

XXXII

THE SPECIES OF *SARGASSUM*, FOUND ALONG THE
COASTS OF THE DANISH WEST INDIES,
WITH REMARKS UPON THE FLOATING FORMS
OF THE SARGASSO SEA

BY

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THE present discussion is based upon material collected during three travels to the Danish West Indies, partly along the coasts of the islands, and partly in the Sargasso Sea.

I. The species of *Sargassum* found at the shores of the Danish Islands.

1. *Sargassum vulgare* C. Ag.

C. AGARDH Species Algarum, vol. I, p. 3.

J. AGARDH, Species Sargassorum Austral., p. 108.

VICKERS, A., Phycologia Barbadosensis, Part II, pl. II.

Fucus natans Turner, Fuci, p. 99 (101), pl. 46, fig. a.

var. *typica*. (Fig. 1).

The specimens which I have referred to the typical form are very much like the figure given by TURNER (l. c.). The linear-lanceolate leaves possess a dentate-sinuate margin, a distinct midrib, and quite numerous, but small and irregularly placed trichostomata; the latter are sometimes very indistinct or quite absent in some of the leaves.

The vesicles are sometimes few, sometimes numerous; they are globular, of the size of a small pea, and most often they are without prolongations at the top; such ones occur, however, now and then.

The receptacles are cylindric, filiform and irregularly ramified.

var. *foliosissima* (Lamour.) J. Ag.

J. AGARDH, Spec. Sargassorum Austral. p. 108.

Fucus foliosissimus Lamouroux, Essai Thalassiphytes (Ann. du Muséum d'Hist. nat., vol. 20, 1813, p. 36, pl. 7, fig. 1).

This form is different from the typical one by having numerous, closely packed leaves which are smaller, proportionally shorter, and more or less undulate, frequently somewhat twisted.

The receptacles are shorter and similar to the vesicles hidden between the leaves.

This species is very common along the shores of the islands and occurs in exposed or sheltered places. In exposed localities, where the sea constantly splashes the rocks *Sargassum vulgare* is able to thrive above the surface; in the more sheltered places it occurs close to the surface, or a little below.

Sargassum vulgare is the dominant species in the *Sargassum*-vegetation forming with *Turbinaria trialata* a vegetation of large, brown algæ corresponding with the *Fucaceæ*-Association in northern seas.



Fig. 1. *Sargassum vulgare* C. Ag. Part of a plant with receptacles and vesicles. (A little over natural size, about $\frac{1}{6}$ magnified).

somewhat oval, now and then provided with a small, leaf-like prolongation at their apex.

The receptacles are mostly aggregated at the upper end of the branches; they are cylindrical and irregularly branched.

This species appears to be closely related to *Sargassum vulgare*, representing probably a mere variety of it.

St. Thomas: Store Nordside Bugt, growing in a rather exposed place.
Geogr. Distrib: West Indies, Bermuda, Teneriffa etc.

Geogr. Distrib. This species is said to occur at nearly all subtropical and tropical shores of the Atlantic Ocean: America and the West Indies, Africa, Spain etc.

2. *Sargassum lendigerum* (L.) Kütz.

KÜTZING, Species Algarum, p. 612.

—, Tabulæ Phycologicæ, vol. XI, tab. 19, fig. II.

J. AGARDH, Species Sargassorum Austral., p. 110.

Fucus lendigerus L., Species plant., p. 1628.

TURNER, Fuci, p. 107, tab. 48.

The specimens which I have referred to this species possess leaves with a distinct midrib and small, most often scattered cryptostomata; these are, sometimes, arranged more or less regularly in a single series on both sides of the midrib.

The basal leaves are more or less dentate; the superior have a somewhat sinuate to entire margin.

The leaves are linear-elliptic 4—5 mm. broad, and until 3 cm. long, with a short stalk or sessile. The vesicles are scarce, often quite absent; when present, according to my observations, they occur only at the upper end of the branch; they reach the size of a small pea, and are often

3. *Sargassum platycarpum* Mont.

MONTAGNE, Cent. III, p. 18, n. 51.

—, Sylloge generum specierumque Cryptogamarum, 1856, p. 385.

J. AGARDH, Species Sargassorum Austral., p. 89, tab. VI.

VICKERS. A., Phycol. Barbado., Part II, pl. II.

