairs; angle below sharp, a group of hairs within and a row at base. Maxilla conical, divided by a suture. At the apex a tuft of very long, feathered hairs. Along the suture a series of shortening hairs. Inner half between suture and inner margin with sharply defined series of long bristles; the outer half with a spot, covered with soft hairs and a short spine near apex. Palpe moderate, terminal digits long. Mental plate extremely high, straight sides and triangular apex with a large central tooth and from nine to eleven teeth on each side; the first three small and densely crowded. — Colour milky white.

As will be seen from the description of the larva of *C. pipiens* and *C. nigritulus* there are great and conspicuous differences.

The larva of *C. nigritulus* is always about two millim. smaller than that of *C. pipiens*; the number of subdorsal hairs in *C. nigritulus* is from four to five, in that of *pipiens* only two; the scales in the comb are much longer in *C. nigritulus* than in *C. pipiens* and the sipho is about one third longer than that of this species; further the teeth in the pecten are narrower. Also the arrangement of the frontal tufts differ a little in the arrangement.

Chap. III.

Contributions to the Biology of the Culicines.

a. General Biological Remarks.

It is only during the last years that we have got some information with regard to the longevity of the mosquitoes in the different stages of life; but the information we have got is still but slight, and most of the remarks with regard to all relations between the different stages and the seasons of the year still contradict each other. This is mainly due to the fact that the determination, more especially of the European species, has been very deficient; further, sufficient attention has not been paid to the fact that species with wide areas of distribution are by no means obliged to live their lives in the same manner near the southern and northern limits of their area of distribution.

In his admirable chapter in "Histoire des Insectes" relating to the life-history of *C. pipiens* Réaumur pointed out that this mosquito laid its eggs in egg-rafts, the well-known egg-boats; the boats were laid upon the surface of stagnant waters. For more than a century it has been regarded as a fact that this was also the case with all other mosquitoes. This thesis was strengthened by some observations with regard to *T. annulata*, the eggs of which were also laid in egg-rafts.

In Europe it was especially Galli Valerio and his pupils who showed that *C. pipiens*, with regard to the egg-laying process, could by no means be used as a model for all other mosquitoes. The significance of the many papers of these authors is weakened by the fact that the determination of the explored species is very deficient; some of the communications are, as Eysell (1907—1909) has pointed out, undoubtedly wrong. It has however been shown that some of the *Culicidæ* of Switzerland hibernate as larvæ or are able to hibernate as such, more especially below withered leaves "in den eingetrockneten und mit Schnee angefüllten Pfützen"; that larvæ during the whole winter develop into pupæ at a tp. of 4—6° C.; that eggs of *Culicidæ* are able to endure desiccation etc. Some of the statements are unquestionably correct, some disagree with those of other observers and need corroboration.

In 1909 Eysell showed that only those mosquitoes (*C. pipiens* and *T. annulata*) which hibernated in the imago stage, laid their eggs in egg-rafts, the others laid them singly. Later on Howard, Dyar and Knab 1912 pointed out that it is only the genera *Culex*, *Culiseta* and *Tæniorhynchus*, which form egg-boats in accordance with the type of *C. pipiens* and deposit the boats on the surface of stagnant waters. In the vast group of *Aëdini* the eggs are laid singly or in small batches and hardly ever on the surface of the water, but on the moist mud of the ponds where the imagines were hatched, and often upon wholly sun-dried ground, commonly covered with withered vegetation. The above-named authors further showed that the *Aëdini* hibernate as eggs; the eggs rest until the following spring and are hatched in the water from the melted snow; the *Aëdini* have only one generation. An expedition (KNAB 1908 p. 540) to western Canada was especially of great significance.

The statements with regard to the *Aëdini* in North America are unquestionably correct; on the other hand there is no doubt that some of the *Aëdini* at all events in other parts of the world are able to hibernate both as larvæ and as imagines; some of them have more than one generation in the course of the year. The European literature upon this point is difficult to use mainly because the determination is very uncertain.

As mentioned above in recent years hibernating mosquito larvæ have often been found in Europe; most of the indications belong to *A. maculipennis* some to the Culicines. Besides the above-named papers by GALLI VALERIO I refer the reader to the following papers. DUPREE and MORGAN (1902 p. 1036), (1903 p. 88), EYSELL (1907 p. 210), LACAZE (1918 p. 729), WATERSTON (1918 p. 1), ECKSTEIN (1918 p. 530). WRIGHT (1901 p. 882) maintains that larvæ of *C. pipiens* and *T. annulata* are to be found in October; exposed to severe cold they survive if the water does not freeze to the bottom. WRIGHT supposes that it is really the larvæ that provide for the continuation of the species through the winter in these northern countries and probably throughout Europe; further, that it is during winter that the destruction of the mosquitoes as larvæ is to take place. This supposition of WRIGHT's is not correct. That *C. pipiens* can live as larva in October is really quite right, further that it can endure a freezing period, but no one has hitherto found the larvæ of *C. pipiens* and *T. annulata* below the ice; all in all a destruction of mosquitoes during the winter in the larva stage is an impossibility in our latitude.

When finally proved, the fact that there exist mosquitoes which can hibernate under the ice as larvæ, was regarded as highly remarkable. The larvæ being hitherto only known as air breathing animals, we were inclined to suppose that hibernation under the ice in this stage was hardly possible. In this connection we shall call attention to the following considerations.

In accordance with the fact that the larvæ in winter are almost sessile animals their claims of nutriment are but slight, and the process of combustion therefore also very slow. Judging from the behaviour of *C. morsitans* in my aquaria in the winter months, this supposition may be regarded as highly probable. Further it must be remembered that even the iceclosed waters are only rarely quite destitute of air-bubbles containing a greater or smaller amount of oxygen than the atmospherical air. These air-bubbles derive from the green plants and are sooner or later deposited under the ice. I have often seen other air-breathing insects in search of these air-bubbles, and it is possible that also mosquito larvæ use them for respiratory purposes.

Undoubtedly the mode of respiration of the hibernating larvæ is mainly cutaneous. Exactly in the winter months the water is much better aërated than in spring even in such drying ponds where all processes of decomposition on the bottom have only a very slow course and where many green plants in drying ponds more especially *Hottonia* greatly contribute to the aëration of the water. In this connection attention must of course mainly be paid to the tracheal gills; with regard to this point I refer the reader to pag. 15.

At the same time as the hibernation of the mosquitoes in the larva stage was pointed out it was also shown that mosquitoes could hibernate in the imago stage. In addition to the above-named statements by HOWARD, DYAR and KNAB and by EYSELL I more especially refer to the following authors: WESTWOOD (1872 p. XVI and 1876 p. VII); WADE (1888 p. 52); GRAY (1900 p. 250); ANNETT and DUTTON (1901 p. 1013); CAZENEUVE (1910 p. 155); ECKSTEIN (1919_{III} p. 530); most probably most of the indications belong to *C. pipiens* and *T. annulata*; the modern explorations in Germany commenced with a view to mosquito destruction (ECKSTEIN, BRESSLAU; TEICHMANN, PRELL), all seem to show that all mosquitoes which hibernate in our houses in Europe really belong exclusively to *C. pipiens* and *T. annulata*.

With regard to the *Aëdini*, as far as I know, we have never in Europe found any of them hibernating in houses; that they should hibernate as imagines in Nature itself has often been supposed, but never thoroughly corroborated. On the other side communications from the arctic regions, from the Siberian Tundras (FINSCH 1876) as well as from the arctics of North America (STERLING 1891, STEWARD 1891; with regard to this littr. see NUTTALL and SHIPLEY 1902 p. 63) seem to show that the *Aëdini* of the arctic region are able to hibernate in the frozen masses of the tundras and in clefts and hollows of the snow, appearing in millions as soon as the first sunbeams in spring heat the surface of the snow. Further explorations may show how these communications are to be brought into accordance with those of KNAB with regard to the hibernation of the *Aëdini* as eggs, if not under arctic conditions, still under very hard climatic ones, with high degrees of frost. Even in our country the possibility is not quite excluded that some of our *Aëdini* should be able to hibernate as imagines. I more especially refer to the late broods of *O. caspius* and *communis*.

With regard to the egglaying and related processes of our Central European *Aëdini* we have only very few observations. With regard to all those species which lay their eggs in batches (*C. pipiens* and *T. annulata*) and about which we know that the single batches are laid at smaller and greater intervals, we are able to speak of a series of broods in the single generation. With regard to the *Aëdini* this is not possible; most probably the eggs are thrown off uninterruptedly during the whole summer. As far as I know, more thorough explorations have only been carried on with one single species, the yellow fever mosquito: *Aëdes calopus- (Stegomyia fasciata)*, only found a few times in southern parts of Europe and last in England (LANG 1920 p. 112). MACFIE (1915 p. 205) indicates that the maximum life of the female is sixty two days; FIELDING (1919 p. 25) has kept the species living for 93 days. The first blood-meal is taken on the second or third day, and three or four days elapsed between each act of oviposition. Egglaying continued throughout life. Even with regard to *Stegomyia fasciata* BACOT (1916 p. 1) has mentioned the fact, highly remarkable also in this connection, that the whole development from egg to imago can be completed in the course of only four days. From a biological point of view it is highly interesting that the development of the very same species dependent on outer conditions, in the one case can be completed in the course of four days, in the other in the course of many weeks; further that among the mosquitoes there are species which finish their whole development in four days, others which normally spend about eight months either in the egg-stage or in the larva-stage.

Heimann (1913 p. 31) has shown that the sex differentiation with regard to *C. pipiens* takes place already at a very early stage of the development; cut series show that already in larvæ of 2 mm differentiations between ovaria and testes may be shown; it may be pointed out that the observations were made upon a species the larva of which only lives a few weeks and perhaps only a single week. It ought to be investigated whether the rule also holds good for larvæ which live for

	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Debr.
I.												
Aëdes cinereus	•	•	•	•	• —	— +	+	+	+	•	•	•
Ochlerotatus caspius	•	•	•	• —	— •	+	•	• —	+	+ •	•	•
— curriei	•	•	•	• —	— •	+	•	• —	+	+ •	•	•
— cantans	•	•	•	• —	—	+	+	+	+	•	•	•
— vexans	•	•	•	—	—	+	+	+	•	•	•	•
— annulipes	•	•	•	—	—	+	+	+	+	•	•	•
— excrucians	•	•	•	—	—	+	+	+	+	•	•	•
— lutescens	•	•	•	—	—	+	+	+	+	•	•	•
— detritus	•	•	•	•	•	•	—	+	+	•	•	•
	•	•	•	—	—	+	+	•	•	•	•	•
— communis	—	—	—	—	—	+	+	•	•	•	•	•
	+	+	+	+	+	•	•	•	•	—	— +	+
— punctor	•	•	•	•	— +	+	+	•	•	•	•	•
— prodotes	•	•	•	—	— +	+	•	•	•	•	•	•
— diantæus	•	•	•	• —	— +	+	+	+	+ •	•	•	•
— sticticus	·	·	·	··	··	··	+	+				
Finlaya geniculata	•	•	•	—	+	+	+	+	+ •	•	•	•
II.												
O. rusticus	—	—	—	—	— +	+	•	•	•	—	—	—
Culicella morsitans	—	—	—	—	— +	+	+	+ •	—	—	—	—
Tæniorhynchus Richardi	—	—	—	—	—	+	+	+ •	—	—	—	—
III.												
Theobaldia annulata	+	+	+	+	+ •	+ •	+ •	+ • —	±	— +	+	+
Culex pipiens	+	+	+	+	+ • —	+ • —	+ • —	+ • —	+ • —	— +	+	+
— ciliaris	?	?	?	?	?	?	?	+	+	?	?	?
— nigritulus	?	?	?	?	?	—	—	+	+	?	?	?

eight months or even more as is the case with *C. morsitans.* With regard to sex differentiation see also Adie (1912 p. 463 and 865).

Having now in the foregoing worked out the main points in the biology of our Danish mosquitoes I have in the table on p. 136 tried to sum up the results of my investigations and hereto attach the following remarks. From a biological point of view the Danish Culicidæ are referred to three different groups. The first and the greatest contains all the *Aëdini* with the three genera: *Aëdes, Ochlerotatus* and *Finlaya*; only one species *O. rusticus* belongs to the second group. A characteristic of the first group is that all the species winter exclusively or mainly as eggs. The species often spend more than seven months in the egg stages, the other stages are all restricted to the five summer months. Of these the larva stage only lasts from four to six weeks and is commonly restricted to April—May. The imago stage lasts from the latter part of May to August, for some species, f. i. *O. detritus,* only two months in autumn. In most of the species there is therefore only one generation. Two generations occur regularly only in two species: the brackish water mosquitoes: *O. caspius* and *O. curriei.* Our most common species *O. communis* with regard to its life history differs very much in the different localities; in most of them it is in accordance with the other *Aëdini* but it may have two generations and is able to survive both as larva and as egg, probably also as imago.

In rainy summers most of the species which regularly possess only one generation may probably get a second generation; this may especially be the case with *O. lutescens*; all in all this generation is very insignificant in comparison with the spring generation. Apart from the above-named exceptions I for one am inclined to refer the main part of almost all our *Aëdini* larvæ from July and later on, to eggs which belong to the same generation as the spring generation, but which have been deposited under bad hatching conditions.

The group contains the pronounced dwellers in the drying ponds which often only possess water in the time from the snow-melting period to June.

All the Danish species are pronounced blood suckers attacking man as well as horses and cattle. It is just among the members of this group that man has some of his most tormenting enemies among the mosquitoes.

Some of the species are probably rather short living as imagines but most of them live remarkably long, about three months or more, especially in damp summers. It is a matter of fact that different species of *Aëdini* hatched as imagines in April—May contain eggs the whole summer till late in August or even in September; this is the case with *O. cantans, annulipes, excrucians, lutescens* and perhaps other species. The eggs are laid singly, never in batches, probably always upon wholly dry land.

During the whole summer all the temporary pools of the forests, and meadows are normally dry or moist but covered with dry leaves or grasses. Just in these localities which to a human eye are often almost inseparable from the surrounding ground, and which never get stagnant waters, the countless number of individuals, especially those of the species *O. communis*, *cantans* and *lutescens*, must throw their eggs above the ground during the whole of the summer. My own insufficient observations tend to show that the main part of *O. communis* and *prodotes* throw their eggs from the latter part of April to the beginning of July; *O. cantans* from the latter part of June to the latter part of August. When driving in my carriage through the large forests of Gribskov near Hillerød I have visited several hundreds of temporary ponds in spring and found larvæ in all; later, in summer and autumn, I found the same ponds covered with brown leaves, dry and indistinguishable from the surrounding ground. It is most extraordinary that the huge masses of mosquitoes which almost make the sojourn in the forest intolerable in late spring and during the whole of the summer throw their eggs in the summer months, the very same eggs which cannot be developed without access to the water, upon wholly dry land, in all the small inconspicuous hollows covered with dry leaves, and just as dry in July and August as the small hills which border the hollows. It is as if the mosquitoes, by means of their maternal instincts, were able to select all the localities where water will appear half a year later and which to a human eye are indistinguishable from the surrounding localities where there will never be water.

Owing to the enormous amount of larvæ which appear in spring in our forest ponds one would be inclined to think that it would be very easy to observe the egg-laying processes over the dried up surfaces of the temporary ponds. As often mentioned in the previous pages this is not the case; only with great difficulty and rarely have I seen the egg-laying process of the Aëdini; as far as I know no one has hitherto observed it in Nature itself; that it should be confined to a special time of the day is rather improbable; if so, it is most likely during the night. It is most probable that the egg-laying process goes on during the whole of summer owing to the remarkably long life period of these species as imagines, and that only a few specimens are active at every time of the day.

Most of our *Aëdini* belong to the forest ponds, some to the temporary ponds on open land; two live in brackish water pools, one in tree-holes.

The second group consists of *Culicella morsitans*, *O. rusticus* and *Tæniorhynchus Richardi*. It is characterized by the fact that the species do not winter in the egg but in the larva stage; the latter lasts from September till May i. e. eight to nine months; the imago stage as in the foregoing group is restricted to the summer months; the egg stage is extremely short in this group, only lasting one or two months; the imago from May—June to the latter part of September. There is only one generation. The eggs of *T. Richardi* are laid in egg-rafts; how it is with regard to *C. morsitans* I do not know, but I should suppose that they are laid singly. The egg boats of *T. Richardi* are most probably laid on the surface of stagnant pools among vegetation, those of *C. morsitans* singly over the dry bottom of temporary forest pools. As far as I know neither man nor cattle or horses have been subject to attacks from this group in our country; further explorations will most probably show that this is not correct.

The third group consisting of the two mainspecies *C. pipiens* and *T. annulata* is again of quite another type; here it is the impregnated female which hibernates; the life of the imago with regard to the female lasting about seven months; the male hibernates only in the spermatozoan stage. In spring the female lays her eggs, and these are always laid in egg-rafts. *Culex pipiens* is the only Danish, and probably the only North European species in which we have with certainty regularly observed a series of generations in the course of the summer. Further south the same is the case with *T. annulata*. EYSELL (1907 p. 198) says correctly: "Nur die im Imagostadium überwinternden Stechmücken vermögen mehrere Generationen in einem Jahre zu erreichen". As far as we know the two species in our country only rarely attack man; *C. pipiens* probably mainly attacks poultry; *T. annulata* is best known as flower visitor but also sucks blood from cattle.

With regard to the impregnated females hibernating in the imago stage it may be added that parthenogenesis in the mosquitoes, at all events as a rule, is highly improbable (KELLOG 1904 p. 59; LÜHE 1903 p. 372).

It has often been said when the attacks of mosquitoes in the warmest summer time have been extremely fierce that this is due to the large amount of generations and broods which follow each other with incredible celerity. This supposition which has especially taken root among common people, but has really been nourished by the scientists, is quite wrong. The huge masses of mosquitoes are not due to new generations; almost all our mosquitoes except *C. pipiens* and the brackish water mosquitoes have practically only one single generation a year; if a second generation appears, this is against the rule, and the number of individuals is much smaller than in the first. The huge mosquito masses in the summer months are principally due to the fact that the different species, which are hatched after each other, keep on adding to the amount, and for a short time of the year all bite simultaneously; when this has not hitherto been understood, it is also because we have in a very high degree underrated the longevity of the mosquitoes; as mentioned above it may, more especially in damp, cold summers when the lust of blood is feeble, be prolonged to about three months. One would be inclined to think that exactly in the rainy summers, when the ponds are filled with water, the best conditions would be found for production of new generations and augmentation of the mosquito plague. This supposition seems however to be quite wrong as regards our country. In 1918 we had a very dry summer, in which all the ponds from the latter part of May till the latter part of October were dry; many ponds were not filled with water before next spring. In 1919 many ponds were laid dry in the latter part of May but got water again in July; then most of them were dry again in Aug.—September and got no water before December. As mentioned before after the complete desiccation in June 1919 we really found larvæ of *O. communis* and *O. lutescens* in July, but the number which was hatched was extremely small, and there is no doubt that the mosquito plague was greater in 1918 than in 1919. The mosquito attacks during the rainy period in July and on the beautiful autumn days in August—September were but slight.

The regular examination of the above-named 40 ponds gave as main result that there are a few ponds in which only a single species is hatched. This is however an exception; in most of the ponds a greater number of species are hatched. I have made schemes for all forty ponds, but as they resemble each other very much, I will only mention a single one of them as a model. It belongs to the Stenholtsvangs ponds, about two kilom. from Hillerød. This pond, which was under observation for four years 1917—1920, in 1917—1919, in all three years, gave quite the same result. In this pond seven species are hatched; the seven species follow each other with quite the same invariable regularity. In January there live plenty of *C. morsitans* larvæ and a few larvæ of *O. rusticus*; in free water on sunny days, between ice and land, diminutive larvæ of *O. communis*. This fact is unaltered till April when the ponds thaw. Then the ponds teem with larvæ of *O. communis*, the water is practically a black living mass of larvæ; the larvæ of *Culicella morsitans* have retired to the deeper parts of the pond; when dredging in the surface we only get very few larvæ of this species. Suddenly in the course of a week the whole bulk of *O. communis*-larvæ are altered into pupæ, and in the same weeks the insects leave the ponds as imagines. But simultaneously with the metamorphosis into pupa of *O. communis*, and most probably a little earlier, eggs of *O. cantans* have been hatched; already a fortnight later this species, owing to the much higher temperature, leaves the pond as flying insects. A little later the eggs of *C. diantæus* and *Aëdes* are hatched, and in June these species are imagines. Simultaneously with them *C. morsitans* leaves the pond and so also *O. rusticus*. In June the pond is wholly dry.

The dry bottom of the pond contains no mosquitoes in any stage in June. In the following three months the case alters again, and all the species find their way to the pond again, laying their eggs on the dry bottom. Side by side, perhaps under the same leaf, the eggs of the different species slumber the long summer sleep; in autumn, when the rain begins, the deepest part of the bottom takes some water, often only a few liters. This is enough to revive the eggs of *C. morsitans* and a little later *O. rusticus*. The larvæ of these two species appear, but the moist conditions have not the slightest influence upon the eggs of *O. communis, cantans, diantæus* and *Aëdes*. Before the eggs of these species can be hatched, they must, besides being burned by the sun, also be frozen in the ice, and not till January are any of these eggs hatched. At this time only the larvæ of *O. communis* appear, the others do not appear before they have passed the whole winter in the egg stage, the larvæ not leaving the eggs before April. The two species *C. morsitans* and *O. rusticus* pass the winter as larvæ under the ice.

In 1920 the development of the mosquito life in the pond apparently gave a picture of a somewhat different kind. The facts were the same as regards April; larvæ of *C. morsitans* and *O. rusticus* were found on the bottom, and the water teemed with enormous masses of *O. communis*. Owing to the warm weather in the latter part of March and in the beginning of April the development was at a somewhat greater speed than in the foregoing three years. Then the weather was bad, and during the whole of April and in the first part of May the temperature did not rise above 6—8 degrees Celsius; the weather was extremely rainy. Under these conditions the *O. communis* material was not hatched, and the pupa stage was prolonged beyond the normal limits to about two or three weeks; as the temperature of the water was however about six to eight degrees, all the other mosquitoes in the pond were hatched from eggs; before *O. communis* left the pond as imagines most of the larvæ, belonging to the species *O. cantans*, *diantœus* and *Aëdes*, were ready to pupate. Then when the fine summer weather arrived, all the mosquito species of the pond were almost simultaneously hatched, and in the course of about a week all the species had left the pond. The pond had water the whole summer but from about July to September not a single larva was found in the pond.

Having followed the development of the species in this pond for three years and having followed it in about thirty forest ponds of quite similar appearance, I have seen that the above-named scheme is a true prototype of the development year after year in a great number of forest water ponds; in some of them *O. rusticus*, *O. diantœus* or *Aëdes* may be lacking, but where they are to be found, they are always intercalated in the very place in the developmental series where we should expect them to appear.

Everyone who has tried to carry through an exploration of this kind, will admire the almost incredible regularity with which the development of the species takes place. Over an area of only a few square yards seven species have laid their eggs. The eggs lie side by side in August, they are exposed to the same outer conditions, the same burning sun, the thaw of the summer morning, the first moisture from the autumn showers; one day the eggs of all the seven species can be brought to swim in the very same little water-filled hole, or diminutive pond. But the seven species are by no means hatched simultaneously; deep in their life history immutable laws are laid down which rule the life of each of the species. The temperature and degree of moisture, which forces one species to pass from one stage to another, has no influence at all upon another species which only awaits its appointed time.

In the temporary ponds upon the plains and meadows not overshadowed by forests I have never found this highly remarkable alternation of many species. In these ponds as a rule we only find two or three species: in inland ponds, mainly *O. excrucians*, *lutescens* and *annulipes*, now and then *O. communis* and *rusticus*; near the sea shore *O. caspius*, *curriei* and *detritus*. As mentioned above, also here we find localities where the temporary ponds in spring all teem with larvæ of one of these species, and where incredible myriads are hatched in the course of a few days. The rule is however that in the open country, more especially far from the coast, in many localities we find a great many temporary pools in which I have never found a single mosquito larva. As late as April of this year I have travelled over a great part of my area of exploration and visited several hundreds of temporary ponds scattered over the fields and meadows, and only found mosquito larvæ in ten of them. This is in contrast to the conditions in the forest ponds, where almost every single pond in spring contains larvæ often belonging to many species. There is also this difference between the mosquito life in forest ponds and ponds of the plains that the first-named almost always teem with myriads of mosquito larvæ whereas in the last named — apart from the brackish water pools — we often find only very few specimens almost always belonging to the above-named species differing from those which inhabit the forest ponds.

Finally I wish to call attention to the following results which, as far as I know, are in accordance with those of all the authors who have made a more thorough study of the biology of the mosquitoes. It is often maintained that the attacks of mosquitoes are more troublesome in the vicinity of large lakes, and that the mosquitoes are hatched especially in them. The fact is that our mosquitoes are never hatched in lakes, but all belong to very small pools, most of them living in ponds which are dry or frozen for about eight months of the year. Another thing is that they often occur in the small ponds which border larger watermasses, and which are cut off from them.

Further it has often been stated that the mosquitoes are actively able to spread over large areas. For all our Danish Culicines this supposition is, according to my opinion, not correct. They are almost all remarkably stationary animals; many of the colonies never leave the vicinity of the pond where they are hatched; we are only attacked when we place ourselves at the borders of the pond; this especially holds good for *Aëdes cinereus*. Where small, sharply defined woods are spread over a rather wide area f. i. in North Seeland, it often happens that different species are prevalent simultaneously in the different forests. Most of us will also observe that we are very rarely attacked in the open country, but that we are subject to even very violent attacks if we seek the shade in one of the woods; the more attentive observer will further notice that if we are attacked simultaneously in the open country and in the forest, the attack in the former locality is almost always due to *O. lutescens*, whereas quite different species are prevalent in the forests. In my opinion everything seems to indicate that our mosquitoes are really very stationary animals, only rarely leaving the forest where they are born; perhaps the mosquitoes of the open meadows have a somewhat greater power of spreading, at all events passively, owing to the wind; this would most probably hold good with regard to the brackish water species, more especially *O. caspius* which leaves the coast after hatching, flying landwards in search of man and cattle. With regard to some of the *Anophelinæ* — in our fauna more especially *A. bifurcatus* — the case is different. (See the following).

It is a well known fact that the mosquitoes in different parts of the world occur in countless numbers and make the sojourn in these places almost intolerable to people and mammalia; this is f. i. the case in the arctic region and in many parts of the tropical world. But the plague is serious also in a great part of the temperate zone and a long series of papers dealing with mosquito swarms and mosquito attacks have appeared. Some of them are cited in the following. SWINTON (1768); DALE (1833 p. 543), BOLL (1858 p. 186), HAGENOW (1860 p. 457), WEYENBERGH (1871), SMITH (1890), DOUGLAS (1895 p. 239), BLÜMMEL (1898 p. 15), WHEELER (1894 p. 373), SINTENIS (1891), KNAB (1906 p. 123), WEBER (1906 p. 38), MEISSNER (1908 p. 8), GERMAR (1913 p. 137, 1917 p. 336), ZETEK (1913 p. 5). Some of these papers deal with phenomena of more biological interest; I more especially refer to the paper of ZETEK, concerning the determination of the flight of the mosquitoes and that of WHEELER dealing with anemotropical phenomena. Connected with the swarmbuilding phenomena are also the peculiar auditory organs described by JOHNSTON (1855 p. 97) and MAYER (1874 p. 577).

In our own country we only rarely have occasion to observe large swarms of *Culicidæ*; it is perhaps mainly the case with *O. caspius*, but for my part I have not had an opportunity to make any observation of that kind. In recent years we have received many accounts, especially from Central Europe, relating to the mosquito plague, and a long series of papers dealing with the means by which the mosquitoes should be destroyed have appeared. I more especially refer to the following papers: BRESSLAU & GLASER (1918 p. 290 and p. 327); ECKSTEIN (1919 p. 93 and p. 530), SACK (1911); TEICHMANN (1919 p. 118), BRESSLAU (1917 p. 507), PRELL (1919 p. 61).

In my own country we have hitherto never tried to destroy the mosquitoes, and in my opinion the plague is not so great either that such a destruction should be necessary in most cases. I only wish to make an exception with regard to *A. maculipennis* in our stables. See later.

b. The Blood-sucking Habits of Culicines.

As pointed out by almost all authors from recent years, the mosquitoes have originally lived upon a vegetable diet, plant juices, nectar etc. As well known all the males are still exclusively vegetable feeders, the very few, rather doubtful, exceptions will be mentioned later on. This also holds good for probably more than half of all the females of the mosquitoes; a long series, mainly of tropical genera, are, as far as we hitherto know, exclusively vegetable feeders in both sexes. I refer especially to HOWARD, DYAR and KNAB (1912 p. 111) and to a paper by KNAB (Mosquitoes as Flowers Visitors 1907 p. 215) where the whole of the earlier literature with regard to this subject is cited. Now and then it has been stated that also some of the European species may be found upon flowers; this is more especially the case with *T. annulata*. From observations from the last three years but especially from 1920 I am inclined to suppose that the meteorological conditions are able to force the mosquitoes, more especially all the *Aëdinæ*, to be flower visitors at all events during a shorter or longer part of their life. In 1920 when the immense swarms of *O. communis* and *O. prodotes* were hatched, the temperature suddenly fell for a fortnight, never rising above about 6—8 degrees Celsius. Immense swarms of mosquitoes, females as well as males, were sitting in the grass, flew up when the grass was moved, but never tried to bite. At the same time *Taraxacum vulgare* and *Cerasus padus* were in blossom. About ten days after the above-named mosquitoes were hatched, these two plants, especially *Taraxacum*, were regularly visited by mosquitoes; on the meadows almost every flower had one or two females of *O. communis* and many three or four; the females were sitting on the flowers and pierced their proboscides into the heads now here now there. The phenomenon lasted for about eight days here in North Seeland; simultaneously with my own observations Mr. KRYGER had an opportunity to make quite similar ones on the large moors south of Copenhagen. Then we got fine weather with a temperature of about 20° C., and in the course of a few days the immense swarms rose, the higher temperature awaked their lust of blood, and sojourn in the forest was almost made an impossibility. In the foregoing years I have now and then, in the latter part of cold rainy periods, found a few mosquitoes upon flowers. In a cold rainy period from 25/VII to 7/VIII 1920 I was often attacked by *O. lutescens* and *O. cantans*. It struck me that many of these specimens were gorged with a fluid which could not be blood being clear like water. Squeezing the females clear drops appeared. They were sweet like sugar and were unquestionably honey. In the cold period many of the mosquitoes had been forced to be vegetarians.

The fact of the matter is unquestionably that the lust of blood of the *Aëdini*, at all events in our country, is dependent on the temperature, and that vegetable matter, more especially in the cold spring months plays a much greater rôle in the diet of the mosquitoes than we have hitherto thought. (See also HOWLETT 1910 p. 479).

I have myself no observations with regard to the relation between mating process, bloodsucking and egg-laying. Formerly most authors maintained that a bloodmeal was necessary for the females to ripen their eggs; with regard to the literature I refer the reader to NUTTALL & SHIPLEY (1902 p. 65). Now it has been shown that females which were held upon a vegetable diet were also able to lay eggs from which adults were reared in some cases (SEN 1917 p. 729; 1918 p. 620). NEUMANN (1910 p. 27) has kept *C. pipiens* alive for two years in a large aquarium; many generations have been hatched but they have got no nourishment. He further maintains that also *C. nemorosus* is able to produce eggs without a bloodmeal but in that case the eggs do not develop, and that *Anopheles* is also said to be able to do so after hibernation. See also GRÜNBERG (1907). GOELDI remarks that fertilized eggs may remain dormant in a female for 102 days, if a feed of blood is withheld. MACFIE (1915 p. 205) has observed with regard to *Stegomyia fasciata* that the first blood meal was taken by females on the second or third day after emergence from the pupa. Fertilisation and a blood meal precedes oviposition, and fertilisation preceded the blood meal. Eggs were laid on the sixth or seventh day: After this they regularly fed once, soon after each batch of eggs was laid. Three or four days elapsed between each act of oviposition; egg-laying was continued throughout life; the maximum length of life of the males being 28 days, that of females 62. BACOT (1916) states that a female of *S. fasciata*, which had subsisted on honey and white of egg 56 days without egg-laying, was given three blood-meals; fertile eggs were deposited four days after the first blood meal. Besides he remarks that all experiments to induce oviposition in the absence of a blood meal met with negative results in this species.

Undoubtedly a generalisation with regard to the significance of a blood meal for the ripening of the eggs in the mosquitoes is by no means allowable; every thing seems to point to the fact that the species differ very much from each other, and that there is a regular transition from species which are exclusively vegetable feeders to such to which a blood meal is, if not a necessity, at all events the most natural form of nutriment.

It is a very remarkable thing that we know species which, in a vast part of their area belong to the most troublesome blood suckers, and in others never seem to suck blood. This seems to be the case with *C. territans*, which according to SMITH and FELT (1904 p. 309) is extremely annoying in North America, whereas in Europe — if the determinations are correct — it is said never to sting man. This has been pointed out by SCHNEIDER (1914 p. 46), ECKSTEIN (1919 p. 64), PRELL (1919 p. 63).

In our own fauna, too, we possess species which seem never to use blood as nourishment, others which do not suck from man; further, species which seem only rarely and under special conditions to sting man, and lastly, species which seem ready to sting almost at all times. To the first belongs one of our largest species: *Culicella morsitans*, a species of wide distribution, but according to many authors (THEOBALD, SCHNEIDER 1914 p. 43); never acting as blood suckers. I have hatched this species in many thousands at my laboratory, I have been sitting in the very same dried up ponds over which the females were flying and probably egglaying, and I have caught them in the evenings when they came through the open windows facing the lake; moreover I have never found females, whose stomachs were red and distended by blood.

For a long time I thought that this was also the case with *T. annulata*; I have had the mosquitoes in hundreds in my hatching cages, have very often visited the ponds where the larvæ were hatched, and in September gathered plenty of them behind the shutters of the laboratory; further, numerous females on the walls over the cisterns in which they were hatched; nevertheless I have never seen a female gorged with blood, and I have never myself been bitten. FICALBI (1897) has arrived at quite the same result with regard to Italy and so has SCHNEIDER (1914 p. 43) with regard to the environment of Bonn. THEOBALD quotes an observation by HATCHETT JACKSON that on a warm sunny day in November they settled on stems of periwinkle and wall flowers and, inserting their proboscides, were apparently engaged in sucking (1907 p. 278).

On the other hand we often find indications in literature which show that *T. annulata* may be a very troublesome blood sucker. I especially refer to THEOBALD (1907 p. 277) and to PRELL (1919 p. 65) who says that in Spa he has found females gorged with blood.

According to THEOBALD the sting may be very troublesome; "cases have occurred especially in women, where there have been four or five simultaneous punctures, and the patient has felt so indisposed as to have to retire to bed with fever ranging up to 101° F." These indications are in accordance with those of ECKSTEIN (1919 p. 63), EDWARDS (1912 p. 261) and LANG (1920 p. 101) who states that it may become troublesome in mild weather in the winter.

Last year, during my exploration of the cowstables, I found a great many specimens of *T. annulata*, sitting on the ceiling and upon the walls together with *A. maculatus*; they were very often gorged with blood. They were common more especially in Aug.—Sept. Later on Mr. KRYGER told me that he, too, had found them extremely numerous in the stables in Jutland more especially on the east coast; they were almost always blood-filled. He further maintained that he was often stung by the mosquito, and that the sting was extremely painful. It seems therefore that in our country nowadays *T. annulata* just as *A. maculipennis* is attracted by the stables and mainly sucks blood from cattle.

The bloodsucking habits of *C. pipiens* seem to be of a very remarkable kind. From a popular point of view it is often believed of the mosquito plague that, at all events in Europe, it is mainly due to *C. pipiens*. My own experience, especially in Denmark, and in recent years also that of other observers, especially in Germany, is in contradiction to this supposition.

During the last five years I have studied *C. pipiens* and its behaviour in my own cellar in winter, when it was brought up into my rooms with the peat, further in May out of doors, when it appeared there after leaving the hibernating localities, in the breeding places in the stables etc. During the whole summer and late autumn not a single *C. pipiens* has done me the honour to puncture my skin. As mentioned later on, I have never found a blood-filled mosquito in the cellars, and the few I have seen I have caught on evenings in spring and summer months. Only during winter, when the mosquitoes arrived in the rooms, have I been the object of their attacks; when I have heard that people have been attacked in their rooms by mosquitoes in winter, and I have been able to examine them, it has almost always been shown that the trouble was caused by *C. pipiens*.

Studying the literature, also there we find very few trustworthy indications with regard to the trouble caused by this very species. THEOBALD (1901 p. 135) observes that it "is known to bite some years with considerable severity". HOWARD, DYAR and KNAB (1912 p. 106) state that even *C. pipiens* is among those mosquitoes "which do not persecute man with the same persistence as certain other species f. i. *Aëdes calopus*". Owing to the enormous masses of *C. pipiens* which must every year be hatched from the incredible number of larvæ which fill almost all the ditches and pastures near our farms, there does not seem to be the slightest accordance between the number which are hatched and the annoyance caused by them.

In 1919 an interesting paper by Prell (1919 p. 61) appeared. He has made quite the same observation as I have. In 1917 there were plenty of *C. pipiens* round Spa, but there was no mosquito plague at all. On the other hand, in Stuttgart, where the mosquito plague is now severe, and as far as I can see also partly caused by *C. pipiens*, the plague was unknown before 1900. Prell correctly rejects any attempt to refer "these peculiar facts either to different species" of *C. pipiens* or to migration. He points out that *C. pipiens* like other and perhaps all *Culex*-species has originally been a bird-mosquito; as it is an intermediate host for *Proteosoma* which produces bird-malaria, this makes the supposition very reasonable; even now in many localities it occurs as a bird mosquito. See also Howard, Dyar and Knab (1912 p. 107), Lang (1920 p. 114). Its great power of living as larva in polluted water has been a factor which altered its primary habits, accommodating it to the polluted water basins arising round human habitations. Still the mosquito can keep its old customs of sucking blood on birds; its common appearance in poultry houses makes this very probable. On the other hand its occurrence in human dwellings, more especially in stables, has now offered another source from which it may satisfy its lust of blood, which is: domesticated mammalia and man himself. The power and inclination in this direction is developed to different degrees in the different countries and perhaps also in different years. I should be inclined to think that in higher latitudes and at lower summer temperatures, the old habits will be preserved. (See also Howlett 1910 p. 479).

It seems as if the lust of blood in the *Aëdini*, at all events of our Danish species, is much greater than that of the genus *Culex, Culicella* and *Theobaldia*. American authors (Howard, Dyar and Knab 1912 p. 107) come to the same result. From every part of Europe we hear of severe attacks now from one and now from another species; *O. nigripes* from the far north, *O, communis, cantans, annulipes, vexans, caspius* have all a very bad reputation, everywhere attacking man or large mammals; the landward migration of the salt marsh mosquitoes in search of blood, the behaviour of the mosquitoes of the prairies, which are adjusted to fly towards prominent objects, in that locality almost always large mammals or men, point in the same direction. It need only be added, that the time of bloodsucking in the life of the animals is really rather short.

In our country the bloodsucking period for most species does not last more than about three or four weeks; further it does not begin before two or three weeks after hatching, a fact which I have observed in almost all these species (Exception *Finlaya geniculata* see pag. 102). It may further be pointed out as a phenomenon common to all these species, that in the bloodsucking period there are really rather few days, in which they try to satisfy their lust of blood; these days coincide with certain meteorological data, great humidity of the air, a high temperature and rather low barometer. When on such a warm damp day, especially about sunset, one has witnessed the enormous masses of mosquitoes which from all sides dart upon the wanderer or the horses, and have seen the eagernes with which the attack takes place, one cannot get rid of the supposition that it is only a very small part of the whole crowd of mosquitoes which really gets blood. More especially in cold summers with heavy rains, falling in the main period of the flying time of the above-named species, I should suppose that out of the millions only a very few get a blood meal. A factor which helps the mosquitoes is their longevity, and that their life is prolonged if blood meals cannot be obtained. This is in accordance with my own experience, acquired in Nature herself; in very hot summers the mosquito plague is in the main at an end by the latter part of July, and all spring flyers disappear before July, in wet summers, such as 1919, the mosquito plague lasts till the latter part of August and spring species such as *O. communis* are on the wing and biting as late as the middle of August. As mentioned above according to my opinion there can be no doubt about the fact that the attacks in August do not come from new broods or generations, but are caused by the specimens which are hatched in spring, but have had no opportunity to get blood.

In the literature a few examples are mentioned of males which are able to bite; this is said more especially with regard to *Aëdes calopus* (Ficalby cited from Howard, Dyar and Knab 1912 p. 109), but these authors suppose that the observation is wrong. Of our mosquitoes it is especially the males of *O. nemorosus*: which are said to bite. Stiles was bitten by an *O. nemorosus* with long antennæ (H. D. K. 1912 p. 109), and later on Edwards (1917 p. 216) has been subject to a similar attack. This last-named author shows that none of the three examined males were normal, and that all three had one or more female characters on one or both sides of the body.

With regard to the blood-nourishment and its significance for the ripening of the eggs I wish to make the following remarks:

If we take an *O. lutescens*, newly hatched, and make transversal sections of the abdomen, we shall find a well marked fat body, filling the greater part of the abdomen and a very thin alimentary canal, only occupying a very small part of the abdominal cavity; the walls of the canal show the well known deep folds, the transversal sections therefore showing a starlike figure. If then a fortnight later we let the mosquito suck blood, and now lay the abdomen in transversal sections, we see nothing of the fat body. The abdomen is enormously expanded; the ventral reservoir for the blood fills the whole abdominal cavity only leaving a very inconspicuous space for the nervous system below and the heart above.

If further we let an *O. lutescens* suck blood, keep it for eight days in a hatching cage, kill it and take transversal sections of the abdomen, we shall again get quite a different picture. The ventral reservoir is again shrivelled up lying only in the first or two first abdominal segments and the blood has now arrived in the intestine; but also this is almost empty especially in its anterior part; in the posterior part it contains a blood coagula of larger or smaller size. But round the intestine, where formerly the fat body was, the whole body cavity is filled with hexagonal figures, cross-sections of the ovaries with numerous eggs. Roughly speaking in the course of from eight to ten days the blood nourishment has been transformed into eggs. If then in September we catch one of the *C. lutescens*-females, which, waiting for death, are sitting deep down in the grass covering the dried ponds where they were hatched in spring, and where they have now laid their eggs, and we now take cross-sections of the abdomen, we shall again get another picture. The intestine is empty, but so also is the abdominal cavity round the intestine; the ovaries are shrivelled up to two thin strings; the little mechanism has spent its force, and is now only destined for one thing, to die and make room for another generation now in preparation in the eggs slumbering in the dry mud under the withered grass.

If we now investigate the case of another mosquito, hibernating not as egg like *O. lutescens*, but as imago, like *C. pipiens*, we find an arrangement of quite different sort. A cross-section of the abdomen of a *C. pipiens* in Sept., a few days after it has left the pupa, shows a very thin intestine with strong folds of the wall, a fat body with very small cells, strongly compressed; the sections further show that the dorsal shields are much broader than the ventral ones, which on the other hand are much more vaulted. A deep cleft is conspicuous laterally between the dorsal and ventral shields.

Already in the latter part of September the females of *C. pipiens* have found their places of hibernation. If we now take one of these hibernating females from my cellar, the cross-section gives quite a different result (Fig. 18a). The intestine is as formerly extremely small, and in many of the sections difficult to find. On the other hand the fat body is of quite different structure; the cells are much larger; between them are large intercellular spaces, and the content of oil globules is enormous, the cross-section of the abdomen further shows that this is now extremely extended; the contour is circular; if we lay a hibernating mosquito from October in a vessel with water and open the abdomen, enormous masses of oil globules will pour out; in a living animal we are able to see the oil globules with a lens through the extended body wall. In November—December the picture is quite the same; I have got the impression, that the mosquitoes are at all events just as fat in December as they were in November.

The question is now: What is the source of this fat? Most people would probably say that it derives from the blood nourishment taken in by the females before hibernation. This may be the case, but I am not quite sure that this supposition is correct. Firstly I have never seen a mosquito with blood in its intestine arriving at the hibernating places. Moreover, though in September I have very often been sitting in my garden, observing the swarms of dancing *C. pipiens* males, and caught the females which directed their way into the svarms, I have never got a female with a blood-filled intestine. It seems as if *C. pipiens* upon this point is in accordance with *Stegomyia fasciata*: first mating process and then blood nourish-

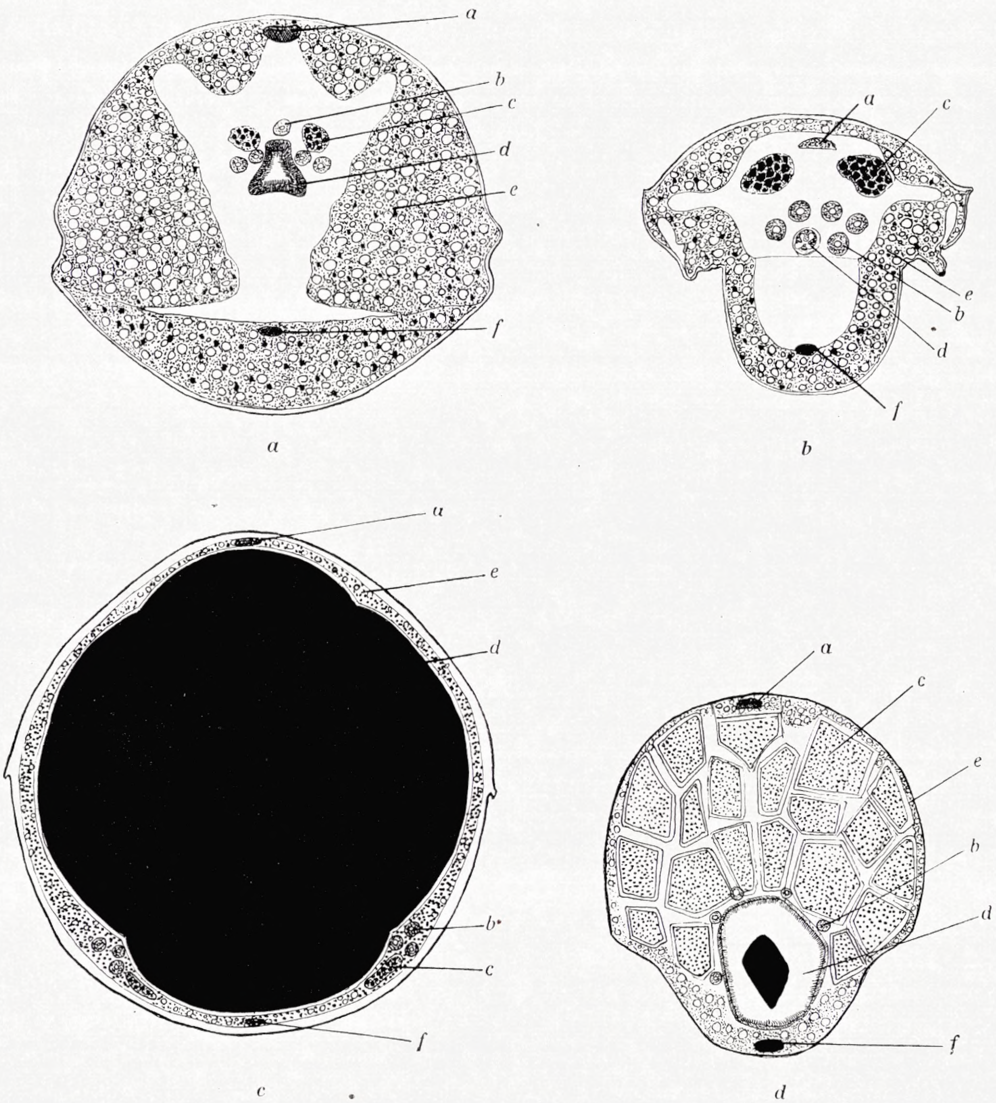


Fig. 18 *a, b, c, d*. A series of cuts through the abdomen of *C. pipiens*.
a, in the last part of October, a few days after the mosquito has been hatched. *b*, in April after having hibernated. *c*, in the first days of June immediately after bloodsucking. *d*, eight days later.
a heart; *b* malphigian tubules, *c* ovaria, *d* intestine, *e* fat body, *f* ventral cord in all the figures.

ment, quite the opposite of what we have seen is the case with *O. lutescens*. I continued the observations in my garden, till the bad autumn days arrived, and found the *C. pipiens* females always without blood in the intestine; a few days after I found the females in the hibernating places, also here without blood in the intestine. I cannot see how we can combine these observations with the supposition that the fat body derives from blood nourishment. We further know that the blood nourishment of *O. lutescens* is converted into eggs in the course of about eight days in summer, and we shall see that this is also the case with the blood nourishment in May in the case of *C. pipiens*. It is therefore in my opinion rather hazardous to suppose that in the course of a few days the blood nourishment in September will be transformed into diffuse fat-masses in the body cavity, and in May into egg-masses.

For my own part I am inclined to suppose that the fat-body of the hibernating *C. pipiens* females derive from those fat-masses, which the animal has accumulated during the larva stage in freshwater, and which it, passing the pupa stage, has taken over into the imago stage. I know very well that this supposition meets with great physiological difficulties. The question is, whether fat in some more condensed form, taken over from the larva stage into the imago stage, may be further utilized in this stage in any way.

Even if the physiologists say that this is an impossibility, I should like a thorough physiological investigation upon this point. It must be remembered that the females of *C. pipiens*, which we catch in summer, are all relatively meagre, differing much from those in the hibernating quarters; as the *C. pipiens* were hatched in the middle of September in the water barrels in my garden and immediately began the mating dances only a few meters from the water barrels, and as only a few days later, after a rainy period, I found the females fat and with empty intestine in the hibernating place in my cellar, I suppose that we here have to do with a fact which strongly calls for a more thorough physiological investigation.

In the course of the winter the mosquitoes become more and more meagre a transverse section (Fig. 18b) gives quite another picture; the form of the body is another and the fat body strongly reduced. One day in April—May they leave the wintering localities like a cloud. Never being bitten by *C. pipiens* in late spring and summer I have only found the females gorged with blood on the walls of cowstables and hen-houses; cross-sections (Fig. 18c) of the abdomen from blood-filled *C. pipiens* and from those about eight to fourteen days later, show quite the same picture as we saw in the case of *O. lutescens*; an enormous gorged inestine filled with blood coagula and eight days later an empty intestine and the body cavity filled with eggs (Fig. 18 d). The above-named cross-sections of the abdomen of the female mosquito at different times of the year are of particular interest with regard to the knowledge of the great phases in the life of the mosquitoes. In some ways they are even more than that. They represent cross-sections through the life history of the mosquitoes; especially those of the blood-filled intestine and of the abdomen, distended by eggs, represent pictures of the results of the two great life preserving agencies: "Hunger und Liebe" the first acting as life preserving factor for the individual itself, the last for the species; when both have been satisfied, the individuals have done their duty and have now only one thing to do: to disappear and make room for new individuals.

As well known the mouth parts and the sucking apparatus of the mosquitoes have often been subjected to thorough investigations from Réaumur to our day. I refer especially to the papers of DIMMOCK (1881), GRÜNBERG (1907), LEON (1904 p. 730 and 1911 p. 7), MACLOSKIE (1888 p. 884), MUIR (1883), THOMSON (1905 p. 145), WESCHÉ (1904 p. 28). A more thorough study of the mouth parts of the different specimens is however still lacking. I have made slides of almost all our species and studied them in preparations of Canada. There are really some small differences in the different species; this especially holds good with regard to the form and hair equipment of the labellæ and to the number of saw teeth upon the maxillæ; but the differences are but slight and their constant number only to be detected after very thorough investigation.

Mating process.

In the course of years, from 1760 (GODEHEU DE RIVELLE p. 617 and RÉAUMUR) and to our own day, many observations on the mating habits of the mosquitoes have been made. Most of them have been collected in the chapter upon mating habits in HOWARD, DYAR and KNAB (1912 p. 120—132).

It has been pointed out that in many species the males congregate in swarms, but that there also exist species in which no swarm-congregation takes place. Even the manner in which the swarms are formed, their position in the air, the size and the behaviour of the single individuals of both sexes, differ from species to species. Of fundamental significance is the observation that the attitude assumed during the copulatory act differs according to the structure of the claws of the female: "In forms with simple claws (*Culex*, *Anopheles*) the position is end to end, the pair facing in opposite directions. The forms in which the female claws are toothed, copulate face to face, clasping each other with their claws" (HOWARD, DYAR and KNAB 1912 p. 121).

Commonly it is only the males which congregate in swarms, whereas the females make their way singly into the swarms from the outside. There are also species where the males as well as the females form swarms, and the pairing takes place when the single individuals drop out from the swarms and unite. Commonly the swarms congregate near the ground and often over prominent objects: hay stacks, isolated trees, church-steeples etc.; they often follows persons, walking over the meadows and grow thicker and thicker as the person walks along. It has been noticed that persons have been surrounded by swarms of females not reaching above the knees, and with swarms of males around their heads. The swarms emit high vibrating notes, often two distinct ones, corresponding to the two different swarms and to the dancing up and down of the mosquitoes. A few species, f. i. *Aëdes calopus*, pair in the rooms of our dwellings and these species only can be hatched and studied through many successive generations. The swarming of the mosquitoes is especially dependent upon meteorological conditions. It is most conspicuous towards evening, more especially after calm fine days; on windy days it may take place, but then only in sheltered places behind large trees, buildings etc. In the swarms the mosquitoes are almost always directed facing the wind. Of great interest is the old narrative of Wahlberg (1847 p. 257), relating to the mating habits of the mosquitoes of the far North. Undoubtedly it deals with one of the *Aëdini*, most probably with *A. nigripes*. He says that travellers, as known well, are attacked by immense numbers of female mosquitoes, but that for a long time it was quite an enigma to him where the males were to be found. A clergyman then told him, that the females were often found upon the surface of the lakes, beaten down by rain and wind in such endless numbers that when blown ashore, they formed thick wind rows. Wahlberg then observed, that no males were to be found near the ground, just where the females in immense numbers tormented him and his fellow-travellers. But from high up in the air he heard a loud singing noise which was found to be produced by immense swarms of mosquitoes dancing in separate flocks. These swarms being examined they were found to consist almost exclusively of males. This indicates that the males of the *Culex*, like those of *Chironomids* and some other non-biting gnats, keep to themselves in a higher stratum of the air, where they flock together in dancing swarms, more especially towards evening, and tempt the females to come up by the noise of their wingbeats.

During recent years I have often had an opportunity to observe the mating habits of our mosquitoes; more especially those of *C. pipiens*, *O. cantans*, *O. communis*, *Anopheles maculipennis* and *A. bifurcatus*. I shall here only dwell upon the *Culicines*.

In the latter part of September small clouds of males of *C. pipiens* may be observed on fine autumn evenings everywhere round Hillerød. On five successive evenings I have observed the swarms in my garden. The swarms always consisted of males only; they always stood in sheltered places, commonly behind a large lime tree; the mosquitoes always faced the wind which was very slight. The swarm was formed about six o'clock, and was still hovering after it was so dark that I could see nothing. The single individuals were flying up and down, commonly at the same rather slow speed, but suddenly it could be observed how the whole swarm got into the greatest excitement, all the males now flying at a much higher speed. The swarm almost invariably stood in the same place, but I got the impression that now and then some of the males left the swarm and settled on the leaves of the lime; at all events many males were sitting here. The shape of the swarm was that of a column, commonly about two or three meters high and one meter thick. The height from the ground was about five or six meters. I observed the mosquitoes by means of a Zeiss (power $\times 8$). I estimate the number of animals from some hundreds at about six o'clock, to some thousands when the swarm was largest, at sunset between seven and eight. In the course of these two hours I saw, most probably about fifty times, larger and darker mosquitoes direct their way from the outside into the swarm. I could observe the females about two or three meters from the swarm; it was very interesting to see, how straight the lines were, along which these mosquitoes made their way into the swarm; the mosquitoes were always females of *C. pipiens*; it was as if by some magic power the insects were forced to fly directly into the swarm of dancing males. Undoubtedly they were directed by the sound issuing from these males which I have often heard formerly and which others, standing near me, heard very distinctly. Having lost my hearing for very high notes, I am probably not able to hear these notes any more.

The moment a female had reached the swarm, a great excitement was noticeable in it. Now here, now there, a ballshaped, thicker, little cloud was observed; a few seconds later two mosquitoes, male and female, dropped out of the swarm, slowly sank down into the grass or retired some meters from it carried by the slight sunset-breeze. I could never directly observe that the mating position was end to end, as indicated by KNAB (1912 p. 122); the insects were always curled up in a ball and very soon reached the grass. Here the act was accomplished in the course of a few seconds, after which the mosquitoes flew away.

In the first part of October we got a period of bad weather; the mosquitoes disappeared; undoubtedly the males died off, and the females retired to the deep cellars, the ceilings of which were covered with *C. pipiens*. In their spermateca the spermatozoa survived the winter, next year giving rise to new generations. In this, as in many other cases, where the males die off in autumn, and the females keep and preserve the sperma in their bodies, I find our customary phrase, that the males die off rather incorrect; I should suppose that it was more adequate to say that the males only hibernated in the spermatozoan stage; this would be more in accordance with the expression we use with regard to all those species, which die out before winter, and with regard to which we commonly use the term that they only hibernate as eggs.

With regard to *O. fletcheri* I have made the following observations. On 15/VI I was standing on the southern coast of Lolland near Aalholm Castle, on a little hill covered with trees and lying in a vast fen, covered with reeds. Below the trees the ground was covered with more than one meter high nettles. It was near sunset at seven o'clock. The weather was calm; Tp. 20° C.; the day had been very warm. Enormous masses of *O. fletcheri* were sitting in the reeds; as soon as I came down upon the little path, hundreds of females rushed upon me. Studying the nettles I then saw that most of the leaves of the nettles either on the edges or on their tips carried males of mosquitoes undoubtedly *O. fletcheri*; the mosquitoes hung on to the edges of the leaves by means of the two first pair of legs, the hindlegs were astraddle in the air and were now and then moved in circles; the females almost always sat under the leaves. When I now moved the nettles with my walking stick, both sexes arose, and to my great satisfaction I saw that if they touched each other during the flight, pairing immediately took place. For three consecutive evenings I now observed the phenomenon during the time from 6½ to 7 o'clock. At 6½ o'clock the males and females sit on the leaves as mentioned above, about 7½, when the shadows grew long, and the sunbeams golden, the males arise and dance up and down; the dance is very close to the ground, only about one-third to half a meter from the tops of the nettles. The females alter their places; they now hang out from the edges of the leaves, and the hindlegs are often moved either voluntarily or by the light evening breeze. On studying the females a little more closely, we shall see that they are almost all very thick, with a blood-filled intestine; the blood is black, i. e. the blood-meal has taken place some days ago; as mentioned above most of the scale vestiture of the abdomen and of the legs is lost; the mosquitoes shining a bright yellow. More than once I saw a male during the dance touch the hindlegs of the female, stretched out into the air. At the very same moment the female released its hold, and the mating process took place; but I also very often saw a female voluntarily release its hold and make her way into the swarm of dancing males. The pairing was always begun and accomplished during flight; it lasted only from 50 to 70 seconds; the position during the act was vertical, and in this position the insects floated up and down, the line from the highest to the lowest point being only half a meter; commonly the dance went on in the very same place, often the light evening breeze carried the mosquitoes a few meters to one of the sides; in the vertical position the sexes were placed face to face. Immediately after the two sexes had found each other, they danced some seconds up and down, grasping each others fore and middle legs; the hindlegs were streched straight out into the air; then I saw the hindlegs being carried inwards, forming a bow with each other; immediately after this the tips of the abdomens were brought against each other, and the pairing took place. Still flying the two sexes released their holds, and both male and female hovered alone in the air; immediately after I have seen the male seize another female and pair with her. Bacot (1916 p. 1) indicates that in *S. fasciata* one male fertilized 10 out of 21 females. At the same moment I have counted about twenty

Textfigure 19. The mating place of *O. fletcheri.* Aalholm. Lolland.

pairs in mating position in the air. I was standing with my camera in my hand, and more than once I could see the dancing pairs, on the focussing screen of my camera, but it was too dark to get a photo of them. At 8.30 the phenomenon abated, and at nine o'clock I saw no more dancing pairs.