Characteristic of this species (Fig. 2) are the rather large, often oval cryptostomata, arranged in a single series on both sides of the midrib. The leaves are lanceolate, dentate along the margin. The vesicles are not very numerous; in the diagnosis in "Sylloge" MONTAGNE writes l. c.: "vesiculis nullis". In my specimens the vesicles were only noticed in the fertile part of the thallus; they are globular, sometimes ellipsoid, now and then with a short prolongation at the top.

The receptacular branches are flat, bearing long projections at their margin.

The species was found on rocks close to, or a little above the surface of the sea, in rather exposed or somewhat sheltered places.

St. Croix: Green Cay, Coakley Bay, Long Reef.

Geogr. Distrib: West Indies and warmer shores of America.

4. *Sargassum Hystrix* J. Ag.

J. AGARDH, Nya Alger från Mexico (Öfversigt K. Vet.-Akad. Förhandl. 1847).

—, Spec. Alg., p. 322.

—, Species Sargassorum Australiæ, p. 91, tab. VII, figs. 1—5.

Carpacanthus spinulosus Kütz., Tab. phycol., vol. XI, p. 15, tab. 46, fig. 2.

The few specimens found resembled the figure in KÜTZING, Tab. phycol. quoted above. The leaves had an irregularly serrate margin, a distinct midrib, but small and indistinct cryptostomata.

The vesicles are large, but scant.

The receptacles are ramified, and provided with long projections along the margin.

The specimens were collected floating in the sea to the north of St. Jan: off Hermitage and Annaberg.

Geogr. Distrib: West Indies, shores of America, etc.

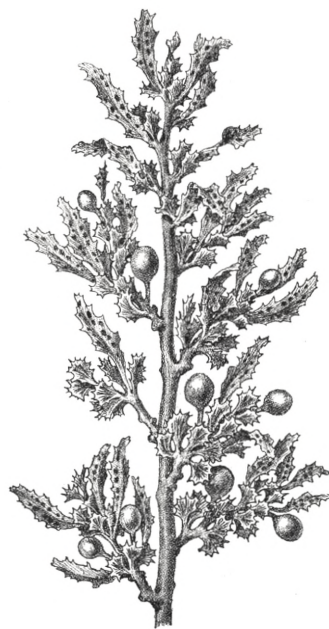


Fig. 2. *Sargassum platycarpum* Mont. Part of a branch with receptacles and vesicles.

(About $\frac{1}{6}$ magnified.)

II. The floating *Sargassum* found in the Sargasso Sea.

SAUVAGEAU in his interesting paper: "Le *Sargassum bacciferum*, la mer des Sargasses et l'Océanographie"¹⁾ protests against the frequently incorrect or contradictory statements given in Oceanographies and similar works, dealing with the life and origin of the Gulfweed. He writes:

„Il serait regrettable que cette notion absolument erronée, propagée par des océanographes, puis adoptée sans contrôle par de notables naturalistes, devint classique.

En réalité, on ignore complètement d'où viennent les *S. bacciferum* de la mer des Sargasses. Rien ne prouve non plus qu'ils soient arrachés aux côtes, puis modifiés dans leur constitution, car, bien que la détermination spécifique de la plupart des *Sargassum* présente de grandes difficultés, les botanistes n'admettent aucune forme de passage réel de *S. bacciferum* à d'autres espèces. . . . Ainsi, ou bien le *S. bacciferum* vit à l'état fixé, dans une contrée insoupçonnée d'où des courants inconnus transportent au loin presque uniquement des individus stériles, ou bien il végète à l'état flottant depuis un temps immémorial, et se maintient par bouturage naturel,"

In the subsequent pages I shall try to show that this last mentioned supposition of SAUVAGEAU holds good, and that it is especially due to the idea of a single author²⁾ that this incorrect view has been introduced.

Having visited the Danish West Indies three times I have had the occasion to cross the Sargasso Sea several times, and in different places, coming from various ports in Europe; or from St. Thomas to the Bermudas. During these voyages I have had a good opportunity to become acquainted with the floating Gulfweed and to make collections.

I shall now begin with a systematic treatment of the forms collected, and afterwards I shall try to throw some light upon the biology of the Gulfweed, its affinities and origin.