In the forest which borders some of my experimental ponds near Hillerød (Stenholtsvang) I have often observed the swarms of *O. communis* and *prodotes*. The swarming always took place about a fortnight after the mosquitoes were hatched; the swarms consisted only of from twenty to fifty individuals; but of such small swarms there were many hundreds around the ponds; they were always standing in the small open spaces between the trunks, mainly from one to two meters above the ground; they could best be observed when suddenly sunbeams fell down between the trunks. In the swarms the single individuals kept their vertical position, only slowly gliding forwards and backwards in the same plane. Also with regard to this species did I see the females from the shade of the forest steer into the swarm and after a short battle drop out with a male. The mating process took place in the deep shadow of the trees at every time of the day.

With regard to *Theobaldia annulata* Mr. KRÜGER has sent me the following interesting observation.

"On October the thirteenth a little past five, after noon, I arrived at Gentofte. I then saw something that looked like smoke on two chimney tops on one of the villas which I passed. A peculiar undulating motion in the smoke made me pay a little more attention to the phenomenon. I then observed that it was two mosquito swarms which were standing over the chimney tops. A few moments later I had opportunity to ascertain that all the cottages in the little town had mosquito swarms over the chimney tops. By means of a fieldglass I saw that all the swarms consisted of mosquitoes, that all were males and most probably all Culicines. Every swarm consisted of about 200, rarely about 400 specimens. The swarm undulated to and fro; the single mosquito moved forward and in small jerks back and downwards. The swarm was always standing a little aslant from the chimney top. All the swarms were directed eastward, and all the mosquitoes facing in the same direction; most probably because a very faint breeze seemed to come from this quarter.

Chimney tops from which it smoked had no swarms. My daughter had observed the phenomenon before my arrival at my house; she thought that it began at 5 o'clock. The swarm building was always begun at the gable head, but at sunset the swarm was standing over the chimney tops. Ascending the roof of my house I got some of the mosquitoes: they were *T. annulata*, all males. At six o'clock the swarm disappeared; the weather was beautiful, the air warm and soft; no wind; I could never hear any sound arising from the swarms". The observation corroborates the often mentioned peculiarity that the swarms are formed over elevated objects: hay cocks, persons walking over prairies and meadows, cattle etc.

II.

Anophelines.

Chapter IV.

Anopheles and Danish Malaria.

Of the genus *Anopheles* we have three species in our country: *A. maculipennis*, *A. bifurcatus* and *A. plumbeus*. We cannot expect to find any more species. The three species are so well known in the imago stage as well as in the larva stage that redescription and drawings may be regarded as quite superfluous.

A. plumbeus Stephens.

A. nigripes n. sp. Staeger.

A. plumbeus is easily distinguishable from *A. bifurcatus* by its small size and dark colouring. It has been described by Staeger (1838 p. 552) from a single specimen taken in Charlottenlund near Copenhagen. In the Royal Museum is found a series of the species but after 1838 no finds are recorded in literature.

Most probably *A. plumbeus* is rather rare in our country; I have found the species in the Royal Garden at Fredensborg near Esromlake and in the forests bordering the lake of Tjustrup. I have only seen it flying at sunset mainly when it is so dark in the forests that the species may just be distinguished. It bites but not so viciously as *A. bifurcatus*.

The larva has hitherto been unknown in our country; Meinert (1886 p. 395) has described a larva as *A. nigripes* but his figures show that the larva he has found is most probably only a young *A. maculipennis*-larva, at all events not the larva of *A. plumbeus*.

The larva is hitherto mainly recorded from tree-holes where it lives together with the larva of *Finlaya geniculata*. (Edwards according to Lang 1920 p. 78; Lang 1920 p. 78). Eckstein (1919_1 p. 288), Martini (1920_1 p. 52). For a long time I have vainly searched for the larva of *A. plumbeus*, the tree-holes only containing the larva of *Finlaya geniculata*; finally in the latter part of July I found a tree-hole with a great many Anophelin larvæ which when more closely examined differed very much from those of the two other Danish species; they had all the diagnostic features of the larva of *A. plumbeus*; the post antennal hairs being exceedingly small and simple; the outer anterior clypeal hairs too; the equipment of hairs on the thorax and abdomen is much richer and the colour of the body is remarkably reddish brown; the whole larva has, as LANG (1920 p. 78) writes, a more stumpy look than that of *A. maculipennis* and *A. bifurcatus*. I observed the tree-hole almost every day till 15. August, the hole being only a few hundred yards from my summer laboratory; there were about a hundred larvæ in the hole; they pupated in the first part of August and the imagines *A. plumbeus* were hatched before my departure; all the larvæ I saw in the tree-hole were fullgrown; that a new generation of larvæ should appear in autumn is highly improbable. The larvæ were always lying at the surface but at the slightest shaking of the earth round the tree stump they darted away from the surface and disappeared at the bottom of the dark brown water.

ECKSTEIN (1919_3 p. 532) supposes that the species hibernates as imago. Besides I refer to EYSELL (1912 p. 421). The species is often but not exclusively found in tree holes also in peat holes (BLANCHARD 1918, MARTINI 1915 p. 585, THEOBALD (1910 p. 13), it has been recorded from most European countries lastly from France (CORDIER 1918 p. 726; LANGERON 1918 p. 728). Its significance as Malaria carrier is very small (BACOT 1918 p. 241); but BLACKLOCK and CARTER (1920 p. 413) have shown that infection really is possible; the peculiar eggs differing from the eggs of other European species in having a ring of floating cells all round have been described by EYSELL (1912 p. 423).

A. bifurcatus.

A. bifurcatus is a well-known species recorded from Denmark already by STAEGER (1838 p. 552); it is regarded as rare and this, as far as I can see, is the case with regard to most of the localities in Central and North Europe. — In my opinion it is not so with our country; insufficient knowledge of the biology has caused the impression that the species is much rarer than is really the case.

The first specimens appear in the middle of May; I have not found specimens after the first part of September; I have found the greatest number in June—July. *A. bifurcatus* is mainly an outdoor species, the home of which is dark forests, old gardens, the outskirts of old beeches, especially where these border on lakes. Even if the locality contains numbers of *A. bifurcatus* during the twenty hours of the day and night we shall hardly see anything of it; in a great many localities in Denmark I and some persons with whom I have been acquainted have made quite the same observations.

Until a little after sunset we have all been tormented by the different *Ochlerotatus* species; then when it is so dark that it is difficult to distinguish the different species from each other, mosquitoes of very slender form and with very long legs appear; it is *A. bifurcatus* — as far as we hitherto know in our country never *A. maculipennis* — which now displaces the *Ochlerotatus* species; — their flight is quite silent, and I have never had the slightest sensation of the mosquito when it alighted upon my hand; the sting is very painful. Different people in the neighbourhood of Hillerød have told me that in the time from ten to twelve they were stung in their bedrooms when the vindows were open by mosquitoes of a remarkably slender form and with very long legs; unquestionably we here have to do with *A. bifurcatus*, so much the more, as I myself have been subject to attacks of this species in my bedroom. In early spring when the evenings are cold, I have also found the cobwebs in stables carrying numerous *A. bifurcatus*; at that time *A. maculipennis* has not arrived here or is very rare. As soon as the evenings have got warmer, *A. bifurcatus* disappears from the stables and is now a particular out-poor species. In my opinion it is one of those mosquitoes of ours which have the greatest power of flight. On calm very warm days with an overcast sky and sultry air it may happen that the mosquitoes are on the wing even in the middle of the day. On such days I have often been lying on the borders of our largest lakes and watched how *A. bifurcatus* steered from the lake perpendicularly on the shore line; I got the impression that the mosquitoes came directly from the lake having passed this and, if so, flown about two or three kilom.

Everywhere in North and Middle Seeland where I have studied the phenomenon I have had an opportunity to observe the attack of *A. bifurcatus* in the time from nine to twelve evening; only rarely was I attacked by *A. nigripes* and never by *A. maculipennis*. The species of the genus *Ochlerotatus* did not quite disappear, especially *O. cantans* was troublesome but *A. bifurcatus* did not arrive before eight or nine o'clock, and in most localities it preponderated over the *Ochlerotatus*-species.

I have observed the males at two different times of the year; in the last days of April and in the latter part of August and first days of September. The males congregate in small swarms, commonly not consisting of more than from twenty to a hundred individuals. On calm evenings or on days with warm weather and overshadowed sky in the outskirts of the forests we may often find these small swarms in the small "bays" in the foliage; these swarms of Anophelines are easily recognizable from those of the Culicines owing to the picture of the position of the body during the flight. Of a flying Culicin male we only see the body and the antennæ which are spread out laterally; a flying Anophelin male presents itself as a much longer line, because the male palpi are pressed to the proboscis, and proboscis and palpi appear almost as thick as the thorax and abdomen; this impression is augmented because also the antennæ are held nearer to the proboscis during flight than is the case with the Culicines. In the swarms the mosquitoes all fly almost at the same distance from the earth, flying horizontally out and in without altering the vertical position in the swarm: More than once I have seen the females following straight lines, steer their way directly into the little swarm which is then in a moment altered into a ball in which the single individuals are pressed against each other; a few moments a pair drops out of the swarm, and falls down into the grass where the mating is accomplished. On a calm day I once saw such a whole series of dancing *A. bifurcatus* swarms all almost at line, all standing in the small "bays" of beech foliage and all with the faces directed towards the moors from which the females steered their way into the swarm.

From the middle of May the egg-laying processes go on; as far as I know a little later than the process begins for *A. maculipennis*. The larvæ of the two species are easily distinguished from each other by means of the clypeal hairs; in the larva of *A. bifurcatus* the inner pair is simple, and the outer only cleft a few times; in *A. maculipennis* the inner is cleft several times, the outer is a thick brush; moreover the float hairs of *A. bifurcatus* have about sixteen leaflets, those of *A. maculipennis* about twenty-two. Also in the comb of the two species there are great differences. Moreover, as far as I know, the larva of *A. maculipennis* is always of a much brighter colour, commonly green, whereas that of *A. bifurcatus* is darker. Furthermore it may be pointed out that most probably all fullgrown larvæ of Anophelines which are to be found in May—June mainly or only belong to *A. maculipennis*, whereas all Anophelin larvæ which occur from October and during the winter months always only belong to *A. bifurcatus*. The two species meet each other as larvæ only in the month June—September; during this time, as far as I know, *A. maculipennis* everywhere preponderates over *A. bifurcatus*; in the six winter months the opposite is the case, and in the true winter months we only find the larvæ of *A. bifurcatus*. As well known (Grassi 1901 p. 53; Levander 1902 p. 11) most of the Anophelin-larvæ are found in the thick green layers of algæ on the surface of smaller ponds (*Cladophora*, *Oedogonium*, *Spirogyra*); as far as I know especially near the coast. It is very difficult to observe the larvæ in Nature; but from my boat when lying in the *Potamogeton* region of our ponds I have learned to see the larvæ between the *Potamogeton* leaves. The larvæ are often found together but those of *A. bifurcatus* preponderate in clear cold localities.

It is a well known, often established, fact that whereas *A. maculipennis* hibernates only as imago, *A. bifurcatus* hibernates as larva. See f. i. Nuttall and Shipley (1901 p. 452; 1902 p. 64); Galli Valerio and Narbel (1901). In September I have, especially in a little valley near Suserup, seen the swarms of males of *A. bifurcatus*; then the females probably lay their eggs; at all events vast numbers of small black Anophelin larvæ occur; at that time these larvæ appear almost everywhere in small ponds rich in vegetation. Their home is the water rim, the larvæ lying, like the *Dixa* larvæ, almost upon dry land; in this water rim the females have deposited their eggs; these are rather difficult to see in Nature, but if we take a piece of milky coloured glass or of white paper and bring it under the surface, but as near this as possible, we shall see that the eggs are extremely common, further that the numerous black Anophelin larvæ originate from these eggs. The larvæ now live in the water rim for more than two months, but when the temperature of the water is about zero, they disappear and hide themselves at the bottom of the ponds; at that time they have almost reached the fullgrown size, the hibernation as far as I know always taking place in the last rarely in the second larva stage. During winter the larvæ do not grow, most probably they eat very little, satisfying their respiratory claims through the air dissolved in the water. — In spring the larvæ appear again in the water rim, and in the detritus washed ashore in the spring months the pupæ appear together with those of *Dixa*, *Ceratopogon* and many pupæ of *Chironomidæ*. Eckstein (1918 p. 530) has arrived at quite similar results. Martini (1920 p. 63) indicates that *A. bifurcatus* most probably quite like the *Aëdini* hibernate as eggs which should then be hatched very early at low temperatures. I do not think this supposition is correct. It seems as if *A. bifurcatus*, both as imago and as larva, is more accustomed to low temperatures than *A. maculipennis*, occurring partly as larva in cold, slow running mountain streams and as imago higher up in the mountains. (See f. i. Prell 1917 p. 243; Martini 1920 p. 67). How many generations are produced in the course of a year I do not know, but I should think not more than two. — The one is laid as egg in Sept., winters as larva, the larva life lasting about eight months, and is imago in May; the other is laid as egg in May—June; the larva life lasting not more than one or two months; and the imagines appear in mid-summer.

As far as we know there are only few of the *Anophelinæ* which hibernate as larvæ (see Griffits 1918 p. 1996. Lacaze 1918 p. 729). Leger 1917. Nuttall and Shipley 1901 p. 452).

A. maculipennis.

When I began my investigations on the Danish *Culicidæ* I supposed that *A. maculipennis* was one of our most common mosquitoes; Staeger (1838 p. 552) writes "common from April to September; the female common on the windows of houses". To my great astonishment I never saw *A. maculipennis* in Nature. The single *Anopheles* species which for years I could find was always *A. bifurcatus*; in houses I certainly saw a few but never any great number.

It is a well-known fact that in our country we have formerly had a very serious malaria epidemic; we are therefore forced to suppose that at that time, not a century ago, swarms of Anophelines must have been hatched every year. As for the whole of Europe *A. maculipennis* is nowadays undoubtedly the chief malaria carrier and as North of the Alps we have never found more than the three *Anopheles*-species mentioned in this work, and the significance of the two others as malaria carriers, especially of *A. nigripes*, has always been but slight, we are almost forced to suppose that it really was *A. maculipennis* which was the malaria carrier a century ago; as my investigations however showed that *A. maculipennis* nowadays seemed to be an extremely rare mosquito, it really seemed that all those naturalists and physicians were right, who maintained that one of the main causes of the disappearance of malaria from more northern latitudes was really the disappearance of *A. maculipennis*.

One day in 1918 I happened to enter a cowhouse, lying near my laboratory at Tjustrup. To my great astonishment I then saw *A. maculipennis* in incredible numbers hanging down from the ceiling of the stable and especially from all the cobwebs in the dark, windsheltered corners of the stable. A closer examination showed that of *Culicidæ* the stable only contained *A. maculipennis*; that almost all were females and only a very few males; further that almost all females were blood-filled.

In the following weeks I then explored about twenty farms lying in the middle of Seeland; later on ten in the north of Seeland. In every stable I found the mosquitoes; the number varied, but was very often about 100 specimens upon one square yard; very often I saw stables in which the number must be estimated to be many thousands in all.

The fact interested me very much, never having thought that my limnological studies would carry me away from the moors and lakes into the stables; that however was the case for more than two years. I immediately saw that here probably was the clue to the enigma why one of the most terrible epidemics, from which our country had suffered, had totally disappeared from the country in such a relatively incredibly short space of time.

On two journeys to Lolland-Falster, formerly the real home of the malaria, I studied the behaviour of *Anophelines* there; in 1919 I explored another old malaria centre, the marshes in the western part of Jutland. In 1920 I further requested Mr. Kryger, on a journey which lasted about a month, to explore the life modus of *Anopheles maculipennis* in the southern part of Jutland, from Kolding along the east coast to Skanderborg; further an area round the large lakes near Silkeborg, then westward over the heath and finally near the large downs along the west coast of Jutland.

For my own part I chose a single farmyard lying near my laboratory at Tjustrup, used the stables as a laboratory and visited the stable in the time from June to September, often almost every day and at all events every seventh day; further I visited it now and then also at other times of the year, and moreover at all hours of the day and night. I wish to give my heartiest thanks to the owner of the farm, the chairman of the parish council Mr. Jørgensen. Of course without any scientific education, yet he was soon interested in the exploration, often looked for the mosquitoes himself, and allowed me to begin, carry on, and complete my investigations at every time of the year and the day. In this connection I also wish to bring my best thanks to Mr. Petersen, veterinary surgeon at Ringsted, Mr. Jørgensen, Nysted, Mr. E. Petersen, Silkeborg, and Dr. Helms at Nakkebølle Fjord; Prof. C. O. Jensen, Copenhagen; they have all given me information of different kinds. In April 1920 I delivered a discourse in the Royal Society at Copenhagen on the malaria mosquitoes and their relation to the Danish malaria. Some weeks later, Prof. C. J. Salomonsen called my attention to a paper by E. Roubaud published in April 1920, the very same month in which I delivered my discourse. I immediately saw that it had happened that two scientists in two countries, without having the slightest suspicion thereof, had studied quite the same phenomenon simultaneously and on quite the same principles. It was with the greatest satisfaction that

I saw that we have arrived at quite the same results. I do not think that the excellent paper of ROUBAUD has made mine superfluous; the same theory which already in 1918 I had worked out for myself with regard to the disappearance of the malaria in North-Europe I have seen that ROUBAUD has also worked out for France. His thoughts and mine upon this point can, as far as I can see, never be more than a theory; but it is a matter of course that this theory is greatly strengthened by the facts that two scientists, in different parts of the globe, have arrived quite independently and simultaneously at quite the same result.

In accordance with my discoveries and starting from the new facts gathered from Mr. KRYGER's note-books from his journey in Jutland, I shall now in a somewhat abbreviated form give an account of my investigations, then mention the results of ROUBAUD and finally discuss the relatively slight differences between his and my statements. All in all I suppose it will be understood that the old saying that two eyes see better than one has been corroborated also in this case.

With regard to the anatomy and general biology of *A. maculipennis* I refer the reader to the many papers published upon this subject especially: GRASSI 1901; IMMS 1907 and 1908; CHRISTOPHERS 1901, NUTALL and SHIPLEY 1900—1903 a. o. I especially wish to point out the last-named admirable investigation relating to the anatomy of imago and larva; of particular interest is the study of the digestive organs (1903 p. 166).

1. The explorations have been carried on over North, Middle, and South-Seeland, over the islands Lolland and Falster, and over a large part of Jutland (see above). From these explorations, carried out in more than a hundred farms, it may be supposed that almost every stable in the country at special times of the year harbours *A. maculipennis*. In the time from June—September *A. maculipennis* has been found in every stable hitherto explored. From the exploration hitherto carried on it has been quite impossible to point out special areas of distribution where *A. maculipennis* either preponderates or is rare; I once thought that the mosquito was more common in the southern part of the country, but this is certainly not right. In the woodlands, on the vast meadows on the southern coast of Lolland-Falster, in the marshes at the west coast of Jutland and over the sandy country of Mid-Jutland the mosquito seems everywhere to be common. Most probably the peculiarly regular distribution over the country is in accordance with the fact that breeding places are to be found everywhere and that want of food cannot exist.

2. The mosquitoes appear in the stables on the first days of May, at that time the number is but small and during the whole of May it is not augmented; at that time we only find females; in the middle of June the new summer generation appears, making known its existence rather suddenly by means of rather numerous males and an enormous amount of females. Any augmentation of females from the latter part of July I cannot ascertain; the males almost totally disappear, but in the last part of August I have got the impression that the number is again augmented. From the middle of September to November the number of both males and females

diminishes and from the latter part of November it is almost impossible to get a single specimen in stables which in July sheltered thousands of *A. maculipennis*. The hibernation does not take place in the stables. When studying the hibernation places of *C. pipiens* I only very rarely found *A. maculipennis* in them. The number of *A. maculipennis* which I have seen in human dwellings in winter is also always extremely small; in the district of Silkeborg it has been maintained that the females in late autumn fly into the rooms; otherwise I have never heard anything of this and I take it to be highly improbable that our rooms are the real hibernation places of the species. On the other hand I have myself found the species in small numbers in remarkably cold but always dark localities, especially out-buildings. The veterinary surgeon Mr. Petersen has kindly told me that in the western part of Jutland, near Ribe, on the farm Villebøl, on 23/II 1917, he found numerous *A. maculipennis*, hanging under the ceiling of a peat house; it was in company with *T. annulata*. I suppose that such localities are the real hibernating places, at all events in our country, not the stables. — Most probably this is in accordance with the high temperatures in winter in the stables; low temperatures being a life condition for the mosquitoes, as they do not suck blood during winter.

That the hibernation as a rule does not take place in stables but in outbuildings etc. is corroborated by many other authors. I refer especially to Eckstein (1919_{III} p. 531); Martini (1920_1). Also Annett and Dutton (1901 p. 1013) maintain that *A. maculipennis* hibernates in outbuildings, cellars, dairies; cheese rooms, pantries; lumber rooms, ware houses, coal cellars. The two last named authors state that the mosquitoes were very difficult to rouse during hibernation. How long the mosquitoes remained in the same position during the winter months it was not easy to determine, but it was noticed that many of the *Culicidæ* were wholly or partially enveloped in a thick mould which had grown in and around their bodies thus fixing them in the attitude described.

3. In my opinion the number of *A. maculipennis* is greatest in the hog-sties; not so great in the cowhouses and smallest in the horse stables; often the number is also great in the hen-houses. As however the rearing of swine during these last two years has been very greatly diminished, so much so that often there are no hogs at all in the sties, it has been difficult for me to corroborate this supposition.

It is always so that dark and dirty, badly ventilated stables without draught contain a greater number of *A. maculipennis* than light, clean, well ventilated stables; newly whitewashed stables always contain only very few specimens. Mr. Kryger as well as myself have observed dark stables were *A. maculipennis* has been present in thousands, we are almost inclined to say in millions; when the door has been opened and we have tried to touch the ceiling with a net, crowds of mosquitoes have hovered around us. It further seems that the number is greatest in the small stables with low ceilings, it is further greatest in stables with many animals, much smaller in stables with only few cows or horses. The mosquitoes occupy the ceiling more than the walls and always prefer the darkest corner; in particular they hang down from the cobwebs; every cobweb often carries about thirty to forty specimens; where it has been possible to count the number I have often found about 80 to 100 upon a square meter.

Even in summer when the *Anophelines* are mainly to be found in the stables the cattle is often in the fields; on the larger farms they are mainly out of doors day and night, on the smaller ones the cattle is driven into the stable before night. In the last case the number of *Anophelines* is exceedingly large. In every stable there are however almost always a few pens in which young cattle or sick animals have been locked in. It is then very peculiar to see that even that part of the ceiling and walls which borders on these pens contains a much larger number of mosquitoes than the empty pens. To get a true estimate with regard to the number of *Anophelines* a very careful examination is necessary; it has been shown that a great many mosquitoes hide themselves between the collar-beams and the ceiling and similar localities which are almost excluded from examination. — It can also be shown that where among a series of stalls, each with its head of cattle, there are some empty ones, the number of Anophelines over these empty stalls is smaller than over those which contain cattle; nor is the ceiling over the middle walk so closely covered as the ceiling over the stalls.

4. Even in those farms where the stables contain large numbers of mosquitoes, the rooms occupied by the family are almost quite free from mosquitoes. The opposite may be the case and more especially this has been the case upon some large estates where all the cattle has been out in the meadows for a long time, and the servants' rooms have been in connection with or very near the stables. — As a common rule it may however be pointed out that on most of our farms there is the most striking contrast between the number of mosquitoes in stables and in the living rooms.

Accounts from excellent observers, in whom I have the greatest confidence, seem to point to the fact that in localities where there are exceptionally many breeding places for Anopheline-larvæ, and where the number of cattle present in the vicinity is but slight f. i. in the little town of Silkeborg (about 10.000 inhabitants), quite surrounded by lakes and moors, it seems as if the mosquitoes here may enter the houses; this may especially be the case in autumn. Personally I have not myself had any occasion to corroborate this assertion.

5. The mosquitoes of the stables are almost all blood-filled; extremely thick; where I have tried to count I have always found that about 90 % have the stomachs full of blood and only 10 % have empty stomachs; in many of them the contents of the alimentary canal is black, in many of them it is red. Rather often we find specimens where the hind part of the contents is black, the fore part is red. In my hatching cages I have seen that an *A. maculipennis* with red contents of the alimentary canal in the course of twenty-four hours has altered it to black. When therefore I find mosquitoes with contents half black and half red, I am in-

clined to suppose that the mosquitoes suck or at all events are able to suck blood very often, most probably almost once in the course of twenty-four hours.

It is difficult to see the real blood-filling process; I have never seen the mosquitoes suck on bright days; nor have I been able to see the process during night, most probably because it was always too dark in the stables and the mosquitoes had left their victims when light arrived. On the other hand, in the time from ten to twelve evening, very often when I came into the stable, especially in the hog-pens, I have seen almost all the pigs rub themselves against the boards of the stall; this I have only rarely observed in day-time. On dark days in dark stables I have further often seen or rather just been able to catch a glimpse of the sucking *Anophelines*; curiously enough I have most often observed them on the eye-lids of the cows; more than once I have tried to catch them while they were sucking but this was always an impossibility; the cows moved and the mosquitoes darted away. — I have not tried to determine the blood in the mosquito stomachs; I soon learned to regard this as quite a superfluous investigation. Later on I learned that already Mühlens "konnte das Blut mit der Uhlenhutprobe als Schweine- bez. Rinderblut anweisen" (Martini 1920_1 p. 60). It may be added that the few specimens which I have found in the latter part of October have never been red but have had a yellow coloured abdomen not distended with blood. The blood-sucking period lasts only till about 15/IX.

6. The mosquitoes are always remarkably indolent, and sluggish; when entering the stable the observer gets the impression that the mosquitoes sit almost as if glued to the ceiling and walls. I shall not here discuss the well-known position which the Anophelines generally adopt in contradistinction to the Culicines; (see especially Prell 1917 p. 242) but only once more emphasize the peculiar position when they hang down perpendicularly from the cobwebs by only one claw of the forelegs. The animals are quite motionless and do not alter their position for many hours; the moment, however, the glass approaches the mosquito and the distance is diminished only a few inches we immediately see the hindlegs make oscillations and often describe circles in the air; if then the vessel is not rapidly put over the mosquito it takes the wing; unquestionably the long outstretched hindlegs are used as organs of feeling.

At first I thought that the number of mosquitoes which I should find at night hanging indolent from the ceiling would be smaller than by day; this may perhaps really be the case but after all the difference is but slight. On 10/VIII I marked the resting places of 40 *A. maculipennis*; time seven o'clock in the evening; the next morning at nine o'clock twenty-nine of the mosquitoes had not altered their places. I have got the impression that the females almost live their whole life in the cow-houses, only fly out of doors to pair and for the purpose of egg-laying; on calm evenings I have observed the mosquitoes from outside either fly through the open door or against the windows, but I have never been able to observe a flight from the stable into the open; Mr. Petersen writes to me that in the western part of

Jutland near Ribe he has made quite a similar observation; any general flight of Anophelin females in the evenings round the farms or under the large trees which are often found in the gardens near the farms I have never been able to observe.

7. Whilst the females, in my opinion, must mainly be regarded as stationary stable mosquitoes during the summer, the males are rare in the stables; I have never found more than about 10 % males; Mr. Petersen has come to quite a similar result. At Nysted (Lolland) I have in the middle of June observed the small swarms of males dancing behind and between shrubs; it was evening; sunset; the observation was made about fifty meters from the stable in which, at the same moment, about one hundred blood-filled females were hanging. Here too I had occasion to observe a few females steering their course into the swarms, but these females came from the outside, the swarms of males being between them and the stable; as far as I could observe without catching them they were all lank, without blood in the stomach. The observation of the swarming of the *Anopheles*-species is of some interest; it has hitherto been denied; recently it has been corroborated by Banks with regard to Philippine species (1919 p. 283).

8. I have never directly observed the females egg-laying; having often tried to see the process by day I am almost convinced that it takes place at night, and especially in the early morning hours. This is also stated by Levander (1902 p. 18). In my hatching cages the females never laid eggs in the day time, but the water reservoirs very often contained eggs in the morning. With regard to the structure of the eggs and the form of the egg groups I refer the reader to earlier authors. As far as I can see the eggs are often laid in the water reservoirs nearest to the farm; it is only the distance from the stable which determines their usefulness; the quality of the water is a matter of entire indifference to the mosquito. Any predilection for clean water I do not find. Hitherto I have never, as is the case with *C. pipiens* and *T. annulata*, found the eggs indoors in cemented water reservoirs but I should not wonder if this will be the case some day. I have found the larvæ in the dunghill pools lying only abt. 10 meters from the stable; in these pools a great many larvæ are hatched. In most of our villages we commonly find pools very rich in organic matter often covered with water bloom, our Danish "Gadekær"; generally they are bordered by grassy vegetation. In these pools I have always found the greatest number of the larvæ of *A. maculipennis*. I suppose that these pools are the nightly rendezvous places for all the egg-laying females from the stables of the village; that *A. maculipennis* should not be bred in polluted water is therefore not in accordance with my own observations (see Gaver and Pringault 1914 p. 401 a. o.). I may add that I have often found a large number of larvæ near the marshy borders of larger ponds or small lakes. What mainly characterises the egg-laying localities is that they are almost always sunlit, not dark as is mainly the case with many of the localities for *Culex*-larvæ.

9. As is well known a *C. pipiens* throws its eggs in egg boats; we suppose that every female produces about four eggboats. I regret that the far-branching

investigation of the biology of our mosquito fauna has not left time enough to study the egg-laying processes of *A. maculipennis* in a more thorough manner. From observations in my hatching cages, but never corroborated in nature, I have got the impression that also the eggs of *A. maculipennis* are given off if not in rafts, at any rate in series; that periods of egg-laying succeed periods in which eggs are not laid; how many of such periods exist in the life of an *A. maculipennis* I really do not know. At highest summer temp. I have observed that a blood meal almost disappears from the stomach in the course of about four to six days; when then opened, it has been shown that the abdomen was filled with eggs. I feel quite sure that from the moment of blood-filling and to the moment of egg-ripening the mosquitoes do not leave the stable, but it seems that they suck blood more than once. As mentioned above in my opinion they do not leave the stable except for mating and egg-laying, and it is most probable that, during flight, for one of these two reasons they do not suck blood. If this is right it means that *A. maculipennis* in most districts of our country does not suck blood out of doors. With regard to larva life I refer to *A. bifurcatus.*

10. It is a very peculiar fact that of the owners and inhabitants of about a hundred farms which Mr. Kryger and I have visited, more than ninety have not had the slightest idea that their stables contained mosquitoes at all. When we have asked permission to visit their stables they have invariably answered "we have no mosquitoes in our stables"; often the owners have been angry and said that they wanted to see the mosquitoes before they would believe it. It has always been rather a jolly moment when we studied their faces, after having presented them with some hundreds; their astonishment was beyond all bounds. A few of them were well aware that their stables were inhabited by mosquitoes, but these persons have always maintained that the mosquitoes which stung them in the forests and in their gardens were of another kind; that the mosquitoes of the stables were blood-filled they have never observed.

11. The most striking fact elucidated from conversation with the owners was that the mosquitoes of the stables never sting man. This is in full accordance with my own experience: I have never in my life been stung by a single *A. maculipennis.* Moreover, I have been sitting at the farms near the open stable doors, expecting that the mosquitoes would use me as a sucking object. I never succeeded. I have asked the herdsman, who was to attend the sows when they were to farrow and was therefore forced to lie as near as possible to the sow, if he had ever been stung by the mosquitoes. Even if the stables contained many hundreds, the answer was invariably "No". There is not the slightest doubt upon the point that the mosquitoes of the stables suck blood from our farm animals and not from man.

12. From this common rule we have only been able to get a very few exceptions. Mr. Kryger has shown that there is evidence that *A. maculipennis* at all events in two localities in Jutland still attacks man. In one locality the mosquitoes were caught while sucking and determined by him as *A. maculipennis*; in two other

localities as well as in the third, where the fact was ascertained, the nursery, the bedrooms and the servants' rooms were full of *A. maculipennis*; the people maintained that during night they suffered horribly from mosquitoes, and that their sleep was disturbed by the insects. It has been maintained that *A. maculipennis* everywhere round Silkeborg attacks man. This more especially holds good in autumn.

Most probably the statement is quite correct. For all three localities it can be pointed out that there is a want of cattle. In one locality, the great estate of Nørholm, the cattle was out of doors; the Anophelines have flown into the servants' rooms and satisfied their lust of blood on man; of the two other localities one, Silkeborg, is surrounded by water in an area where undoubtedly vast numbers of *Anopheles* may be hatched and where the number of cattle to nourish the number of Anophelines is but small; the third spot was at Gudenaa where the same is the case; here the house was in possession of a fish farm with large hatching ponds which contained plenty of Anophelin larvæ but no stock of cattle.

It seems therefore that in localities where special conditions prevail, *A. maculipennis* nowadays also attacks man, but we have here only to do with exceptions; the rule is that this is not the case.

13. As *A. maculipennis* is now ascertained to be an inhabitant of our stables, the question is if they may be regarded as quite harmless insects; I am not quite sure that this is the case. More than once we have explored stables which only contained two cows. When in such stables we are able to count about 100 *A. maculipennis* on a m^2 and may estimate the number of mosquitoes at many thousands, and 90 % of them are blood-filled, it may really be a question if the cow is able to produce the same amount of milk, whether the stable is mosquito-filled or empty of mosquitoes. If I estimate the amount of mosquitoes in such a stable at 5000 only, a number which is unquestionably too small, it means that about 5000 drops of blood are hanging on the ceiling and walls. If then I suppose that this number is almost unaltered from the 1st of June to the 1. Sept. and that the blood is renewed every fourth day — this is probably too little — this again means that the cows have been tapped of more than 100.000 drops of blood. If we further suggest that 100 drops are about 5 ccm blood, this again means that the mosquitoes have tapped the cows of 5 liters of blood during the summer. I suppose that this may be regarded as rather strong, at all events rather unnecessary, bleeding.

It may in this connection be kept in mind that quite similar calculations have been made by Wilhelmi (1917 p. 69) with regard to *Stomoxys calcitrans*, and that Bishopp (1913) for the same species and from explorations in North Texas has shown that loss of milk production owing to the same cause should be estimated at 40—60 %.

With regard to the Anophelines it may in this connection be remembered that a study of the literature from Grassi (1900) up to our own day seems to show that no conformity with regard to all indications as to the blood filling processes: — how often they take place; the relation between egg laying and blood filling; the influence of temperature, can be aquired, in the present state of our knowledge. I shall restrict myself to remarking that Martini (1902 p. 152) for North Germany indicates that at tp. of 20° C. in the rooms the blood sucking process takes place every fourth day till egg-laying, and that this goes on two or three weeks later on.

14. If now from a veterinarian point of view it will be admitted that the number of Anophelines in the stables has some significance, it may be added that it is very easy to destroy the mosquitoes; the best means are white washing of ceiling and walls, destruction of cobwebs, draught and light. The number of mosquitoes is always greatest in the dark, dirty, small stables without light and draught. In large, fine stables, well ventilated and white-washed the number of mosquitoes has certainly no practical interest.

It may also be added that the swallows play a prominent part in the destruction of the mosquitoes; where there are many swallows' nests, there are few mosquitoes. I have often seen them pick the mosquitoes away from the ceiling. On the other hand I have never seen the spiders destroy them and never found remains of them in the webs, even where the mosquitoes in huge numbers hang down from inhabited cobwebs; see also Knab (1912 p. 143). He mentions several other *Nemocera* which are also found there. Only the *Ceratopagonidæ* suck upon the prey of the Aranea; what the other Nematocera have to do there we do not know. That they should find any protection there I find quite improbable.

15. Being no veterinarian I only venture to suggest the question if the thought is quite unnatural that there may be occasions where the mosquitoes may be able to play a rôle as disease-carriers.

16. It is a well-known fact that entomologists who have been punctured by *A. bifurcatus* always maintain that the sting is much more painful than that of the Culicines; further that the effect lasts much longer. See also Nocht (1901 p. 908). My own experience goes in the same direction. Here as everywhere we often hear about venomous punctures of mosquitoes. It happens that quite suddenly many people suffer from such punctures; in 1920 the field workers on a large estate suffered greatly from venomous punctures of mosquitoes in September. In one of the above-named localities at Silkeborg the families and especially the children got one venomous puncture after the other and had to be treated by a doctor. In that very locality an Entomologist, Mr. Petersen, pointed out that *A. maculipennis* was to be found in the rooms. I should think that here we have to do with a case, worthy of special investigation.

17. From the Middle of Seeland as well as from Lolland I have gathered from twenty to forty females in the stables and examined the alimentary canal, but I have never seen cystes on the walls. As up to 1920 in the autumn I never heard of a single case of malaria which must be regarded as indigenous, I ceased to make these observations, regarding them as rather unnecessary.

18. Commonly *A. maculipennis* is sole master of the stables; only in spring *A. bifurcatus* arrives too. Especially in the autumn *C. pipiens* appears, but now and

then *T. annulata* may be present in relatively large numbers; these large mosquitoes, which, quite like *A. maculipennis*, are almost always blood-filled, resemble flies and are as sluggish as *A. maculipennis*. Also MARTINI (1920_4 p. 13) states that he has rather often found *A. bifurcatus* in stables.

19. With regard to the number of generations in our country we only know very little. The last broods of the last summer generation hibernate and most probably die out in June, living about eight months. The summer generation is born in June and produces a series of broods; that these broods again produce a new generation is in my opinion probable, but more than two generations a year I do not suppose will appear. KULAGIN (1907 p. 867) has arrived at a similar result with regard to Russia (one generation). PRELL (1917 p. 262) seems to be of a similar opinion: he says: "dass die *A. maculipennis* Larva verhältnismässig höhere Ansprüche an die Temperatur stellt als *Culex* und daher für gewöhnlich sich wesentlich langsamer entwickelt. Bei einer durchschnittlichen Tp. von 20° C. war eine Zucht allerdings bei schwacher Ernährung nach 5 Wochen noch nicht über das zweite Stadium gekommen". ECKSTEIN (1919_2 p. 94), MARTINI (1920_1 p. 63) indicate 2—3 generations at Strassbourg and Hamburg. Unquestionably the number of generations in the south is much greater. GRASSI (1900 p. 81) found that the development from the moment when the larva left the egg and to the transformation to imago lasted 30 days at tp. 20—25° C. Twenty days later these flies in turn laid eggs. In the long Italian summer there will certainly be time for a whole series of generations; this has also been stated for England by NUTTALL and SHIPLEY (1902 p. 68) and for Austria by KERSCHBAUMER (1901 p. 85).

If now we will summarise our knowledge with regard to the biology of *A. maculipennis* in Denmark nowadays, we shall arrive at the following remarkable result.

A. maculipennis is almost for the whole of its life bound to human habitats; in summer to the stables, in winter to outhouses, only leaving the houses for mating and egg-laying processes. It sucks blood upon the domestic animals, pigs, cattle and horses, not upon man; this is only the case where opportunities to suck blood upon animals are wanting or insufficient; nowadays the females are extremely sluggish, hanging blood-filled, often in incredible numbers, upon the ceiling and walls of the stables. They are hardly ever met with in Nature itself and as a rule they do not fly through the windows into the rooms in the evenings.

It is a well-known fact that malaria was formerly one of the worst epidemics we have had in this country. Its history here has been treated by C. A. HANSEN (1886) and by GOLDSCHMIDT (1886 p. 29). With regard to older literature I more especially refer to COLD (1857 p. 109). I shall here by no means enter into detail, but referring the reader to these papers only call attention to the following facts.

Before 1813 there had been some malaria attacks but hitherto they had not been very conspicuous. In 1826, after a very warm summer, a terrible epidemic broke out. On the island Langeland about one fourth of all the inhabitants were attacked; the leading physicians supposed that the whole generation of the period living in the middle part of Seeland would succumb. Again in 1831 the epidemic ravaged Denmark as one of the most terrible epidemics we have ever had; the term "Lolland fever" originates from that time. It lasted to 1834. In the years 1847—49; 1853—56, 1859—62 a series of smaller epidemics appeared. From that moment we observe an uninterrupted fall of the curve though with some undulations and a series of low vertices; nowadays endemic malaria does not exist in our country; from abroad cases of malaria have been brought in; in the year 1914, 33 foreign malaria cases have been treated; not a single one of them can be regarded as indigenous. It is a disease nowadays extinct in our country.

How terrible was the epidemic about 1830 will be seen from the following description (C. A. Hansen) (1886 p. 151): After a few days of a nasty smelling blighting fog in July the malaria suddenly attacked a very great part of the population. As by a flash of lightning several hundreds were attacked in all directions in the same parish. Upon Lolland there were two parishes with 2000 inhabitants of which 1800 were attacked and 98 died. The percentage of mortality was greater in the Cholera year 1853 when more than 50 % of the attacked succumbed, but the actual number of attacked persons was much greater in the malaria years. Suddenly during work in the fields the workers dropped down. The whole stock of servants even of larger farms and estates would be attacked simultaneously; the cattle could not be milked and any stranger who cared to was allowed to take the milk. In Maribo county (Lolland) 28,788 persons were attacked i. e. about half of the whole population; 1114 died. The malaria occurred mainly in the benign form, but also perniciosa occurred. The malaria devastated the whole country, especially Lolland—Falster, a district in Middle Seeland, North Seeland round Lyngby, the island of Langeland and the area round Silkeborg, Jutland.

It is very peculiar to see that in the same county where formerly more than 28,000 people were attacked in one of the large epidemics, the medical officer of the county was only able to count 300 attacks in the time from 1875—87, from 1887—1900 only 10 and after 1900 not a single one. Old people are still living who have either had malaria themselves or have given me the most vivid description of the disease and its general character.

If now we will try to combine the description of the disease in old days with what we nowadays know with regard to the transmission of the infection and with the biology of the Anophelines nowadays in our country, we shall see that these different facts, gained in very different ways, cannot be brought into connection with one another.

Before discussing the matter I wish to call attention to the following fact. Being no physician I am forced uncritically to accept the material at hand as it is.

I must take it for granted that the disease in the beginning and in the middle of the nineteenth century really was a true malaria, mainly benign, but partly pernicious. When however we read these reports on the old malaria epidemics we are, in my opinion, almost forced to direct our attention to several points which seem incompatible with our recent knowledge of the disease and its manner of infection. This especially holds good with regard to the extreme rapidity with which these old malaria epidemics by all accounts set in. When we hear that SCHAUDIN in St. Leme in malaria affected houses only found from 5 to 16 per cent. of the *Anopheles*-material affected, and that in Macedonia, a country which is infected to a very high degree with malaria, only 2 per cent. of the Anophelin material (MARTINI 1920_4 p. 72) is said to be infected, how is this compatible with the old reports that, as by a flash of lightning, several hundreds were attacked in all directions in the same parish and that whole crowds of working men in the fields suddenly dropped down sick to the ground. This in the first place presupposes myriads of clouds of infected Anophelines, and we may be permitted to ask from where these infected clouds suddenly came; further this suddenness is dependent on a remarkable simultaneousness in the attack which must have occurred before those meteorological phenomena (dense fog etc.) which are often tacitly regarded as partly responsible for the outbreak.

As however I have never seen any criticism of all these records of the old malaria epidemics, it is only with the greatest hesitation that I write the above lines. As matters now stand we are forced to regard all these accounts as really relating to malaria, leaving it to future research to add to this criticism or show it to be unnecessary.

If now we take it for granted that the old epidemics were true malaria, we are also forced to take it for granted that, as it is stated about the disease nowadays so in former days, too, it can only have been transmitted by means of mosquitoes; without having recourse to strict arguments of any kind it must be admitted that at the present standpoint of science this is the only correct point of view to set forth. It is one of the few cases in the kingdom of science in which the old word: blessed are ye who do not see and yet believe, is in accordance with the true spirit of science. If this is right, it must also be admitted that the sole mosquito which has been able to bring disease or death to so many people almost a century ago can only have been *A. maculipennis*. At the present time we have only three Anophelines north of the Alps, of which *A. nigripes* does not come into consideration as a plasmodium carrier, while *A. bifurcatus* as such is to a very high degree subordinate in significance to *A. maculipennis*. We are either forced to suppose that the malaria was transmitted by *A. maculipennis* a century ago or to accept a scientific absurdity e. g. that a century ago we possessed species north of the Alps which at that time transferred malaria, but which have now disappeared.

These considerations being correct the great question arises: Why has *A. maculipennis* in our country only three generations ago transferred malaria to man whereas nowadays it has not the slightest significance as a malaria carrier? The question however coïncides with another, often put: Why has malaria disappeared from our country? This question has been answered in very different ways. Disregarding a series of quite fantastic answers I only wish shortly to call attention to the following.

1. The number of Anophelines has regularly diminished in the course of years. This may be possible but, on the other hand, there is no doubt about the fact that every farm in our country has enough mosquito material to infect its inhabitants. German authors have arrived at a similar result (MARTINI 1920_4 p. 28).

2. The improvements in agriculture, especially the extensive drainage works, have dried up the hatching localities of the Anophelines. This may be possible, with regard to our country the answer however may be treated in accordance with 1. With regard to Germany MARTINI (1920_4 p. 22) states: "dass die Veränderungen der Wasserverhältnisse des Bodens es in erster Linie sind, die uns die Malaria vom Halse verschafft haben".

3. The quinine treatment of the disease has killed the parasites in man and the Anophelines have had no opportunity of getting parasites and of spreading the contagion (KOCH 1899 a. o.). This is unquestionably true; many physicians however maintain that the quinine treatment has indeed weakened the virulence of the disease especially near the northern limits of its area of distribution, but do not think that it can be made responsible for its total disappearance. (CELLI, SCHOO, SCHÜFFNER in ZIEMANN 1918 p. 109). They more especially call attention to the fact that the malaria is the same even in localities, where the farmers use quinine in abundance: It may f. i. be pointed out that even in 1918 about 5000 cases were to be found round Emden; (MARTINI 1920_1 p. 75). Further that formerly malaria has disappeared from certain areas, and that at a time when quinine treatment was quite unknown.

4. It has been stated that the improvement of the houses and dwelling rooms has played an essential rôle in diminishing malaria. In this supposition there is unquestionably some truth. MARTINI (1920_4 p. 22) says that formerly: "Knechte und Mägde in Verschlägen an der Diele schliefen, nach der auch die Ställe offenen Ausgang hatten und die Herrschaft in ähnlichen Verschlägen neben dem Hauptraum des Vorderhauses". Especially "die wundervollen Unterschlüpfe, welche diese Schlafstellen den Mücken boten und die von *Anopheles* wimmelten" are significant. Also in our country the houses have been of similar kind. Nowadays as the peasants live in houses of much better construction, as the admittance to the sleeping rooms is much more difficult for the mosquitoes, and the temperature in the rooms is lower, great outbreaks of malaria epidemics are rendered difficult. MARTINI (1920_4 p. 22) correctly remarks as follows: "Der Hygieniker versteht nun auch warum in ganz Deutschland die kleinen Leute die Fenster so ängstlich zuhalten, besonders abends und nachts. — Die alte Volksweisheit die vielleicht älter ist als selbst die Malariapandemien des letzten Jahrhunderts weiss, dasz durch die offenen Fenster abends

die Fieber hineinkommen und dasz in den Marshen die laue Luft der schönsten Juli und Augustabende giftig und krankheitsschwanger ist".

Even if all these considerations are correct, I for my own part am inclined to suppose that the improvement of our houses cannot be regarded as the main cause of the disappearance of the malaria. The number of Anophelines in the stables nowadays is too great for that.

5. Another explanation of the phenomenon that the malaria has disappeared from our own and adjacent countries is, that the mean temperatures of the summers of the last 150 years has by degrees been lowered. It is especially FLENSBURG (1911 p. 1244) who with regard to Sweden has shown that cold summers diminish the malaria attacks, warm summers accelerate them; a mean temperature of 15.3° C. for July always brings decrease or cessation, a mean temperature of below 15° C. cessation. For the marshy country at the North Sea MARTINI (1920_4 p. 27) states that: "angeblich eine Veränderung der mittleren Sommerwärme von 15 auf $16^1/_2$, also um $1^1/_2$°, in marschigen Gegend Epidemien erzeugen kann". Also MARTINI is therefore inclined to see in the low summer temperatures after 1870 a factor which has diminished the malaria epidemic. Formerly the Danish physicians, especially C. A. HANSEN, have arrived at similar results.

These observations are in accordance with those of JANCSO (1905 p. 624) who shows that if an *Anopheles* infected with malaria plasmodia is held at a temperature of 16° C. no cystes are formed upon the walls of the alimentary canal; the infection of the mosquito may take place at tp. below 16° C. but only if the tp. rises rapidly after the infection. It is in accordance with these observations that malaria hardly ever passes the July isotherm of 15—16° C. As *A. maculipennis* in our country is really near its northern limits of distribution, and we may have summers when the middle tp. of July does not rise to 16° C., it will be understood that climatic conditions in our country are able to produce undulations and changes in the virulence of the disease. Yet it may be admitted that JANCSO's statements have been a little weakened by KING (1917 p. 495) and WELCH (1917 p. 98) who show that the tertian parasites in *A. maculipennis* are able to endure, at all events for some days, a tp. of 35° F. for 17 a tp. of 46.

That there really exists a very close connection between the climatic and meteorological conditions and a new outburst of epidemics has often been pointed out in recent years. Especially the explorations of the SERGENTS (1903 a. o.) in Algiers have shown the very near relation between the degree of moisture of the air and the epidemics. The more moist and cold the summers in Algiers are the more serious are also the epidemics; for this country the explanation of the fact is that the burning African sun dries out the eggs and the larvæ do not develop. In our northern latitudes it is really the warm and moist summers which may be regarded as one of the main conditions for an outbreak of malaria. With regard to Germany MARTINI (1920_4 p. 21) comes to quite a similar result. He says: "Ich selbst bin davon überzeugt, dasz eine Senkung des Grundwasserspiegels nicht ohne eine erhebliche Verminderung der Mückenzahl abgehen kann besonders in den Marshen. Bringt doch auch ein trockener Sommer sofort ein Schwinden der *Anopheles*, wie dass letzte Jahr zeigte. Auch vom Ausland wissen wir, dass nasse Jahre Malariajahre werden".

6. A sixth explanation I have seen in print and also more than once heard expressed by physicians. It maintains that speculations as to the disappearance of malaria are of no particular interest. Like all the other great epidemics this has had its time of raging; its virulence is now over, its time has passed. — This explanation is in my opinion unsatisfactory. In its old area of distribution, where it has now mainly disappeared, it now and then breaks out again with epidemics by no means quite insignificant; in the southern part of Europe it is still in many localities a terrible scourge for the nations, and in many localities in the tropics horrible epidemics suddenly break out e. g. Sumatra (Schüffner & Swellengrebel 1917 p. 1) and California which have formerly almost been exempt from the disease, but where the rice culture has created new possibilites for the development of the Anophelines. — (Freeborn 1916 p. 247).

If now keeping in mind the above given facts 1—18 (pag. 163—176) with regard to the biology of *A. maculipennis* we will nowadays try to answer the question: why has malaria retreated in our country? why is *A. maculipennis* no more a carrier of malaria to man? the question may be answered quite satisfactorily for this little area. Because, according to its manner of life, it is nowadays quite unable to do so.

It will clearly be understood that a mosquito which generally only sucks blood upon our farm animals and not upon man, which is to such a high degree domesticated that during the blood sucking periods it takes its sojourn in the stables, which now appears as an extremely sluggish animal, only leaving the stables for the sake of mating and egg laying, is really quite unable to be the intermittent carrier of a parasite from man to itself; it is unable to create those mighty epidemics which formerly spread in all directions with the rapidity of lightning, and it is unable to keep even a relatively slight epidemic alive.

If however this is right it will be understood that the mosquito, if it has transferred the malaria to man in our country a century ago and does not do so now, must have altered its manner of life in the course of a century. The question is then, why it has done so. Before we answer this question, we shall call attention to the following fact.

The retreat of malaria in our country is, as well known, by no means a phenomenon restricted to these parts; it is common to the greater part of Europe, but especially to the part north of the Alps. In Norway it has always been extremely insignificant, if present at all. In Sweden just as in Denmark it was of an extremely dangerous epidemical character a century ago or more. It raged especially along the Gulf of Bothnia, round the large Swedish lakes and southwards; the epidemic lasted longer in Sweden than here, i. e. from 1875 to 1908 no less than 60.449 attacks are noted, then the curve falls rapidly; in 1909 only 45 cases are known and nowadays it may be said that it has almost totally disappeared. (FLENSBURG 1911 p. 1213).

In England the malaria was a real scourge a century ago; now England is almost quite free from malaria; it seems only that a few cases may still be noted in a few localities (Romney marsh). See NUTTALL & SHIPLEY (1901 p. 26); LANG (1918); CARTER (1919 p. 2605).

Also in France malaria has retreated, but still there are rather large areas where it is still prevalent but always in a very mild form (Bretagne, Vendée, Charente, Gascogne, along the Mediterranean coast, in the Valley at the Somme a. o. loc.) I refer especially to the papers of ROUBAUD. The case is the same in Holland, but small hotbeds of malaria are still present (SCHOO 1902).

In Germany malaria raged vigorously a century ago, now it has receded to a high degree; but still there are many localities, especially along the river valleys and along the coasts of the North See and the Baltic where malaria occurs; it may retreat for some years but on special occasions (vast inundations, great engineering works) it appears again. German physicians urge that even if the disease diminishes its significance can by no means be underrated; it reduces the mental and bodily power of man, and causes painful neuralgias which last throughout life. MARTINI (1920_4 p. 18) calls attention to the fact that: "Kinder erkranken häufig so atypish, dasz die anschlieszenden Kindererkrankungen nicht als das erkannt werden, was sie sind".

It is further stated that the farmers use quinine and only rarely apply to the doctors; it is therefore difficult to see how widely spread the disease really is. With regard to German and Austrian malaria from recent years I refer to CZYGAN (1901 No. 37) MARTINI (1901 p. 44; 1902 p. 147). PFEIFFER (1901 p. 246). GROBER (1903 p. 601). MÜHLENS (1909 p. 166; 1912). STORCH (1914 p. 77). MALISCH (1914 p. 763). EUGLING (1917 p. 65). STEUDEL (1917 p. 21). SCHAEDEL (1918 p. 143); I refer especially to the valuable papers of MARTINI (1920_1 p. 1 and 1920_4 p. 1).

Formerly the whole of Russia to the 63. degree of latitude suffered from the epidemic, and curiously enough in Finland rather serious epidemics still appear (se f. i. LEVANDER 1902 Nr. 3); more especially the districts of southern Russia round the Black Sea and the Asow Sea are attacked.

In Italy malaria has receded to a very high degree but this is mainly due to the very hard and extremely successful struggles of GRASSI and his school against the disease; still the number of cases especially in the southern part of the country is high.

On the Balkan peninsula it still rages with almost undiminished strength; in Grece alone there are nowadays about 800.000 cases yearly. The disease is here still of the greatest hygienic and economic significance. It is a well-known fact how terribly the oriental army suffered in the Balkans during the world war (NICLOT 1916 p. 753).

We now know that the European malaria mosquito which more than any other is the transferrer of malaria to man north of the Alps as well as south of the Alps, is invariably *A. maculipennis*; we must take it for granted that it transferred malaria north of the Alps a century ago and we know that it does the same south of the Alps this very day. Our question set forth on pag. 186 why it does not transfer Malaria any more in Denmark may therefore be amplified to: Why does it not with some few relatively insignificant exceptions transfer malaria any more over the whole of the central European plain and over North Europe as far as about the 63. degree of latitude. If the question be put in this form every one will see that the above-named old explanations are not satisfactory; this has also been clearly understood by almost all investigators from more southern countries than my own.

Just as in our country it has been thought that *A. maculipennis* was rather a rare insect everywhere. Fearing the outbreak of malaria from troops arriving from Nubia or the orient and coming back to their homes, or sent back as prisoners, the nations have during the war tried to clear up the conditions of new malaria outbreaks in their countries. In different countries the occurrence of *A. maculipennis* has therefore been studied. Curiously enough the attention has been directed specially towards the larvæ. Without entering into details I shall restrict myself to remark that in all explored areas the result is that want of Anophelines is never or very rarely found. I refer the reader to the following literature: Austriche: (STORCH 1914 p. 77); Suitzerland GALLI VALERIO (1917_2 p. 1566); France: ROUBAUD (1916 p. 203; 1918_2 p. 430); LÉGER and MOURIQUAND (1917_1 p. 16); PETIT and TOURNAIRE (1919 p. 332); LAGRIFOUL and PICARD (1918 p. 73); MANDOUL (1919 p. 779); Balkan: NICLOT (1916 p. 753); Germany: I refer only to the list of litr. in: MARTINI (1920_1). In England SHIPLEY and NUTTALL ($1901—1903_1$): LANG (1918). JARVIS (1919 p. 40) has pointed out that from Charing Cross as the centre and with a radius of nine miles *A. maculipennis* has been found in London itself in 16 localities. See also BACOT (1918 p. 241). That the summers should have been too cold over this vast area during the last century is impossible. That the quinine treatment of the nations should have been of such a perfect kind that malaria should have died out owing to this cause is, as far as I can see, a supposition which appeals less and less to naturalists and physicians the more southerly the area of exploration is situated, and less and less the more the matter is discussed owing to new experience. Even if the houses are nowadays better constructed everywhere and the mean temperature of June—July should be lowered, it is highly improbable that malaria from these causes should almost disappear from the half of Europe. It is therefore intelligible that in recent years new explanations have been tried.

I shall here mainly deal with one set forth by the best names (GRASSI, SCHAUDIN, CELLI, LAVERAN; see ROUBAUD 1917_2 p. 401 and 1920 p. 181). It maintains that the Anophelines of the North, owing to a natural or acquired quality have lost their receptivity with regard to the Plasmodia. This explanation was however subverted by ROUBAUD (1918_2 p. 430). He took Anophelines from Paris made them sting malaria patients, pointed out that they got cystes on the alimentary canal, made them sting himself and got malaria which, in spite of quinine treatment, persisted almost for two years. Quite similar experiments were made in other countries and always with the same results. The supposition that *A. maculipennis* should be divided in separate geographical and biological races some of which have receptivity with regard to Plasmodia, others not, is therefore unquestionably wrong.

It is also in accordance with the statement of ROUBAUD that the war with its transport of troops etc. has actually as was expected carried malaria into areas where it was not found; the troops have infected the Anophelines, after which these have brought the malaria to natives, who for a long series of years have never set foot on infected territories. I shall here not enter into details but only refer to the following cases which may be augmented with a long series of others; most of them derive from the west front or from England. JEANSELME (1916 p. 693); ROUBAUD (1917_1 p. 171); CAILLE (1918 p. 282); PÉJU and CORDIER (1918 p. 1039 and 1919 p. 23); PÉJU (1919 p. 1267); BRULÉ and JOLIVET (1916 p. 2304); JAMES (1919 p. 37). BACOT (1918 p. 241). MALONE (1919 p. 202). MACDONALD (1919 p. 669). ROUBAUD (1920 p. 181). DIBLE (1915 p. 577). ROBLIN (1919 p. 605). The interesting and very consoling fact with regard to all these cases is, that they never give rise to greater epidemics, and that from an epidemical point of view they have hitherto really been quite insignificant. CARTER (1919 p. 2605) states that though in 1917 over 10.000 infected men were imported there were only 231 cases of malaria contracted in England. In France only 258.

If however great numbers of malaria carriers were spread over areas where the Anophelines were abundant and, as we now know, able to be infected, the question arises why these malaria carriers have not caused great epidemics. Even the above cited new investigations have in my opinion contributed to its solution, but as far as I can see without the investigators having any intelligence of the fact themselves.

Already in the earlier entomological literature we find it stated that *A. maculipennis* does not suck blood; all these indications derive from the area north of the Alps. England: THEOBALD (1901 p. 194). NUTTALL and SHIPLEY (1901 p. 10). Austria: SCHINER according to SCHNEIDER (1914 p. 20). Germany: SCHNEIDER (1914 p. 21). Still in 1918_2 (p. 430) ROUBAUD maintained that the Anophelines in North France are only to a slight degree blood-suckers; it is very often stated that the mosquitoes of both sexes are flower visitors. These indications are unquestionably wrong, but still they contain a grain of truth.

Already in 1900 GRASSI (p. 82) pointed out that the Anophelines suck blood upon all mammifers also birds especially fowls; they show no particular predilection for man; if a horse and a man be placed in the same room, the horse will be attacked before the man, but if man and a rabbit are placed in the same room, it is man who will first be attacked. It is the volume of the evaporating smelling surface which guides the mosquitoes. Various authors further maintain that it is almost impossible to get the Anophelines to suck blood upon man. CELLI and GASPERINI (1902 p. 141) indicate only 35 p. 100, and the same authors maintain that in Toscana the Anophelines prefer cattle to man. The very same results were also arrived at by ROUBAUD who maintained that *A. bifurcatus* attacked in the open air, but this is not the case with regard to *A. maculipennis*. GILES says that in England it is only in hot weather that mosquitoes show any strong tendency to attack human beings. TÄNZER and OSTERWALD (1919 p. 689) have shown that *A. maculipennis* have abandoned the rooms and retreated to the stables; they suppose because the rooms nowadays are cleaner than formerly. JAMES (1919 p. 37) maintains that houses as a condition for visitation by Anophelines must have a large amount of domesticated animals. DOFLEIN (1918_2 p. 1214) shows that *A. maculipennis* is constantly to be found in stables. MÜHLENS according to MARTINI (1920_1 p. 60) has as stated above ascertained by means of the Uhlenhut proof, that the blood in the Anophelines of the stables really derives from swine and horses.

PRELL (1917 p. 242) has also arrived at quite similar results; his paper being one of the most instructive with regard to the biology of our two most significant *Anopheles*-species. According to him *A. maculipennis* is mainly to be found in stables, not so much in outhouses, mostly in the cow-houses, not so much in hog-pens; in the horse-stables they are most common in the clean well ventilated stables; just like myself, PRELL has seen that swallows in stables diminish the number of mosquitoes. They occur mainly on the ceiling, often in enormous numbers. He says: "In Abständen von knapp 1 cm, von einander sind sie dann manchmal unter möglichster Ausnutzung der Fläche so dicht und gleichmässig verteilt, dasz sie geradzu in Reihen aufmarschiert erscheinen und wie ein Schleier die Decke überziehen". He has further observed that the Anophelines hang down perpendicularly from the ceiling and use the hind-legs as organs of feeling; also that almost all specimens are blood-filled and that they are extremely sluggish: "Der vollgesogene Anopheles legt eine ausserordentliche Flugunlust an den Tag. Jagt man ihn auf, so fliegt er oft nur einige Cm., selten über einen Meter weit fort". In the stables the mosquitoes ripen their eggs; he has correctly seen that among the many red individuals also others are found which have an almost white abdomen, owing to the ripening eggs. — Curiously enough the main result of my own observations that *A. maculipennis* nowadays really may be regarded as a domesticated mosquito is not in accordance with PRELL's view: He says: "*Anopheles* ist eben keineswegs ein "Haustier" sondern eine "Wildart", die nur zum Blutsaugen in Ställe kommt und beinahe möchte man sagen widerwillig dort längere Zeit zurückbleibt". I regard it as highly probable that this supposition may really be correct for Wurttemberg where PRELL has made his investigations; for my country, nearer the northern limits of the distribution area of the species, it is not so, however (see later).

Among the many other observers from recent years who have arrived at the same results as myself, I especially refer to the following: MANDOUL (1919 p. 779); PÉJU and CORDIER (1918 p. 1039). PÉJU (1919 p. 1267). MACDONALD (1919 p. 669).

LANG (1920 p. 75). PRELL (1917 p. 244). VOGEL (1917 p. 1509) and hereto may also be added some remarks by MÜHLENS with regard to the malaria outbreak in Wilhelmshafen (1909 p. 169); MARTINI (1920).

Curiously enough in the great work: Studies in Relation to Malaria, the authors of the first part (NUTTALL, COBBELT and STRANGEWAY-PIGG) seem to show that they have never any idea of the occurrence of *A. maculipennis* in stables.

It will now firstly be understood that the main results of my own observations, that the Anophelines do not attack man, that they suck blood upon our domestic animals, and that they show a remarkable predilection for stables in comparison with our dwelling rooms have all almost simultaneously been corroborated by a great many observers; about the correctness of the observations there can now be no doubt. It may be regarded as a matter of fact that, what I thought had validity only for Denmark, is really valid for almost the whole of Central Europe, Great Britain, and for some few areas to the south of the Alps (Toscana). To me however it is rather a remarkable circumstance that of these many foreign observers all unknown to me, who have almost in some measure made my now published investigations superfluous, and among whom many understand that all the old explanations of the fact that malaria has receded from such vast areas of its former territories, are insufficient, no one, as far as I know, have understood what, in my opinion, must necessarily be inferred from all these investigations.

For it can now be proved that, over the vast area — more than half of Europe — where formerly *A. maculipennis* brought down disease and often death on mankind, the peculiar phenomenon now prevails of an Anophelism without malaria, already known as a remarkable exception in one of the fatherlands of malaria in Europe. From these many investigations, carried on independently by each investigator without any knowledge of the researches of the other workers in the same field, we are now able to show that the real cause why malaria has receded from the greater part of Europe is that *A. maculipennis* has lost its connection with man. If nowadays after the war no outbreak appears North of the Alps, this must in my opinion partly be referred to this fact.

Secondly it must be understood that over vast parts of distribution a change has taken place in the habits and biology of the mosquito within the last century. That this has been the case can in fact be shown.

Apriori it may be regarded as a matter of fact that when the Anophelines even nowadays in South Europe especially in the Balkans, but also in Italy, yearly transfers malaria to hundreds of thousands of people, it cannot live its life there as it nowadays does in more northern latitudes. In his excellent work GRASSI has elaborated the biology of *A. maculipennis* in an admirable manner: "He writes (p. 58) that during the summer months numerous specimens of *A. maculipennis* remain outdoors in Nature. p. 105 he further writes: "Die *A. claviger* stecken sowohl im Freien wie in den Häusern und in den Ställen. In den Malariagegenden wiederholt sich sehr viele Tage hindurch gegen Sonnenuntergang das Schauspiel unzähliger Schaaren von *A. claviger*, welche die sich an den Thüren unterhaltenden oder Abenbrod essenden Menschen angreifen. ... Im Freien können die *Anopheles claviger*, nachdem sie gestochen haben, auf die in der Nähe stehenden Bäume fliegen und sich dort verstecken. ... Die Mücken ruhen sich häufig auch auf den äusseren Hauswänden aus und bleiben dort mehrere Stunden sitzen, am nächsten Morgen aber sind sie nicht mehr verhanden. ... Wir sehen sie die Beute in von weniger oder mehr entfernten Orten her kommenden Schaaren anfallen. Im Allgemeinen steht fest dasz sie durch jene Fenster und jene Thüren in die Häuser ein fliege die nach der Richtung des Wassers liegen u. s. w." SAMBON (1901 p. 195) says as follows: "During summer the *A. maculipennis* do not seem to remain long in the houses and stables. Their number varies greatly from day to day in the same room. Fresh specimens arrive every evening, gorge themselves on the blood ... hide for some hours in the darkest corner they can find and go out again in the morning or the next evening". —

At Maccarese GRASSI says that in July at 21 t. 30 he has hardly been able to defend himself against *A. maculipennis*; this was the case whether he was in the house or out of doors. Also LEGER (1913 p. 41) records that he has caught *A. maculipennis* in many hundreds in the houses and on the railway stations in Corse. With regard to tropical Anophelines DÖNITZ (1902 p. 20) says: "dasz die Tiere sich sogar, nachdem sie sich mit Blut gesättigt haben, die Häuser welche ihnen nicht zusagen verlassen um sich in Freien zu verbergen. Already in Poland MARTINI (1920 p. 61) indicates that at sunset *A. maculipennis* was flying as well in through the windows as out of them. With these statements in mind the above-named differences between PRELL's and my views with regard to *A. m.* as a domesticated mosquito are intelligible.

From these indications we now learn that *A. maculipennis* at all events round the Mediterranean lives a life quite as we should expect the mosquito to live if it were to be able to transfer malaria to man. At any rate it is here to a rather high degree even nowadays an outdoor species which is on the wing to find its prey over rather considerable distances, and to a very high degree it sucks blood upon man.

It is thus actually proved that there is the greatest difference in the manner of life of *A. maculipennis* in South Europe and at the northern limits of its area of distribution. In my opinion it is neither quininisation of mankind alone, nor water drainage of the field, nor lowering of tp., but just this alteration in the biology of the species, the very peculiar transition from an outdoor species sucking upon man to a stable insect sucking upon our farm animals which has been the main cause of the disappearance of malaria from its northern limits.

The question now arises: what has caused this transition? I do not dare to solve it for the many foreign countries but I think I am able to do so for my own country. Only with some doubt do I now enter territories of human knowledge which have nothing whatever to do with limnology and only very little with zoology generally; we must now turn our attention to agricultural history, to the great changes in agriculture which our country has been subject to in the former century. I beg Prof. Dr. JOH. STEENSTRUP to accept my best thanks for the help he has given me upon this point. It is a well-known fact that in the eighteenth century, and still in the first quarter of the nineteenth, the swine were driven to the woods where they lived on mast; special swine stables were hardly known. Horses and cattle lived the greater part of the year out of doors, many of them the socalled "Udgangsög" (jades) the whole of the year. At that time Danish agriculture was based upon cereal culture; a little after the middle of the nineteenth century, after the establishment of cooperative dairies, the stress was laid upon the greatest possible production of bacon, meat, milk and butter. Then it was no more possible to let the farm animals live almost their whole life out of doors. Year after year the stables became better and better; larger and larger; the number of animals continually greater; the time in which the animals lived out of doors continually shorter; the hogs were almost all their lives bound to the hogpens, the cattle was often kept in the stables the whole year round or, apart from a very short summertime, driven into the stables before night. The stables were better and better lighted, during the last century often by electric light.

It will be clearly understood that this change in Danish agriculture must of course be of the greatest significance to the Anophelines; for during a great part of their flying time the large mammalia year after year disappeared from their flying areas. But not only the domestic animals disappeared, man himself by no means lived as much in the fields as hitherto; the agricultural machines make the extensive use of manual working power superflous. Where formerly at harvest time long rows of harvesters and harvest women could be seen in the fields for more than three weeks we now only see a few selfbinders going their way round over the fields.

But simultaneously with the disappearance of all warm-blooded animals from the fields, in our warm well-lighted stables we created refuges which acted upon the mosquitoes as large thermostats spread in many, many thousands all over the country; the odour from all the large animals streaming out on the still evenings through open doors and windows, the heat which thermically attracted the mosquitoes, and the light which attracted them phototactically, converted the stables for our Anophelins, which were on the wing in the evening in search of prey, into thermical and lighted traps by which the mosquitoes instinctively governed their flight. Inclosed inside the stables they found all that they wanted for their life: plenty of food, a suitable temperature, darkness and no draught; only the conditions for mating and egg-laying processes were wanting, but apart from them life in the stables was really possible for flying insects. Arrived in the stables and, owing to the much stronger odour and greater heat, attracted more by the large mammals than by man, the mosquitoes with great skill helped themselves to what was on the table. But simultaneously with that the connection between man and mosquito was broken, and malaria was bound to disappear from our country.

That there really is a connection between the alteration in agricultural methods and the disappearance of malaria is made highly probable by the fact that the rapid fall of the malaria curve coincides with the above-named alteration in agriculture during the period 1860—1880. It is this alteration which in my opinion is the real cause of the variation in their manner of life which the mosquitoes especially north of the Alps have undergone. — How little of mere theory there really is in the above-named facts will be seen if we study the new literature relating to the biology of mosquitoes. With regard to the influence of light upon mosquitoes e. g. *C. pipiens* and *A. maculipennis*, WEISS (1913_1 p. 12) calls attention to the fact that the mosquitoes only fly towards evening and are attracted by light of moderate power; this is corroborated by BENTLEY (1914 p. 9) who states with regard to the Anophelines in India that they are attracted by light. This is in accordance with the fact that the ravages of malaria are more severe in open villages than in those situated in forests; that hedges round the houses prevent malaria, that the strong light from the bungalows of the Europeans attract the mosquitoes. See also HOLMES (1911 p. 29) and MARTINI (1920_1 p. 21) who correctly states that the species in this respect differ very much from each other. With regard to the influence of warm air upon the Anophelines MARCHAND (1918 p. 130) shows that *A. punctipennis*, quite like *Stegomyia fasciata*, is guided by thermotropisms in its instincts with regard to bloodsucking; warm air which pours out from test tubes attract the Anophelines; this is not the case with all mosquitoes e. g. not with those of *Aëdes* (f. *A. sylvestris*); finally as mentioned above GRASSI points out that the Anophelines are attracted by the smell which radiates from animals, the more strongly the larger the animals are. WALKER and BARBER (1914 p. 381) have shown that the rôle played by a species of *Anopheles* in the transmission of malaria in any country is proved to depend chiefly upon (1) its susceptibility (2) its geographical distribution and prevalence (3) its avidity for human blood and (4) its domesticity: Whereas if the avidity for human blood diminishes, the rôle as a malaria carrier disappears.

When really *A. maculipennis* in the course of less than a century has been able to or perhaps rather forced to alter its life in our country the cause is in my opinion that here it lives near the limits of the northern area of distribution. The cold evenings in spring and autumn have most probable always been the time of the year, especially in a rather long series of years with lower mean tp., which have been difficult for the mosquitoes to pass through. Just at that time of the year, before the cattle is driven out of doors, and in the autumn where it is driven back to the stables we have in the middle of the last century created thermical refuges for the mosquitoes in the stables: I am inclined to suppose that in the more southern countries the time in which the mosquitoes have profited by the stables owing to the climatic conditions is much shorter than here. The length of time in which the mosquitoes year after year have been able to accustom themselves to the new life conditions is greater the nearer they are the northern limits of their area of distribution; in accordance with this the indolence and sluggishness and the diminishing life out of doors is augmented in the direction from South to North.

When further malaria has retreated almost completely from all countries north of the Baltic, two other reasons have cooperated. Simultaneously with the always increasing tendency to suck upon cattle the possibility to transfer malaria to man in the transition period where man as well as cattle was stung became always less and less owing to quininisation; the old malaria carriers died out and the number of new cases became fewer and fewer year after year. But also upon another point did the situation of our country near the northern limits of the area of distribution of *A. maculipennis* influence the rapid disappearance of malaria.

Till 1915 it was unknown whether the plasmodia were able to hibernate in the mosquitoes. This has been supposed and has been maintained even in recent years. Lenz (1917 p. 830) maintains that the scizonts circulate in the blood during the flying season of the Anopheline generation that has hibernated. In the case of later generations of Anophelines the conservation of the plasmodia is ensured by new infection. Steudel (1917 p. 21) maintains that among the hibernating Anophelines in a locality on the east front there was a large number of carriers. As far as I can see, the indications by Lenz and Steudel have not been scientifically elucidated. On the other hand Mitzmain and Roubaud have shown that hibernation does not take place in the mosquitoes.

Mitzmain (1915 p. 2117) showed that with regard to *A. quadrimaculatus* this could not be the case. Of 1100 specimens, gathered in negro barracks inhabited by malaria patients, the intestines of all 1100 were quite free from cystes during the winter. The first cystes appeared on 15. May. More thorough investigations in 1917_1 (1917 p. 29) show quite the same thing. In 2.122 hibernating Anophelines not a single individual with cystes could be pointed out; simultaneously Mitzmain shows that in exactly the same area, of 1.184 persons 492 have malaria; the first infected Anophelines do not appear before 15.—26. May. In 1917_2 (p. 1400) Mitzmain shows that low temperatures during the hibernation destroy the cystes, and are a hindrance to the development of the sporozoits in the cystes. In other words, mosquitoes which have got blood with gametocysts during the winter will be sterile during hibernation.

The above-named results of Mitzmain are in full accordance with the results of the investigation of Roubaud (1918_1 p. 264) that in *A. maculipennis* infected with malign tertian malaria the sporozoites will be destroyed if they are not very soon carried out with the sputum; further that they are discharged through a relatively small number of punctures. In 1918_2 (p. 430) Roubaud then showed that hibernation also in the salivary gland is an impossibility. The Anophelines which he infected in October, and which in March—April during the hibernation only got water, did not show the slightest sign of infection. He maintains that at all events in France, and that most probably means in all more northern countries, the plasmodia are only able to hibernate in man and not in the mosquitoes. REGENDANZ (1918 p. 33) comes to a similar result. He maintains that the temperature needed for the plasmodia to develop in the mosquitoes in Roumania is not reached before the end of June when the day tp. was usually over 25° C. and the night tp. was only exceptionally below 16° C.

It will clearly be understood how significant these indications really are; and this especially holds good the nearer we are the northern limits of the area of distribution. For it means that the Anophelin material, every year before the blood sucking period begins, is totally free from plasmodia. Those which had plasmodia before the winter are now free, and the new brood will as imagines be born quite as free from plasmodia as their mothers were. Only when sucking upon malaria patients will the Anophelines get plasmodia; the hibernating females perhaps a second time; the harvest of the summer the first.

Those Anophelines which begin their blood-sucking period in spring are always free from malaria; it is man himself who year after year must infect the Anophelines again if the disease is to be spread. The longer the winter is, the smaller is also the chance of a serious infection of the Anophelin material; the shorter the time of the summer in which the temperature is above about 16° C., the smaller is the chance of the development of gametocysts, even if the Anophelin material has been affected. It will be clearly understood that just at the northern limits of the area of distribution, where the whole period of bloodsucking is restricted at most to five months, it is of the greatest significance that the summer campaign of the mosquitoes begins with uninfected material. Just here a treatment with quinine will in a comparatively short time restrict the chances of disseminating the plasmodia, especially because the Anophelines are inclined to prefer the blood of domesticated animals, and in this way loosen the ties which connect them with man.

The question is now whether the view which I maintain with regard to the retreat of malaria from our country also holds good with regard to the vast foreign territory, from which it has also almost entirely disappeared. I suppose that the same theory also holds good with regard to Sweden, but I do not venture to form any opinion with regard to the other, southern countries. I only wish to call attention to the fact that in South Europe where *A. maculipennis* still attacks man, horses and cattle as far as I know live out of doors most of the year, and the stables are not so large, so closed and so sheltered as in our country; the difference between the temperature out of doors and in the stables is not so great.

There are still some few points to discuss with regard to the biology of the Anophelines living near the northern borders of the distribution area, and North and Central-European malaria. As mentioned above, even nowadays small epidemics of malaria now and then break out in the regions round the Baltic or North Sea. (Holland, Ditmarshen, Wilhelmshafen, Finland); only Sweden and Denmark have been spared. The curves of these epidemics are very peculiar. Already C. A. HANSEN showed that the climax of the malaria curves with regard to the old Danish epidemics was in May, and FLENSBURG has shown the same with regard to Sweden; it was and is even nowadays the same with the greater part of Germany. (See especially MARTINI 1902 p. 147). On the other hand in Italy the climax lies in Aug.—September. In all cases we have to do with the curve of fresh cases (not relapses) and with tertian malaria. ZIEMANN (1918 p. 123) points out that it seems as if the climax of the curve the nearer we get towards the north, has a greater and greater tendency to be displaced towards the left side. KOCH (1899), who is well aware of the phenomenon, supposes that it must be understood as follows: The inhabitants north of the Alps, by heating their houses, create in them temperatures for the mosquitoes lying above the temperatures to which the mosquitoes in more southern countries are exposed at the same time of the year, and temperatures by which it is possible for the parasites in the mosquitoes to develop.

SCHOO (1902 p. 1343) has arrived at quite the same result: He shows that Anophelines caught indoors in Holland, and which were freshly infected, got "Sichelkeime" in the course of twelve days. It was only necessary that the mosquitoes, immediately after the infection, only for two days should be exposed to a tp. of 25° C. If this was the case the tp. might sink from 22 to 10° C. without damage to the parasites. At a constant tp. of 18° C. the parasites in *Anopheles* used 18 days for development and at 30° C. only ten.

The suppositions may have been correct for the old malaria epidemics north of the Alps; it is also possible that they hold good for the smaller epidemics in Holland and Germany at the beginning of the last century. But I venture to remark that if we in our country should get another malaria epidemic and the curve should show the vertex in the same place (in May) as in the curve for the old epidemic in the middle of the ninteenth century, this explanation could not be used. — Our Anophelines do not hibernate either in dwelling rooms or in stables, they hibernate in outhouses and similar localities; here they hang till the latter part of April, not leaving the hibernating places to enter our stables before then. They do not begin to sting before the middle of May. For Finland LEVANDER states that the Anophelines do not arrive in the rooms before the first days of July. It must be taken for granted that they all are free from plasmodia and first must infect themselves. That an Anophelin material of this kind should be able to cause a climax of the curve already in May is highly improbable. On the whole I am not quite sure that the explanation of KOCH and SCHOO of the malaria curve for North Germany and Holland really holds good. Further explorations are desirable. — It must be remembered that we have not the slightest understanding of the fact that the enormous amount of Anophelines which are hatched during summer, and in comparison with which the hibernating material is only a very inconspicuous fraction, does not seem to influence or to have influenced the malaria curve in any way. From our present knowledge of the malaria-plasmodia and the Anophelines we are able to understand a malaria curve with its climax in August, such as is the case with Italy, and a curve with two climaxes, one lower in May, and a much greater in August—September.

Curves of this kind are in fact pointed out for several epidemics north of the Alps (Ditmarshen 1842 bis 63; Doose in Hirsch 1881 p. 175); Wilhelmshafen (Wenzel 1870 p. 28) but they are not the rule. The very curve which in my opinion we are not able to understand, a curve with only one vertex lying in May—June, is that which seems to be the rule for all epidemics north of the Alps. It is only intelligible on two assumptions, which in my opinion are both equally improbable. The one is that the Anophelines of the summer have sucked parasites into the intestine, have formed their oocystes and hibernated with them on the walls of the intestines and then in spring infected man. This is improbable according to all more thorough investigations, which seem to show that the parasites hibernate in man and not in mosquitoes. — The other assumption is that the summer-broods really give malaria to man but that it is latently present till May; man lives with the parasites during winter, but the outbreak does not take place before May. This indeed is by no means in disaccordance with the nature of malaria; it is a well-known fact that a very long time may pass before a malaria attack produced either by external or internal, physic or psychic conditions, really breaks out. See e. g. the report by Kirschbaum (1917 p. 1405) on the malaria outbreak in North West Russia in February in ice and snow. Quite a similar result is arrived at by Werner (1917 p. 1375). Yet also this supposition must be regarded as an absurdity. For we are quite unable to understand why the malaria transferred by hibernating mosquitoes in April—May invariably should be able to influence the curve after the course of a few weeks and produce the high-lying vertex in the course of only a few weeks, whereas that malaria which is transferred in the summer months does not in any way influence the curve before eight months later; if the summer-generations had transferred malaria we should have expected a second vertex on the curve a few weeks later. See also Martini (1920_1 p. 69).

Zieman has pointed out that if there was any possibility that the Anophelines infected themselves, that the parasites from the mother mosquito were transferred to the eggs and from them through larvæ and pupæ into a new generation, the malaria curves would be more intelligible. As well known, both Schaudin and Doflein (1916 p. 933) have reckoned with this possibility. Moreover the supposition is allowable because others of our great parasitical diseases, e. g. Texas fever, really are spread in this manner. As far as I can see here is really a point where more thorough investigations are desirable. But even if it should be shown that the Anophelines are able to infect themselves this would not help us in our case. For north of the Alps we have really only one malaria carrier i. e. *A. maculipennis,* and even this species hibernates as imago and the new broods do not appear till simultaneously with or after the climax of the curve has been reached.

Coincident statements from almost all countries further show that the malaria epidemics, like almost all epidemics, occur in time-waves of different length. It seems that these waves occur almost simultaneously over a great part of Europe; it further seems that these waves come a little later to the northern countries than to the more southern ones. Great malaria waves occurred in 1812—16; 1819—21; 1830—32; 1846—48; 1853—62; from that time on it has, with a few exceptions, almost disappeared from the area north of the Alps. Nowadays these waves can only be understood in this way that the Anophelin material was also affected periodically; we must suppose that in four or five periods of about two to six years, the Anophelin material was affected by plasmodia; during the trough of the curves the Anophelines have not been attacked or only to a slight degree; even if we are now able to show that the great malaria years coincide with high temperatures and great humidity of the air, it is rather difficult to understand that these variations in external conditions are able directly to influence the actual percentage of mosquitoes attacked by plasmodia.

With regard to our own country it is very difficult to understand from where the enormous amount of infected Anopheles material which must be regarded as a condition of the great malaria epidemics formerly, was derived. This more especially holds good for Lolland and Falster, islands with very few lakes and moors. We must suppose that a large amount of larvæ have been hatched along the shores of the Baltic. It is a well-known fact, that *A. maculipennis* does in fact breed in brackish water. Levander (1902 p. 10) maintains, that the predominating breeding places for the Anophelines in Finland are the small bays of the Gulf of Bothnia, and still in 1919 I myself found many larvæ of *A. maculipennis* in the small secluded bays on the southern coasts of Lolland.

I have in the above only wished to call attention to the incongruity between curves and our present knowledge with regard to plasmodia and mosquito life. Perhaps the whole question is not of much consequence; how great credence we can give to these old curves is doubtful; and with regard to new ones, they will most probably be very difficult to use as working material, because they will be influenced by the fight which we shall take up against the disease. If these investigations are carried on, especially in North-Germany, it would be of interest to find out whether it was only the hibernating Anophelines which in early spring sucked upon man, where as the summer generations sucked upon cattle. If this should really be the case, the peculiar malaria-curves in North Germany would be more intelligible.

Whether we consider the malaria curves from the single years or the curves for the whole of the last century we shall almost be forced to assume, more especially with regard to the northern limits of the distribution area both of the Anophelins and of malaria, that, in our knowledge of malaria, there still remains something unknown. This has also been corroborated by others. The old question of Baccelli: "Gesetzt die Stechmücke infiziert den Menschen und der Mensch die Mücke, wer infiziert sie beide" (Grassi 1901 p. 199) has in my opinion not been answered yet.

When this chapter was written and used for a discourse in the Royal Society of Copenhagen in Ápril 1920, Prof. C. J. Salomonsen kindly called my attention to a new paper by Roubaud just published. To my great satisfaction I saw that in our main results we coincide upon almost all points. As however Roubaud and I have approached the subject from quite different points of view, our two papers supplement each other in a remarkable manner.

As a foundation for Roubaud's elaborate and highly meritorious work lies the idea of studying the "rapports nutritifs des Anophèles avec l'homme et les animaux" (1920 p. 187). Originally this was never my intention. During my studies relating to the biology of the mosquitoes I was of course also in search of *A. maculipennis*; struck by the peculiar fact that I never could find it in Nature I accidentally found it in a stable; in spite of my very cursory knowledge of Danish malaria and my being without any knowledge of foreign malaria, my whole knowledge being really restricted to the fact that malaria was formerly a terrible disease in our country and had nowadays disappeared, I, in the course of a few days, understood that here most probably was a possibility of understanding the main causes of the peculiar disappearance of the disease. — On very many points Roubaud and I coincide, upon a main point we differ, and in the main result there is some discrepancy; this is however only apparently, and is due to the fact that our areas of exploration are in different latitudes; in my opinion our results really coincide.

Roubaud has in two localities examined the relation between the Anophelines upon one side and cattle and man upon the other; one locality is the Vendée region, the other the environs of Paris. It has formerly been remarked that *A. maculipennis* is almost domesticated in Vendée, a locality which may be regarded as classical with regard to malaria, whereas it rarely approaches man in the neighbourhood of Paris. This different behaviour of the mosquitoes in these two localities has been explained as a result of the climate.

Even though this may be correct it must however be kept in mind that malaria has raged and does so still in various regions of northern Europe, where the temperature is much lower than that of la Vendée. The main question, therefore, which Roubaud tries to solve is: Why is *Anopheles* domesticated in Vendée, tormenting man and transferring malaria, whereas in the environs of Paris it has no connection with man. — Perhaps I may here insert the remark that even if I have commenced my investigation with the study of malaria, I have not been able to solve this or a similar question, nay not even try to set it forth, because in our country we have no malaria anywhere and because, as far as we know, *A. maculipennis* is spread over the whole country almost in an equally large number. If now we compare the results of ROUBAUD's investigations on the life-history of *A. maculipennis* with mine, we shall find great coincidence.

He calls attention to the enormous amounts of Anophelines on the ceiling and walls of the stables; they are rare in houses which are not inhabited by man or cattle; here we only find some males; in the stables they originally only sought shelter; now they also look for nutriment there. Even in houses which only contain the stable and a single room for the inhabitants, almost all the mosquitoes are to be found in the stables; there are none or only a very few in the room. Man is not attacked by the mosquitoes; they only suck blood upon the domestic animals; the few mosquitoes which can be caught in the dwelling rooms have almost always empty stomachs, those in the stables are almost always blood-filled (never any less than 40 % and often over 90 %). In all these main points there is full accordance between the statements of ROUBAUD and myself; it must only be remembered that ROUBAUD has only studied the biology during summer and not like myself followed the life-history the whole year round. His indications that the Anophelines do not occur in non-inhabited rooms are most probably only correct for the time he has studied the mosquitoes; at all events in our country the Anophelines entirely disappear from stables and inhabited rooms in the six winter months, the hibernation taking place exactly in outhouses, unoccupied rooms; the presumed cause is indicated on p. 164.

The most striking difference between ROUBAUD's and my results is that the Anophelines of Vendée are very active animals out of doors. However favourable the conditions for nutrition may be on the spot where the female has spent the period of daily rest, this is always abandoned for flight in the open air at night, so that a new host must always be found for the meal before the next day's rest. The Anopheline-population of any given shelter is therefore entirely or almost entirely renewed every night. If therefore all the Anophelines present in a certain building were captured and destroyed several days in succession, provided that the host conditions are favourable, the numbers would be constantly replaced, probably without any noticeable modification of the total. It has been proved by marking some thousand individuals that the Anopheline fauna of any given spot, however densely populated it may be, is entirely renewed within a few days; the regular flight in the open directly observed during night by ROUBAUD has been proved to be indispensable to the life of *A. maculipennis*. It will be understood that ROUBAUD and I have arrived at quite opposite results upon this point; in Vendée the Anophelines are on the wing every night during the summer, in Denmark hardly ever, and only for mating and egg-laying processes; I have hardly ever caught an *A. maculipennis* out of doors. I am sure that both our observations for each country are quite correct. The Anophelines of Vendée and Denmark differ from each other upon this point in most localities; (Silkeborg?) the difference is due to the much colder night in Denmark than in Vendeé.

Like myself ROUBAUD sees the main cause of the phenomenon of Anophelism without paludism in the secondary adaptation of this species to animals, especially in countries where domestic cattle are abundant, whereas the Anophelines as I have supposed for Silkeborg, also in France, in territories where the amount of cattle is small, and where vast numbers of Anophelines are hatched, attack man. He says that in the Vendée region two different sets of conditions occur; in the dry districts where the Anopheline-density is not very great, the existing mosquitoes find sufficient nourishment in the cattle of the district; man is practically free from attack and may even be unconscious of the presence of large numbers of mosquitoes in his near vicinity; while in the marshy districts, where the Anopheline density is too great to find adequate nourishment in the cattle present, man is undoubtedly attacked, but even then the Anophelines seem to bite with repugnance and without entirely satisfying their hunger. The conditions in the Paris region offer a close analogy with those of the non-marshy regions of la Vendée. namely the occurrence of Anophelines in fair numbers, characterised by the exclusive adaptation of *A. maculipennis* to bovine hosts which are present in sufficient numbers. So complete is this adaptation that the presence of the mosquitoes often passes entirely unnoticed by man; it is this last case which nowadays is the rule for our own country. — In a very convincing manner ROUBAUD shows how malaria epidemics, the result of abnormal frequency of contact of *A. maculipennis* with man, may suddenly arise in a region well stocked with cattle, merely in consequence of an increased number of breeding places due to flooding, and a consequent increase in the Anopheline population, requiring greater nourishment. This has been known to occur in la Vendée. Further the immigration of small settlements of people with but little cattle into a marshy zone, previously uninhabited, may give rise to the outbreak of fresh malaria epidemics. This explains the occurrence during the war of several small foci of indigenous malaria, reported from districts poor in cattle.

As a final result of his explorations ROUBAUD says on p. 222: "La constitution dans l'Europe agricole d'une race d'A. maculipennis essentiellement adaptée au bétail, a permis, pour le plus grand bien de l'éspèce humaine, la disjonction des rapports habituels de l'Anophèle avec l'homme. Cette variation physiologique n'a pas influé, d'autre part, nous l'avons vu, sur la réceptivité de la race anophélienne à l'égard de l'infection malarienne. Aussi la possibilité d'injection des Anophèles subsiste-t-elle entière. Mais pratiquement, au point de vue humain, le résultat favorable n'en a pas moins été acquis, puis qu'en modifiant leur habitudes de nutrition primitives aux dépens de l'homme, les Anophèles des régions à bestiaux ont brisé le cycle fermé des parasites malariens".

It will be seen that ROUBAUD's view and mine almost coincide. The total disappearance of malaria from our country demands however another explanation than that given by Roubaud; such an explanation I have tried to give but I do not know for how wide areas my explanation holds good (p. 182).

Upon one of the last pages in his work Roubaud and according to him les Sergents (p. 222) has corroborated an idea which I have had but which I was unable to verify. Roubaud has pointed out that the specimens of *A. maculipennis* from more northern latitudes are of greater size than those in more southern countries. It seems therefore, that the secondary adaptation of the species to animals in countries where domestic cattle are abundant, has produced a particular race of mosquitoes, which is distinguished not only by its tastes and affinities but also by its greater size.

Most probably Roubaud's indication is really quite right. In this connection I take the liberty to call attention to the following fact. If we nowadays from our country compare long series of *A. maculipennis* with those of *A. bifurcatus* there is no doubt that the first named species is longer and larger than *A. bifurcatus.* This is also indicated by Theobald. According to him *A. maculipennis* measures 6 to 7.5 mm. *A. bifurcatus* 5 to $5^1/_2$ mm, with proboscis 8—$8^1/_2$ mm. If we however take the old descriptions by Zetterstedt and Meigen we shall find that the contrary is the case; here *A. maculipennis* is indicated as shorter than *A. bifurcatus.* Meigen states (1818 p. 11) for *A. maculipennis* 3 lin. for *A. bifurcatus* $3^1/_2$ lin. Zetterstedt (1850 p. 3467) for *A. maculipennis* $2^1/_2$—3 lin. for *A. bifurcatus* 3 lin. Nowadays there is not the slightest doubt about the fact that the common size of *A. maculatus* in our country is between 6.5 to 7.5 mm. and that the species is larger than *A. bifurcatus.* If the indications of the length of the two species by Meigen and Zetterstedt are really correct, it seems therefore that the average length of the species has really increased in the course of the last century near the northern limits of its area of distribution. This is only what we might expect, according to Roubaud's and my own statements, Meigen and Zetterstedt having measured the mosquitoes at a time when *A. maculipennis* was no sedentary stable mosquito but, as nowadays in the Mediterranean countries, a free flying mosquito.

Roubaud is inclined to regard the variations in the habits of *A. maculipennis* as "une évolution lente et durable des habitudes alimentaires d'Anophèle c'est-à-dire d'une évolution d'habitudes acquises". I do not agree with Roubaud upon this point. Firstly I wish to remind the reader of the fact that all mosquitoes have unquestionably, from originally being flower visitors, in the course of time altered their habits and, with regard to the female sex, are now in many species and genera blood suckers. This biological variation is much greater than that which *A. maculipennis* has undergone with us. Further it must be remembered that *A. maculipennis* is by no means the only mosquito which has altered its habits over part of its area of distribution; the same is said to be the case with *C. territans,* which is a very angry bloodsucker in America, but does not attack man in Central Europe (Schnei-

DER 1914 p. 46). We have seen that variation in habits has most probably taken place also with *C. pipiens* and *T. annulata*.

I suppose that the whole question with regard to variation in bloodsucking habits in mosquitoes must be regarded from the same point of view, viz. that species with a wide area of distribution are not forced to live their life in quite the same manner as those of the northern and southern limits of their area. Further that when some species are carried out of their normal distribution-area and are suddenly forced to live in another area, their biological range of variation is so great that they are able to begin life again under other conditions than those to which they were originally adapted, and in the course of a short time conform their whole organism to the new claims. Finally when a new factor appears in their old distribution area and disturbs the once-sanctioned order of environment, the organisms are to a certain degree able to accomodate themselves to the new factor and this latter again is able, to a degree which almost seems incredible, to alter the biology of the said species.

The peculiar fact that many hymenoptera of the order Fossoria use different forage for their young ones and use the paralytical instinct here and upon Corse in different ways (*Bembex* a. o.); the variation in instinct from fruiteaters to bloodsuckers of the Nestor parrots of New Zealand; the variation in instinct of the Australian Dingos, the variation in instinct in the biology of different species of beetles (*Haltica*, *Anthrenus*) which, suddenly transferred from the old world to the new or vice versa, grow to be noxious animals of great economic significance in their new home, whereas in their original home they are quite harmless animals; the alterations in the biology of the swallows which, from being originally inhabitants of rocks and mountains nowadays owing to the building of castles, church steeples etc. build their nests upon or in our houses over vast areas of distribution; the variation in the life of *Turdus merula* in the last generation of man, are all examples of the same above-named common rules. With regard to the Anophelines the above named changes in the agriculture of our own and adjacent countries was the new factor which in our latitudes altered the biology of this Anophelin species.

When I consider the malaria curves in the time from about 1830 to 1900 and see how rapidly the curves fall and remember that malaria has disappeared from our country in the course of only one or two generations of man, I find that the variations in the habits of *A. maculipennis* have taken place not as an "évolution lente" but very suddenly and with an almost incredible rapidity. From ROUBAUD's investigations we are entitled to suppose that the variation in habits has at all events also affected the animal morphologically; if this holds good for more than the size we do not know; a more thorough investigation of the mouthparts, especially the number and size of the sawteeth on the maxillæ which are in fact subject to variation, would most probably give interesting results. I think that it must be admitted that in the variation in the habits of *A. maculipennis* there really is a basis for the origin of a new type which, in the course of time, may perhaps lose its connection with the maternal species and give rise to a new one.

Nowadays I am inclined to see in our *A. maculipennis*, neither a subspecies nor variety or race, but only stocks of individuals geographically and culturally bound, stocks which nowadays play upon other strings of their life instrument than those usually used. If we get similar life conditions as in the first part of the former century they will however immediately revert to their earlier manner of life. It is by no means an "évolution durable" it is an utilisation of other physical and mental properties but no "evolution d'habitudes acquises". Actually the connection with man is nowadays in the main broken in our latitudes but the circle can be closed again. The probability of the great epidemics occurring is really very small but the deep lying real life conditions for these epidemics are the same nowadays as formerly in as much as they are dependent upon the Anophelines.

Postscriptum.

After the printing of the greater part of the manuscript of the *Culicines* I got from Dr. E. MARTINI his excellent papers relating to the classification and biology of German mosquitoes. I am glad to see that in many respects we fully agree. Only with regard to the synonymy there are, as might be expected, great differences. In the following I have tried to collate Dr. MARTINI's species with mine; I suppose that the references will almost all prove to be correct, because, according to a letter to me, Mr. EDWARDS has arrived at quite the same result.

I add some biological remarks taken from the work of Dr. MARTINI, especially those which supplement my own observations or which strengthen my views where this seems to be desirable. With regard to the *Anophelines* the work has been consulted in the foregoing pages.

Martini.	**W.-L.**
Aëdes cinereus Mg.	*A. cinereus* Mg.
— *lateralis* Mg.	*Ochlerotatus lateralis* Mg. (?)
— *serus* Martini.	— *diantæus* H. D. K.
— *diversus* Theob.	— *rusticus* Rossi.
— *nemorosus* Mg.	— *communis* Deg.
— *sylvæ* Theob.	— *punctor* Kisby.
— *terriei* Theob.	— *salinellus* Edw.
— *salinus* Fic.	— *detritus* Hal.
— *nigrinus* Eck.	— *sticticus* (Meig.) var. *concinnus* Steph.?
— *annulipes* Zett.	— *lutescens* Fabr.

Martini.	W.-L.
Aëdes cantans Mg.	*Ochlerotatus cantans* Mg.
— *abfitchii* Felt.	— *excrucians* Wlk.
— *quartus* Martini.	— ?
— *dorsalis* Mg.	— *caspius* Pallas.
— *rusticus* Rossi.	— *diversus* Theob.
— *vexans* Mg.	— *vexans* Mg.
— *lutescens* Fbr.	— *lutescens* Fabr.
— *ornatus* Mg.	— *Finlaya geniculata* Oliv.
— *rostochiensis* Martini.	— *prodotes* Dyar.
?	— *annulipes* Zett.
	— *curriei* Coquillet.
Culex pipiens L.	*C. pipiens* L.
— *territans* Walker.	—
— —	— *nigritulus* Zett.
Theobaldia annulata Schrank.	*T. annulata* Schrank.
— *glaphyroptera* Schiner.	— —
— *morsitans* Theob.	*Culiseta morsitans* Theob.
— *fumipennis* Steph.	—
Mansonia Richardii Fic.	*Tæniorhynchus Richardi.* Fiç.

It is of particular interest that the whole new mosquito fauna which I have detected here in Denmark has now also been found in Germany; Martini mentions five species: *A. lateralis* Mg. *A. quartus* n. sp. *C. territans* Wlk., *T. glaphyroptera* Schiner and *T. fumipennis* Steph. which we have not found here in Denmark. Of these species *A. lateralis* Mg. and *A. quartus* n. sp. are most probably very doubtful species; this especially holds good for the first named. In our country we only lack *C. territans*, *T. glaphyroptera* and *fumipennis*. *T. glaphyroptera* cannot be expected in our country, but there is no doubt that the two others will be found. Most probably *C. territans* is in some way concealed in my forest races of *C. pipiens*, but provisionally the larva does not allow this supposition. That I have not found *T. fumipennis* must be regarded as simply accidental.

On the other hand my list includes three species which are lacking in that of Martini. These three species are *O. annulipes* Zett. *O. curriei* Coc. and *nigritulus* Theob. All these species are doubtful; I am not quite sure that what I have named *O. annulipes* Zett. can be kept distinct from *O. excrucians*; still the larvæ do not coincide. *O. curriei* is perhaps identic with *O. caspius* Pall.; the larva being unknown; what the species determined as *C. nigritulus* really is, we do not know with certainty; most probably it is related to *C. territans* but the larvæ seem to differ very much from each other.

With regard to the synonymy in the two lists this may be regarded as rather indisputable in most of the cases; there are only two cases to which it is necessary to call special attention. It is rather doubful if my species *O. sticticus* is identic with *A. nigrinus*, a species which according to the description is always difficult to determine. The species *O. salinellus* Edw. has not hitherto been mentioned in this work, but must now, most probably, be registered among the Danish species.

After I had sent Dr. Edwards my *O. prodotes* material from Amager he called attention to the fact that the specimens differed somewhat from the true *O. prodotes*; I tried to get some males, but without success; later on Dr. Edwards wrote to me that the specimens must most probably be regarded as a new species for which he would propose the name *salinellus*. Later on he told me that these specimens were identic with *A. terrieï* Theob. and more thoroughly described by Martini (1920_4 p. 112). It is therefore now necessary to register the species among the Danish mosquitoes; with regard to the description I refer the reader to Martini. With regard to the chapter relating to the single species of Culicines I wish to call attention to the following facts.

Aëdes diversus Theo. = *O. rusticus* (Rossi). Martini maintains that Meinert's figure of *C. nemorosus* belongs to this species. I think that this may be correct and confess that I have overlooked this fact.

Aëdes nemorosus Mg. = *O. communis* (Deg.). It is of interest that Martini has shown that below the withered leaves in the dried ponds other leaves were found which were still moist; between these moist leaves "fanden sich Unmengen von Nemorosus-Larven und Puppen, so dasz man den Eindruck hatte, die Entwicklung ganz grosser Larven gehe fast ungestört weiter".

Aëdes sylvæ Theob. = *O. punctor* (Kirby). Martini states that the home of the larva is "in Torfmoorgräben zwischen Gras und Fadenalgen" not in drying ponds in forests. This may be true, but I must confess that I have never found these larvæ there.

Aëdes terriëi see above.

Aëdes dorsalis Mg. = *O. caspius* (Pallas). It is of interest that also Martini has shown the remarkably severe attack of this species in the autumn, a long time after the other mosquitoes have ceased to sting.

Aëdes vexans Mg. It is highly remarkable that this species, which has a particular significance for large parts of Central Europe, hardly seems to exist in our country; the same seems to be the case in Great Britain.

C. pipiens. Martini states that Mühlens has counted about 10.000 specimens in one square meter in the hibernating places; he supposes that the species has about four to six generations in Germany. He mentions the enormous swarms of *C. pipiens* males in autumn; swarms which are indicated to be "Tausende von Metern lang". Martini has observed one of more than 1 km. in length. Phenomena of this kind have hitherto been quite unknown in our country. He has made the same observation as so many others that *C. pipiens* only rarely sucks upon man and mainly upon birds.

C. territans Walker. The statement that *C. territans* should mainly be a house mosquito, makes it rather improbable that it should have any great distribution in our country. Most probably it is an American species, which has been found in Italy, at Bonn, Strassburg and Hamburg in recent years. In America it is a very angry bloodsucker according to Felt; in Europe it does not seem to attack man.

Theobaldia annulata: Martini has found hibernating larvæ; he also comes to the result that it only rarely sucks upon man. On an excursion to Amager Mr. Kryger and I found a remarkable mosquito closely related to *T. annulata*; the white scales were however yellow and the black brown. After this work was sent to the press Mr. Edwards told me that the specimens were identic with specimens adapted to desert conditions and hitherto found in Mesopotamia; it may be named *T. annulata* var. *subochrea* Edw.

I only wish to call attention to the remarkable mosquito fauna which has now been ascertained to exist upon Amager in the immediate vicinity of Copenhagen. In the drying ponds of Amager common we now know that the following specimens are hatched: *O. salinellus, O. detritus, O. rusticus, O. caspius, O. curriei, O. lutescens, T. annulata* var. *subochrea*. It will clearly be seen how much this fauna differs from that of the drying forest ponds where *O. communis, O. prodotes, O. excrucians, O. cantans, O. diantæus* preponderate.

Ochlerotatus rusticus. After having read the paper of Martini I am not quite sure that two species are not confused in my *O. rusticus* Rossi material. It is possible that some of the material from my forest ponds should be referred to *O. fusculus* Zett.; I have hitherto regarded all my larva material as homogeneous; it seems however that there are some small differences in the arrangement of the hairs upon the dorsal side of the sipho; without delaying the publication for almost a year this cannot be cleared up.

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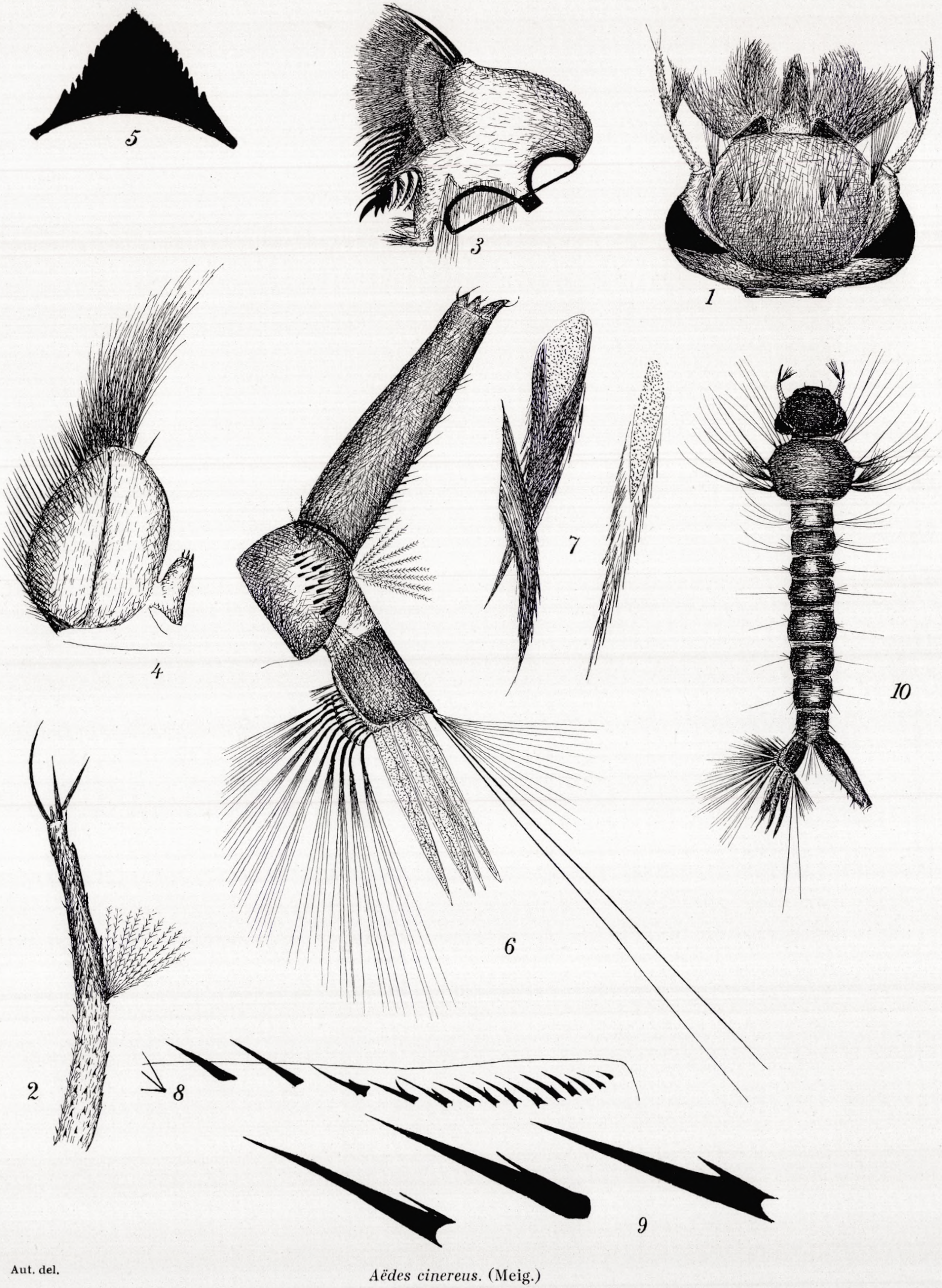
Corrections.

P. 93	heading	for Finlaya	read Finlaya.
- 133	l. 10 from bottom	for 1909	- 1907.
- 134	l. 12 from top	for 1903 p. 88	- dele.
- 134	l. 13 —	for Eckstein 1908	- 1902_2.
- 135	l. 9 —	for 1919III	- 1910_2.
- 135	l. 4 from bottom	for p. 25	- p. 259.
- 143	l. 7 from top	for Weber 1906 p. 38	- 1906 p. 380.
- 154	l. 13 —	for Knab (1912 p. 122)	- Knab (H. D. K. 1912 p. 122).
- 158	l. 17 —	for (Blacklock and Carter 1920 p. 413) but has shown	

read but Blacklock and Carter (1920 p. 413) have shown.

INDEX



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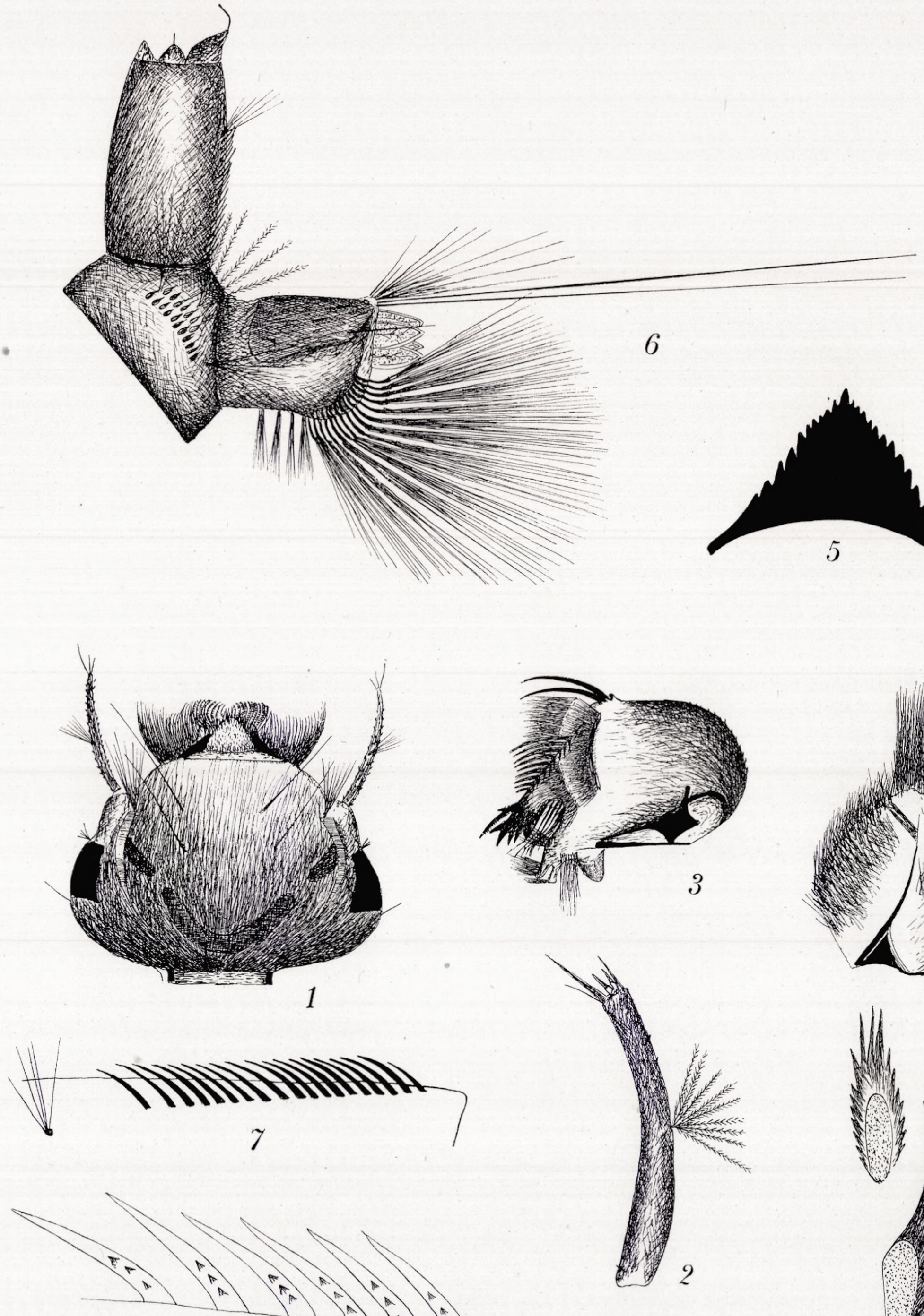

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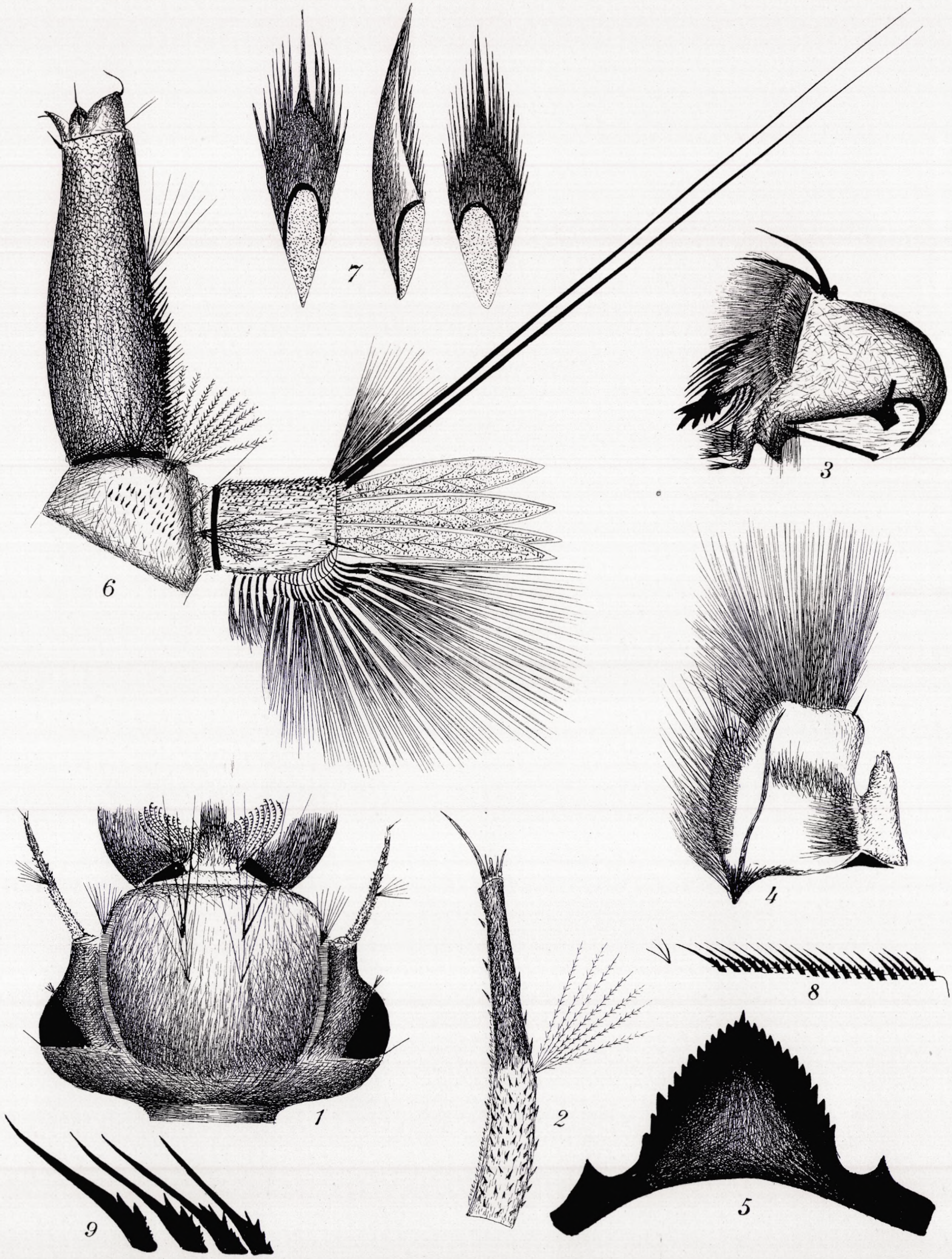

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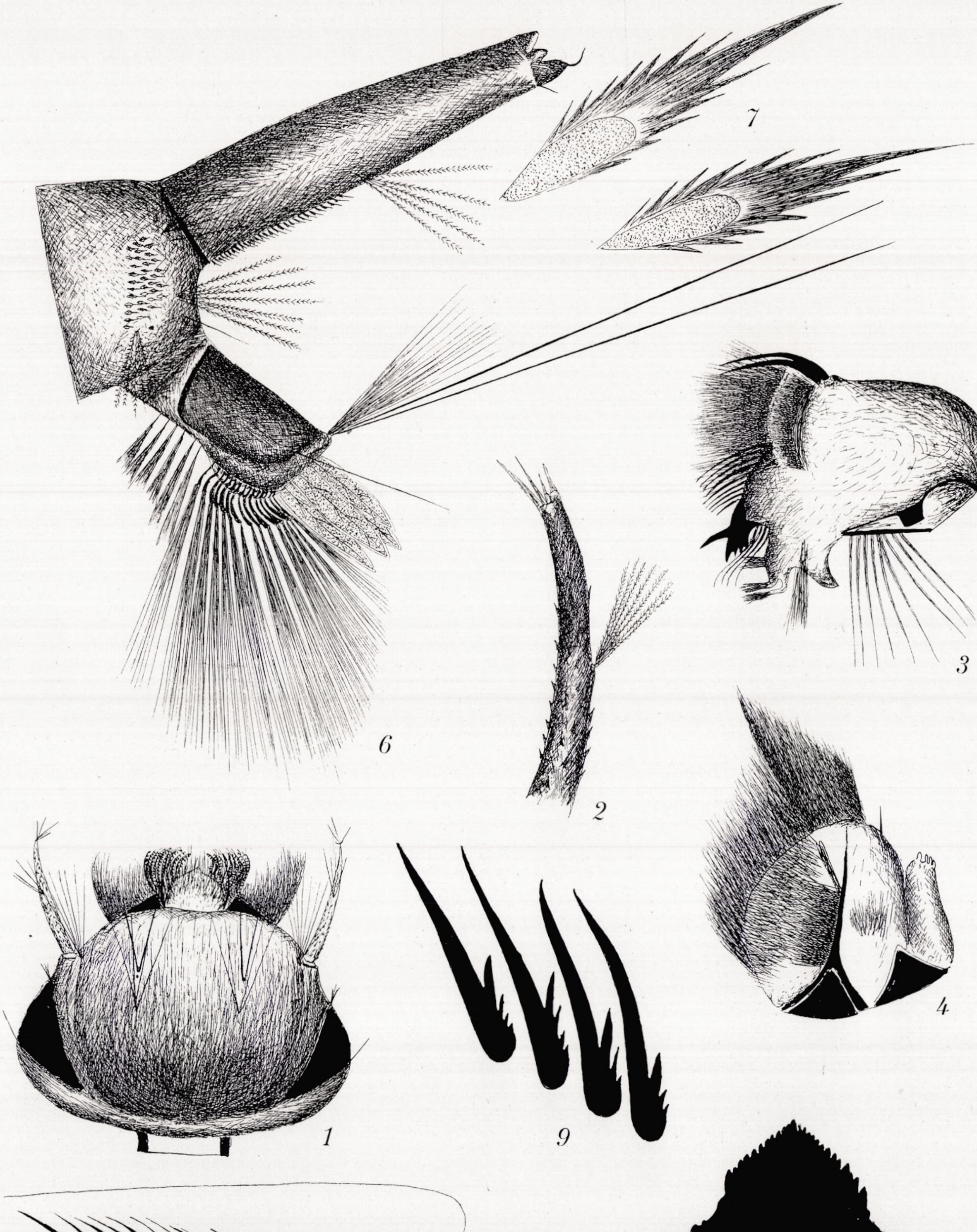

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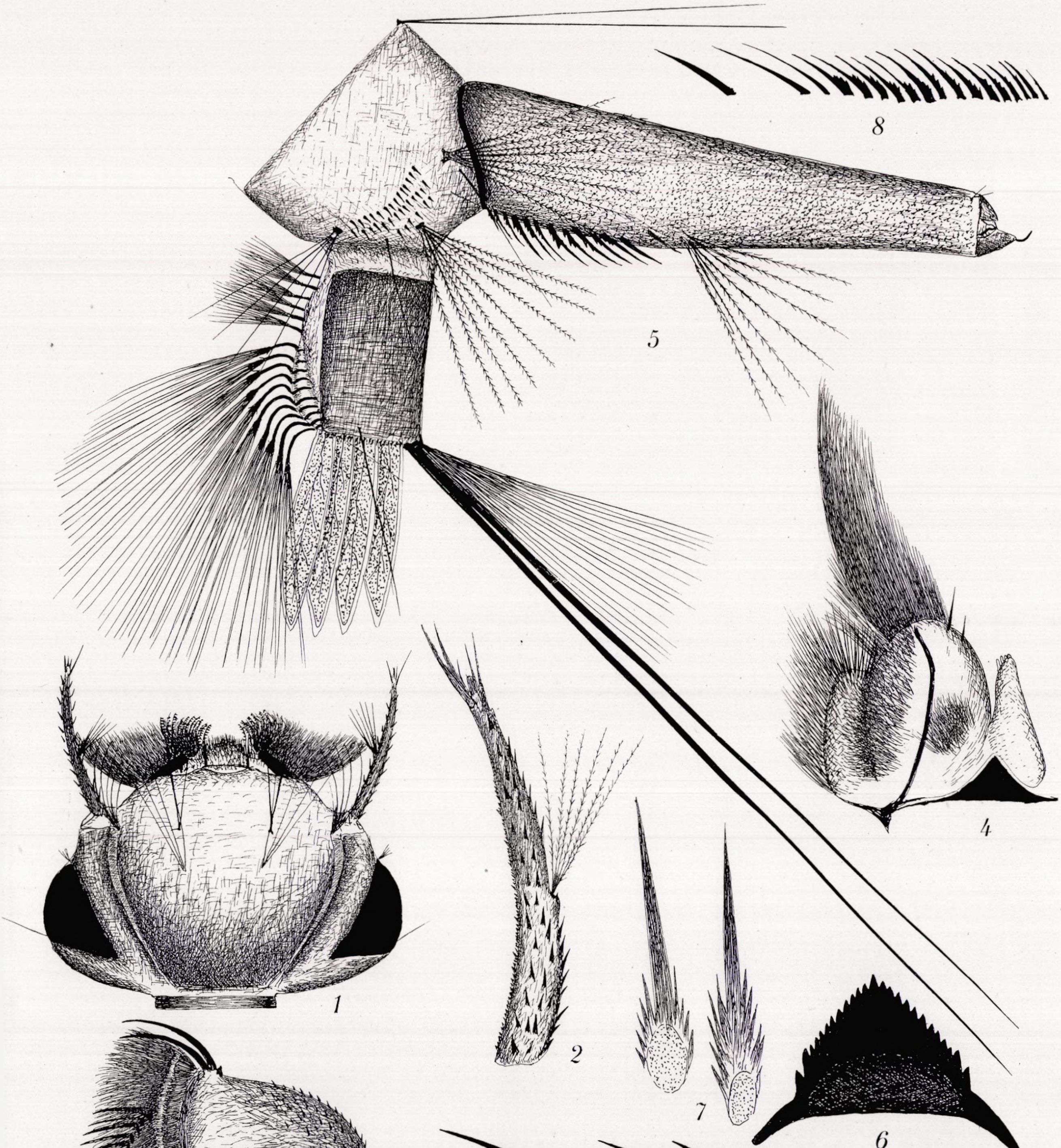

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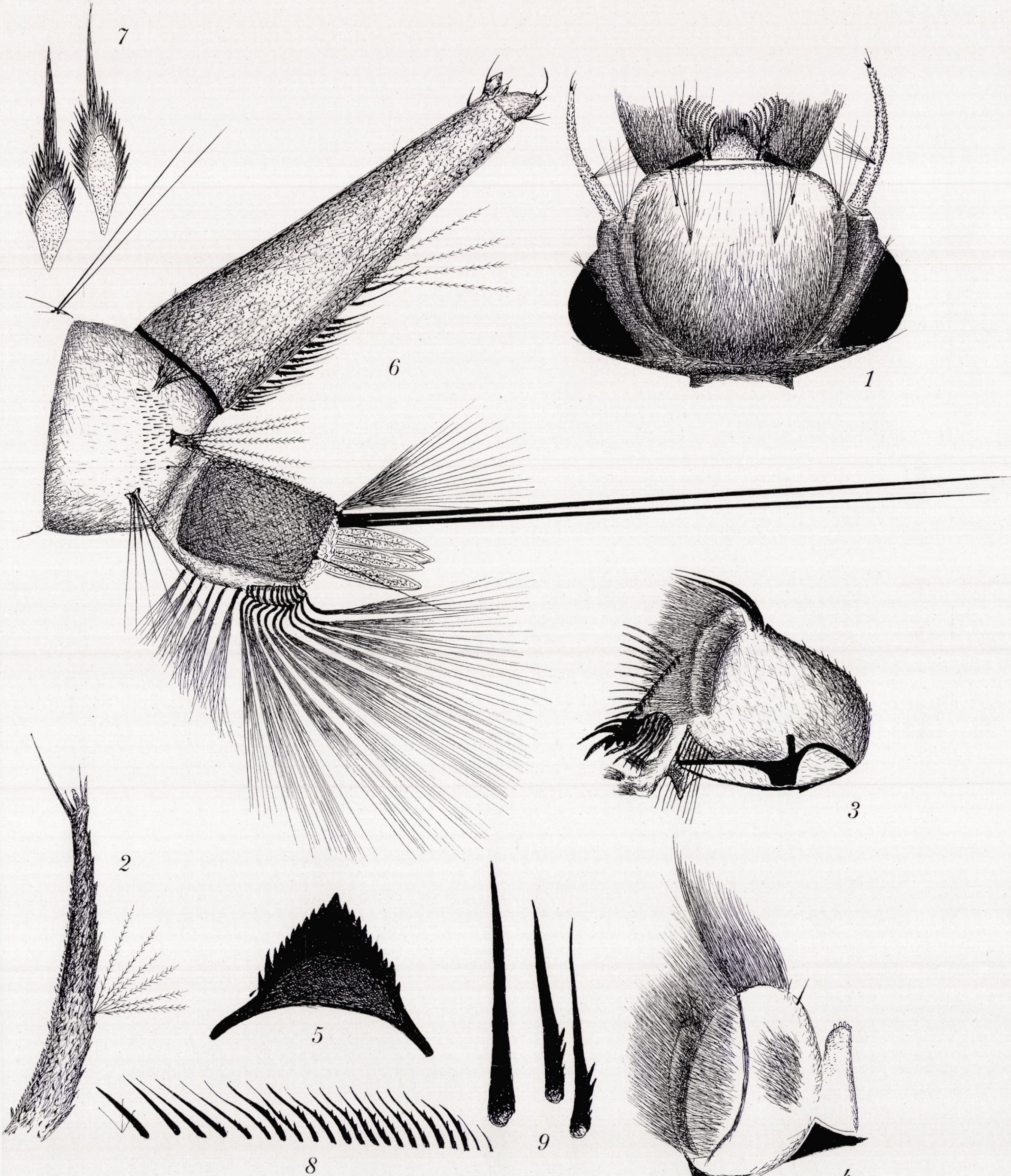

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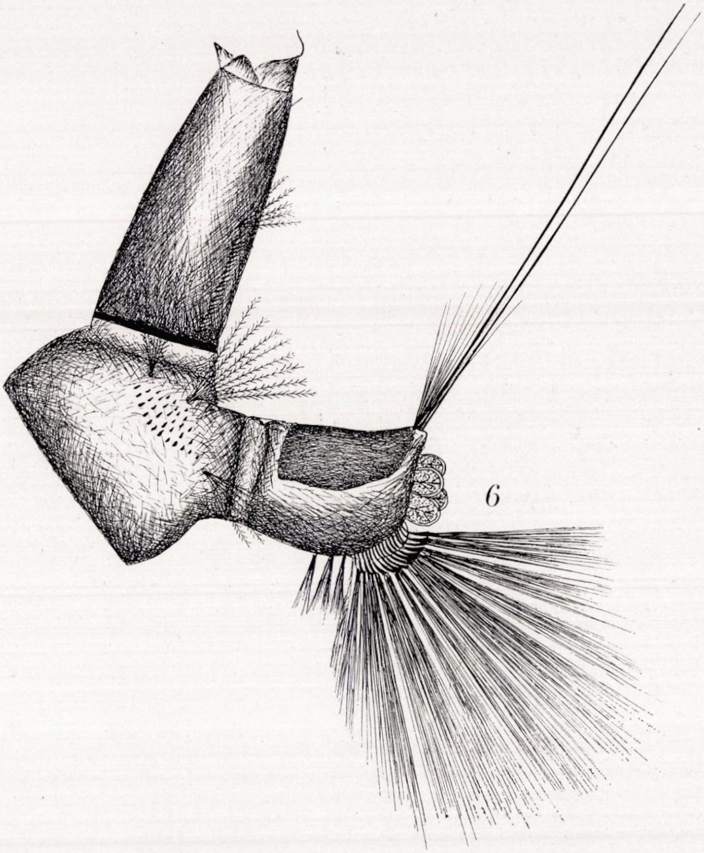

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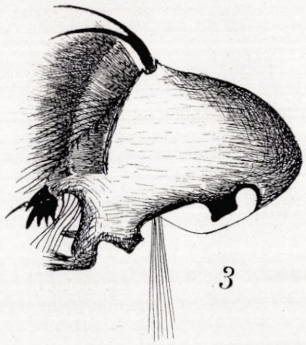

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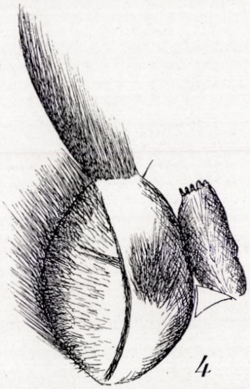

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O. detritus (Haliday.)

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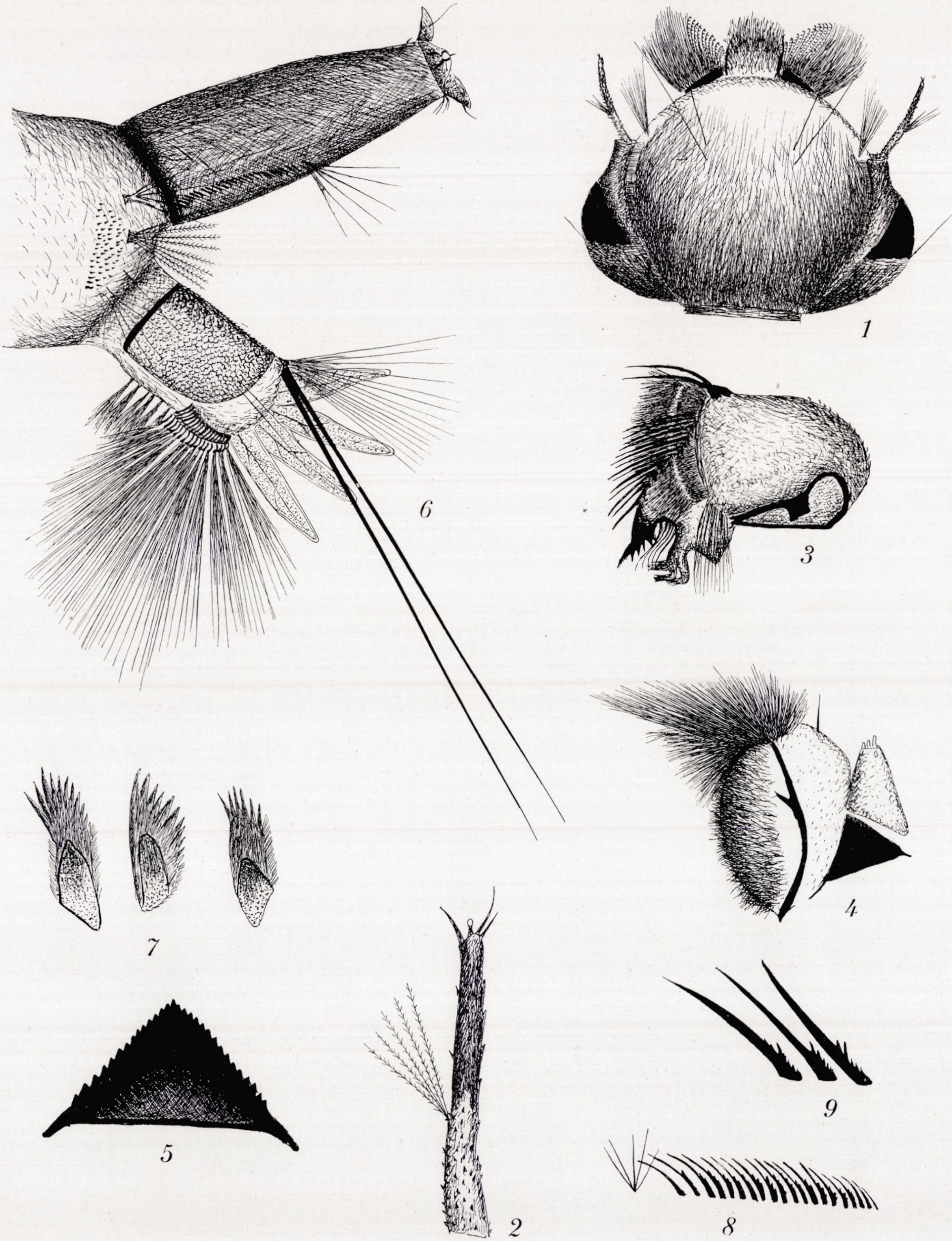

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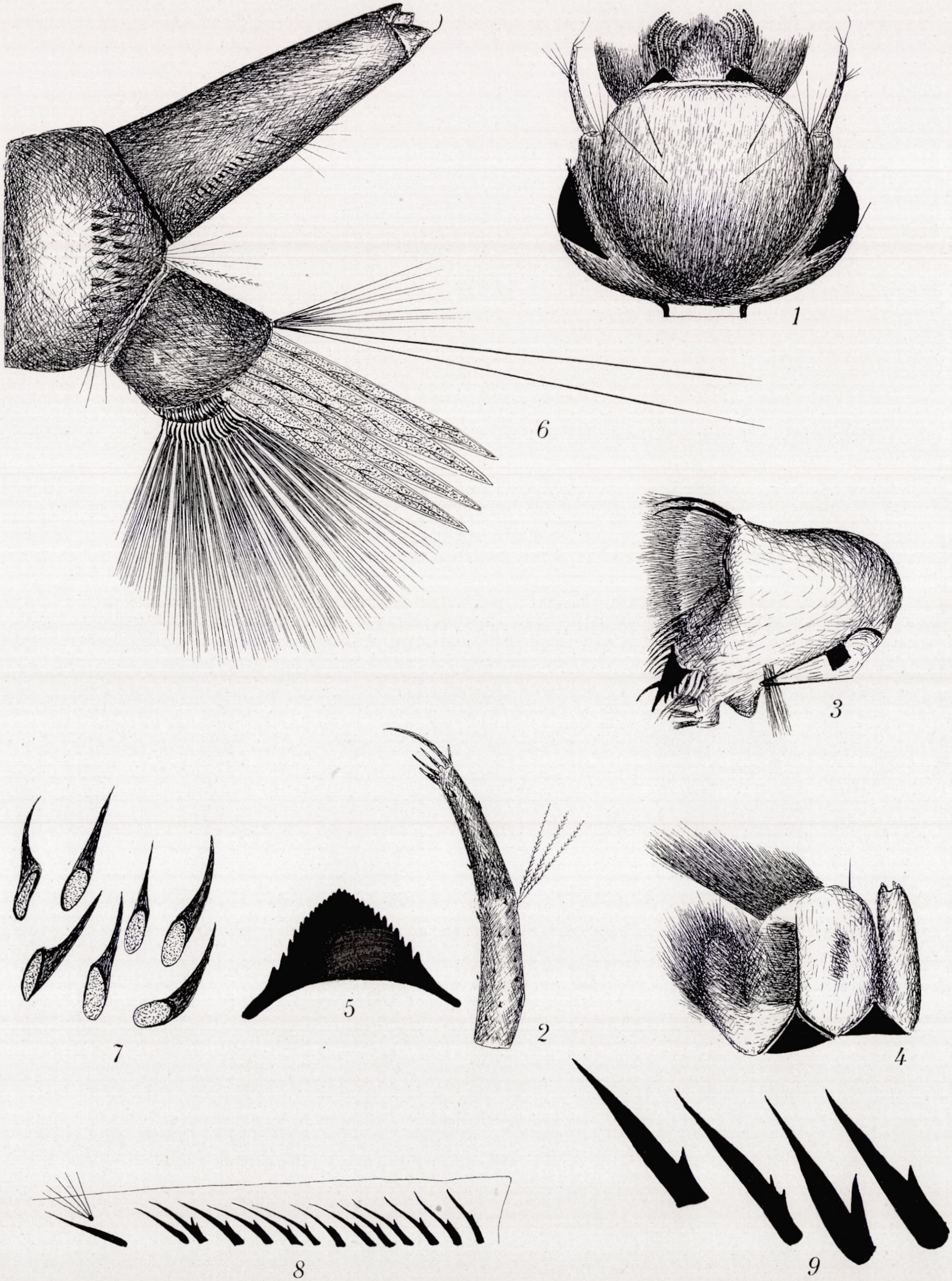

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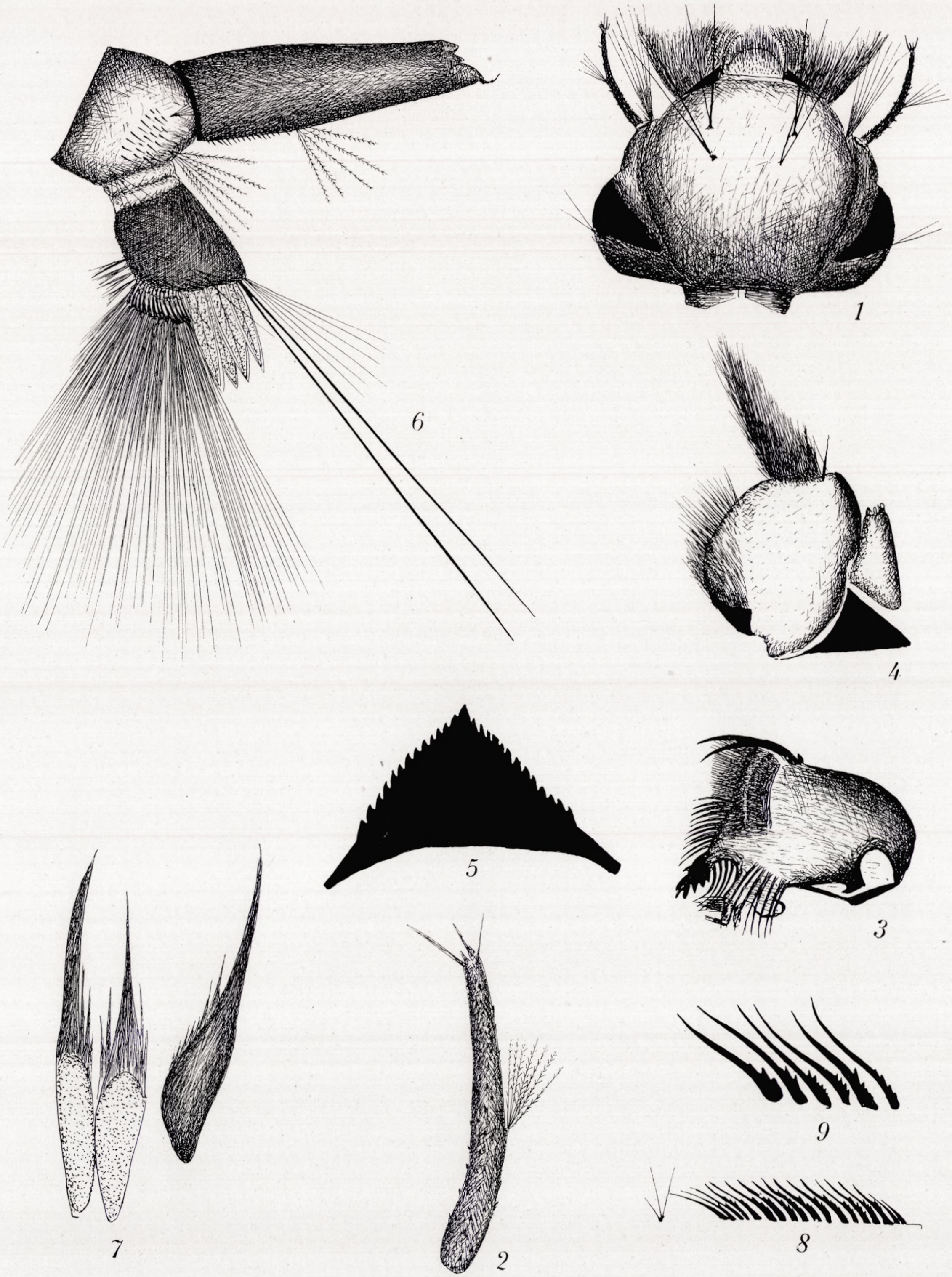

O. punctor (Kirby.)

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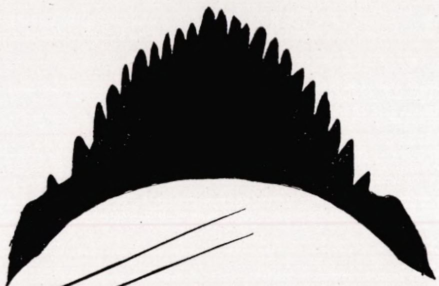
O. prodotes (Dyar.)



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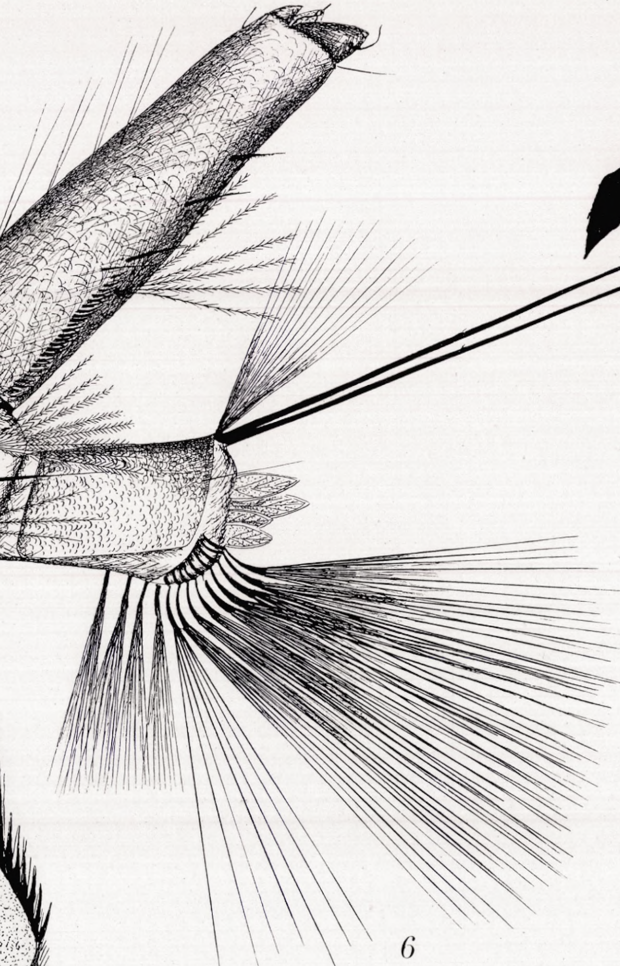

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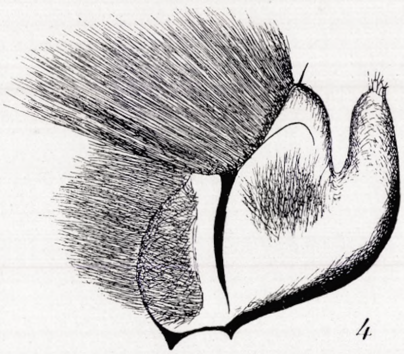

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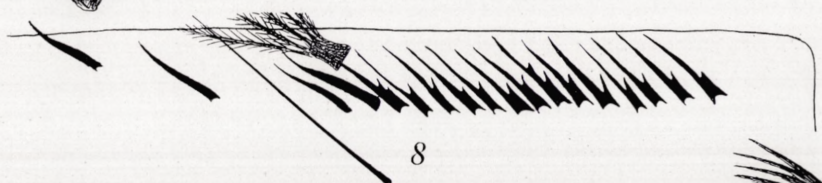

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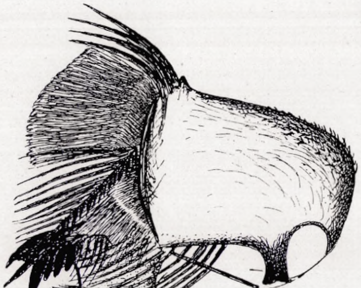

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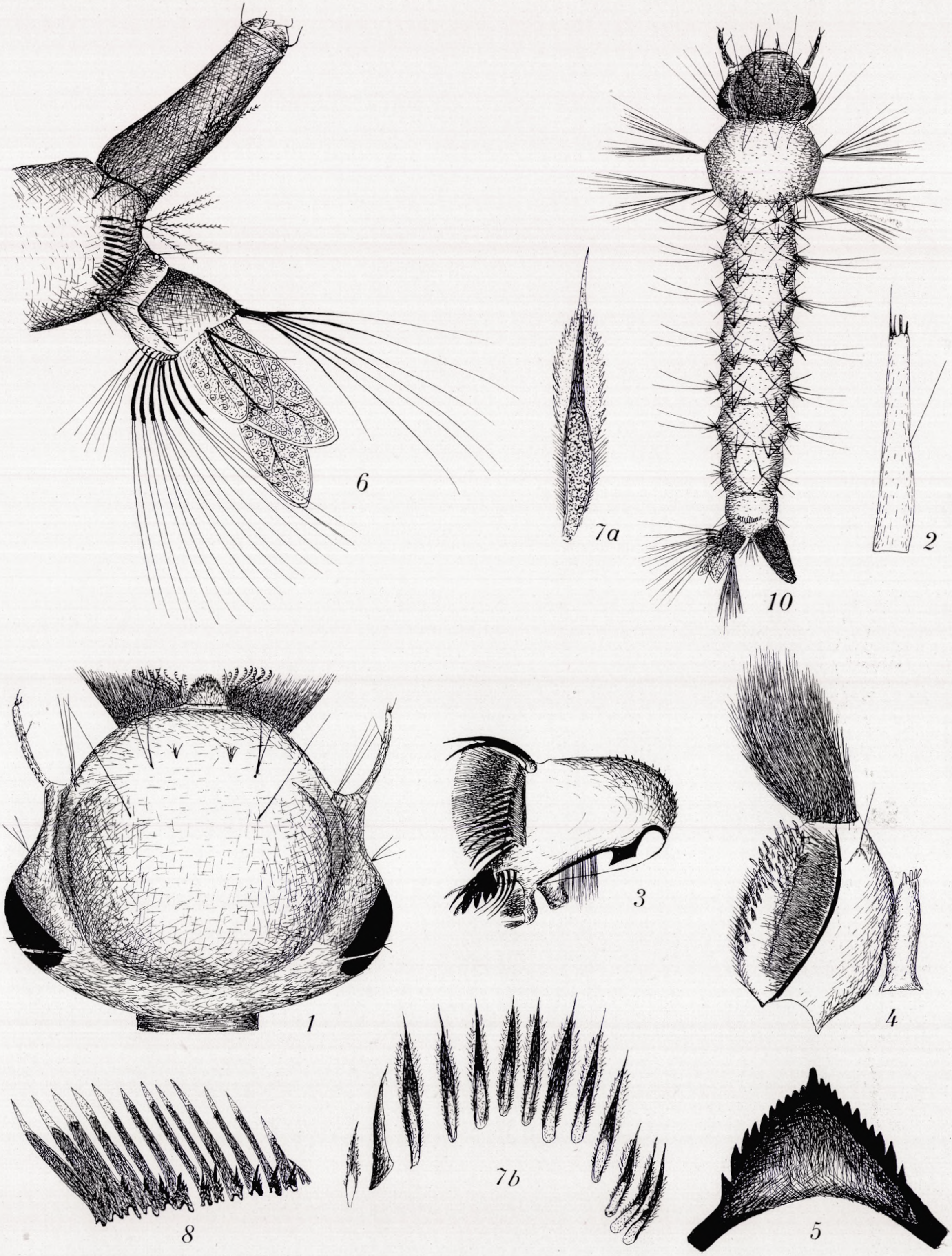
O. rusticus (Rossi.)

Aut. del.

O. diantœus (H. D. K.)



Finlaya geniculata (Olivier.)

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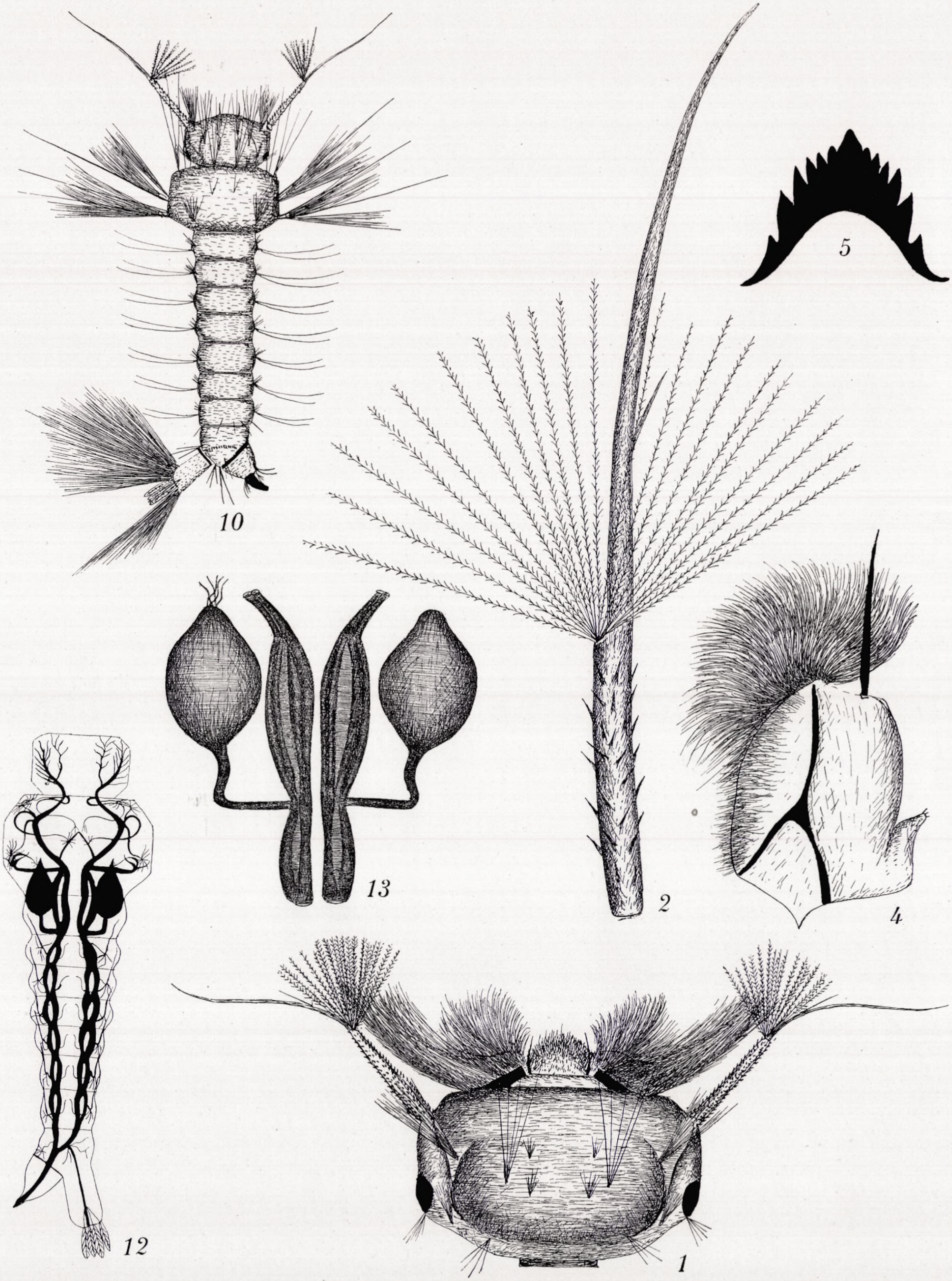

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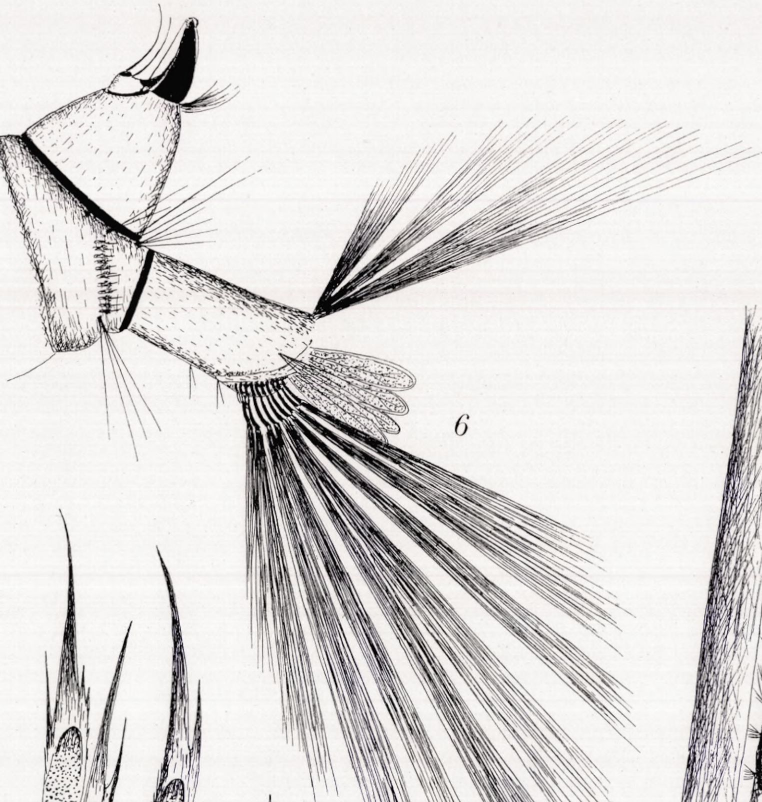

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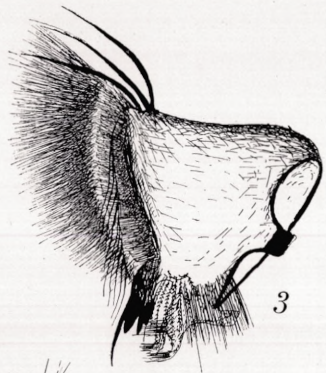

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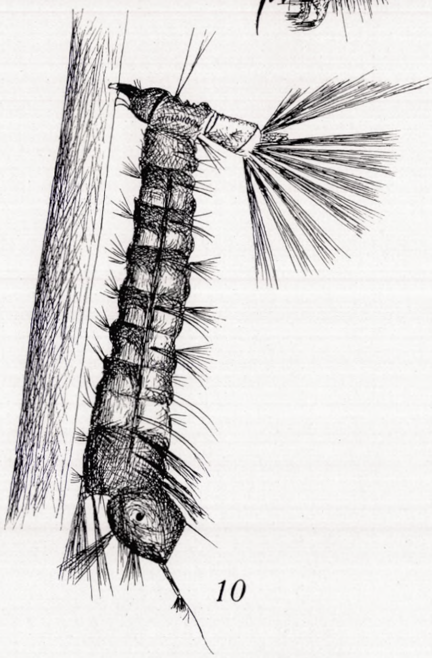

10

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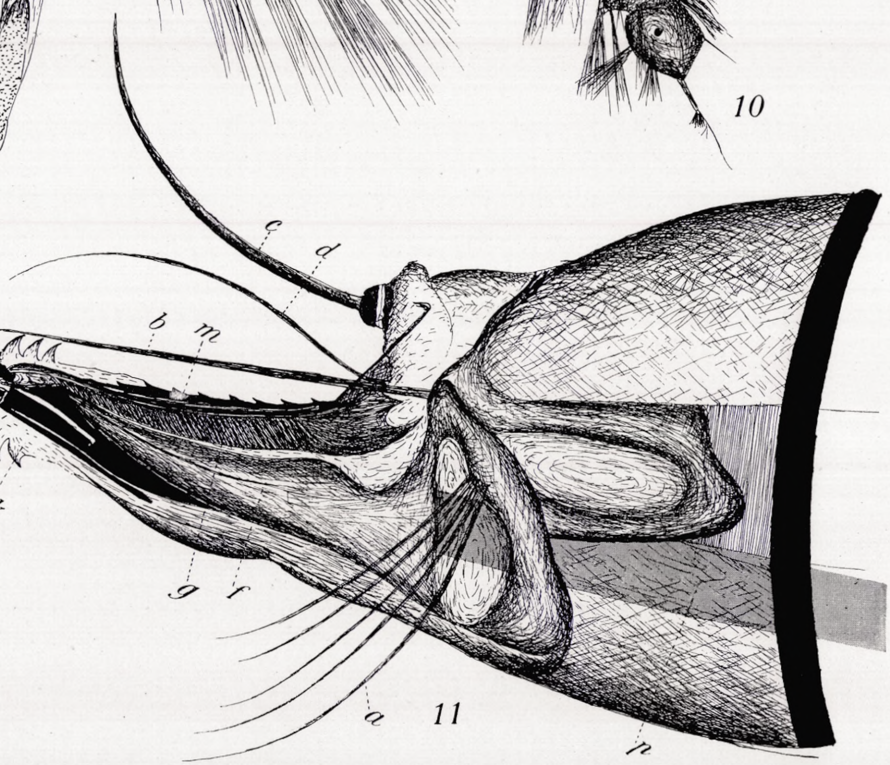

11

Tæniorhynchus Richardi (Ficalbi) II.

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Theobaldia annulata (Schrank.)

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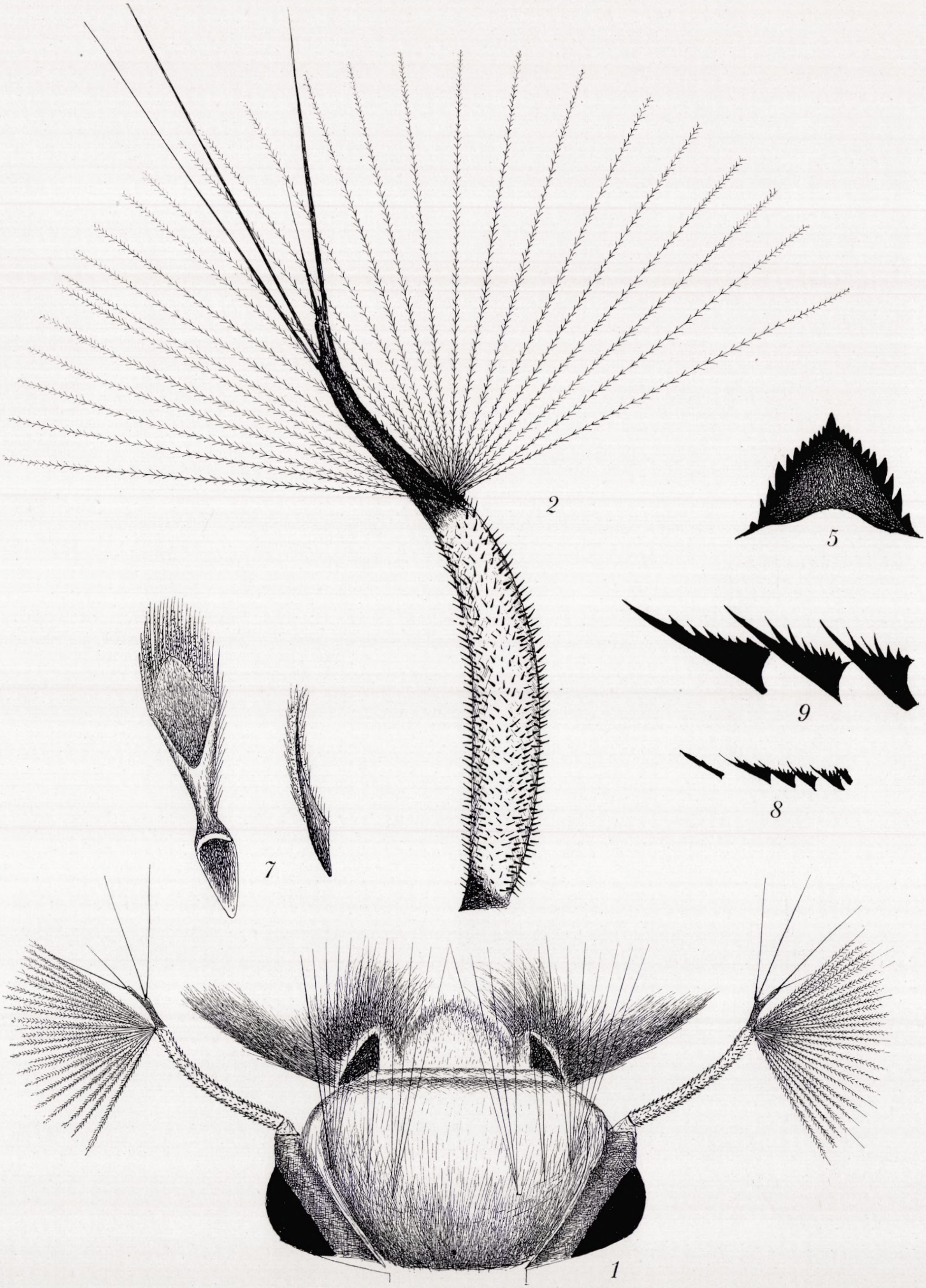

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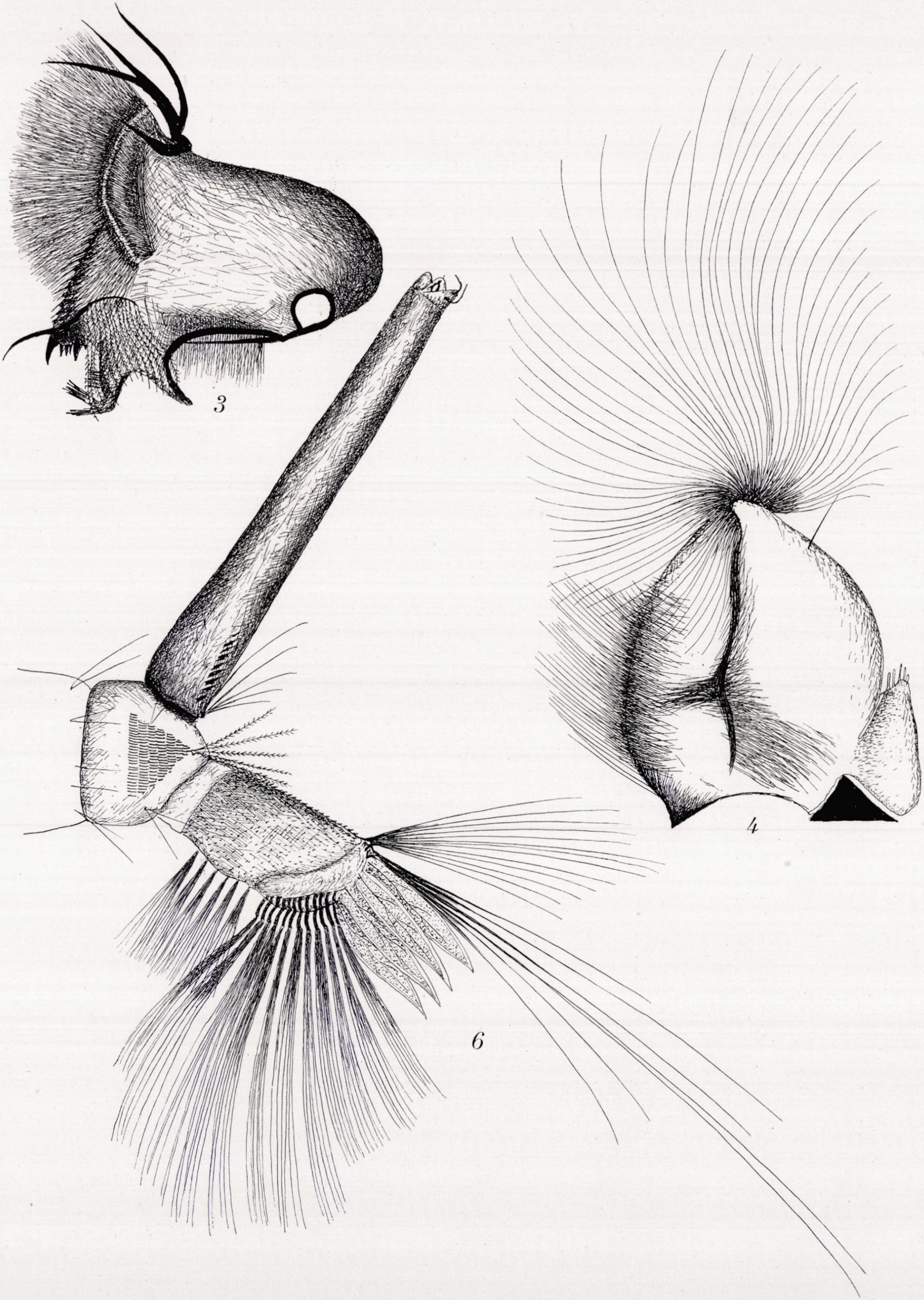
Culicella morsitans (Theobald) I.



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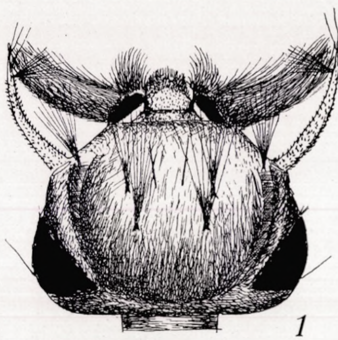
Culicella morsitans (Theobald) II.

Tab. XX



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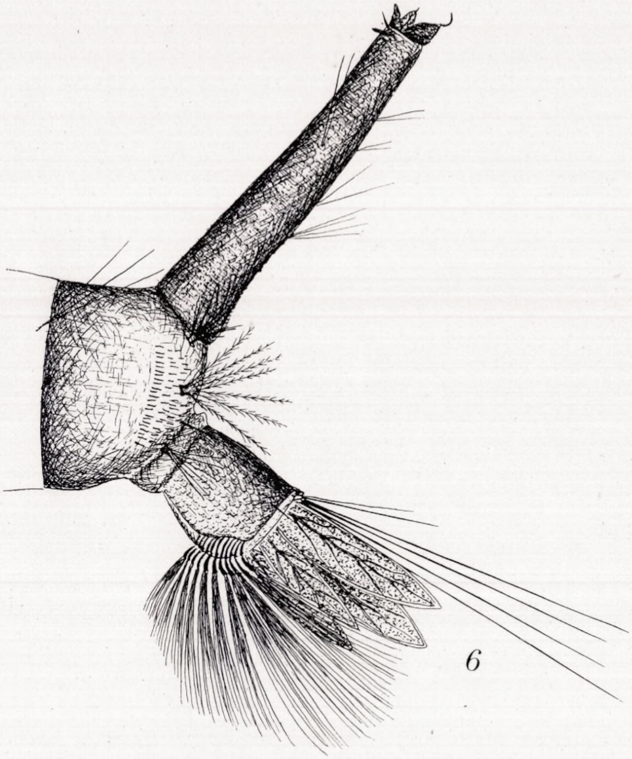

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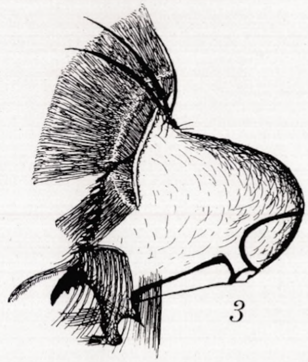

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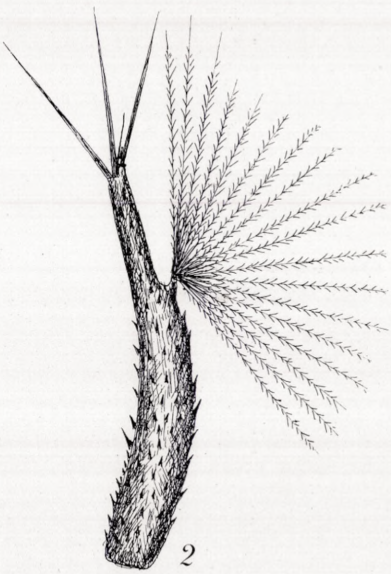

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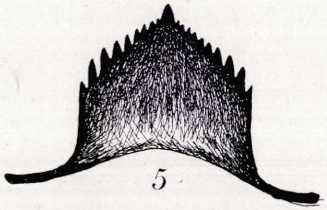

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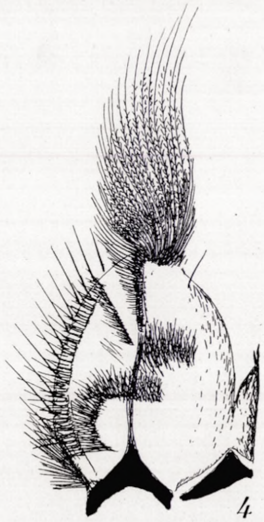

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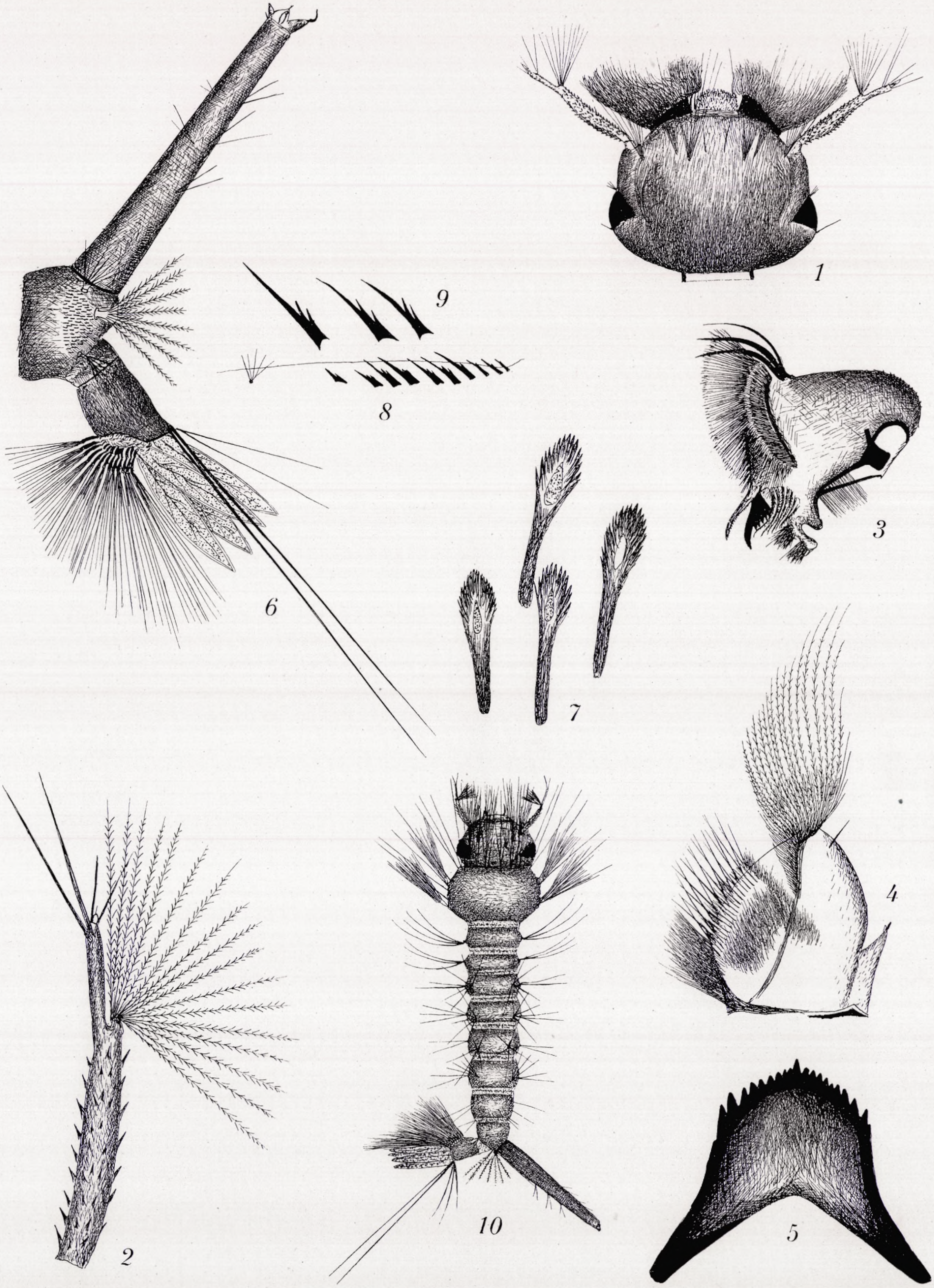
Culex pipiens Linné.



C. nigritulus Theobald.

Aut. del.

Det Kgl. Danske Videnskabernes Selskabs Skrifter.

Naturvidenskabelig og mathematisk Afdeling,

8de Række.

		Kr.	Øre
	I, 1915—1917	10.	75.
1.	**Prytz, K.** og **J. N. Nielsen:** Undersøgelser til Fremstilling af Normaler i Metersystemet, grundet paa Sammenligning med de danske Rigsprototyper for Kilogrammet og Meteren. 1915	1.	55.
2.	**Rasmussen, Hans Baggesgaard:** Om Bestemmelse af Nikotin i Tobak og Tobaksextrakter. En kritisk Undersøgelse. 1916	1.	75.
3.	**Christiansen, M.:** Bakterier af Tyfus-Coligruppen, forekommende i Tarmen hos sunde Spædkalve og ved disses Tarminfektioner. Sammenlignende Undersøgelser. 1916	2.	25.
4.	**Juel, C.:** Die elementare Ringfläche vierter Ordnung. 1916	»	60.
5.	**Zeuthen, H. G.:** Hvorledes Mathematiken i Tiden fra Platon til Euklid blev en rationel Videnskab. Avec un résumé en français. 1917	8.	»
	II, med 4 Tavler, 1916—1918	11.	50.
1.	**Jørgensen, S. M.:** Det kemiske Syrebegrebs Udviklingshistorie indtil 1830. Efterladt Manuskript, udgivet af *Ove Jørgensen* og *S. P. L. Sørensen.* 1916	3.	45.
2.	**Hansen-Ostenfeld, Carl:** De danske Farvandes Plankton i Aarene 1898—1901. Phytoplankton og Protozoer. 2. Protozoer; Organismer med usikker Stilling; Parasiter i Phytoplanktonter. Med 4 Figurgrupper og 7 Tabeller i Teksten. Avec un résumé en français. 1916	2.	75.
3.	**Jensen, J. L. W. V.:** Undersøgelser over en Klasse fundamentale Uligheder i de analytiske Funktioners Theori. I. 1916	»	90.
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