A. The species found by the writer in the Sargasso Sea.

The floating, pelagic forms collected by the writer in the Sargasso Sea may be referred to only two species namely the well-known *Sargassum bacciferum* = *Fucus natans* LINNÉ and a more coarse form which I consider a variety of *Sargassum Hystrix*.

¹⁾ Comptes rendus des séances de la Société de Biologie, T. LXII, 1907, p. 1082.

²⁾ KUNTZE, O., Revision von Sargassum und das sogenannte Sargasso-Meer (Englers Bot. Jahrb., 1. Bd., 1881, p. 191).

1. *Sargassum natans* (L.)¹⁾

Fucus natans Linné, Species Plantarum 1753, T. II, p. 1160 ("*Fucus 11 natans*").

ESPER, Icones Fucorum, I Theil, 1800, p. 49, tab. 23 (= var. *ciliata*).

VAHL, M., Endeel kryptogamiske Planter fra St. Croix (Skrivter af Naturhistorie-Selskabet, 5te Bd., 2det Hefte, 1802, p. 36).

Sargassum pelagium Rumphius, Herb. Amboinense, Vol. VI, 1750, p. 188, tab. 76 (here called *Sarg. litoreum*) = var. *ciliata*.

Fucus Sargasso Gmelin, Historia Fucorum, 1768, p. 92.

Fucus bacciferus Turner, Fuci, vol. I, 1808, pp. 103—108, pl. 47.

Sargassum bacciferum C. Agardh, Species Algarum, vol. I, 1821, p. 6.

J. AGARDH, Species Algarum, vol. I, 1848, p. 344.
—, Species Sargassorum Australiæ, 1889, p. 106.

GRUNOW in ASKENASY, Algen (Forschungsreise S. M. S. Gazelle, IV. Theil, 1888, p. 29)²⁾.

As is generally the case in respect to Linnean diagnoses these are very brief, and *Fucus natans* is only described as follows (l. c.):

¹⁾ In Revisio generum plantarum, pars II, 1891, p. 915, O. KUNTZE writes: "Anstatt *Sargassum bacciferum* Ag. (Turn. 1802) bez. *S. vulgare* Ag. em. O. K. ist übrigens *Sargassum natans* R. Br. (L. 1753) zu schreiben; auch MIQUEL wendete diesen Namen an." When I have not added the name of ROBERT BROWN after the combination *Sargassum natans* it is because the *Sargassum natans* of ROBERT BROWN (in Proceedings of the Linnean Society of London, vol. II, 1855, p. 77) is *Fucus natans* of TURNER = *Sargassum vulgare* C. Ag., and not this species. ROBERT BROWN says himself, and very clearly so, f. i. p. 78: "*Sargassum natans*, or *vulgare*," and, opposite to it: "the Gulfweed (*Sargassum bacciferum* of TURNER and AGARDH)". And on the next page 79 is also mentioned that the leaves of the Gulfweed are destitute of the trichostomata, while such are constantly present in *S. natans*. Where MIQUEL used the combination *S. natans* I have not succeeded in finding.

Besides KERNER, in "Pflanzenleben", 2ter Bd., 1891, p. 622, has written *Sargassum natans* beneath a good illustration of the var. *ciliata* of this species.

²⁾ How far the *Sargassum Chamissonis* Kütz. from the Pacific Ocean belongs to this species or not I do not know; it resembles (comp. Kütz., Tab. phycol., vol. XI, tab. 11) *S. natans* var. *typica* in having vesicles without a filiform appendage at their top but differs by its flat stem (comp. also KÜTZING, Spec. Alg., p. 610). According to REINOLD (in WEBER-VAN BOSSE, Liste des Algues du Siboga, I, 1913, p. 164) there does not seem to be any difference between the forms of *Sargassum natans* from the Pacific and the Atlantic Ocean.



Fig. 3. *Sargassum natans* (L.).
Type-specimen from the Linnean Herbarium.
The plant is partly covered with *Membranipora tuberculata*.

"Fucus caule tereti ramosissimo, foliis lanceolato-serratis, fructificationibus globosis¹⁾ pedunculatis subaristatis. Habitat in Pelago libera natans, nec radicans. Vegetabile ni fallor, inter omnia in orbe, numerosissimum".



Fig. 4. *Sargassum natans* (L.) var. *typica*. Branch with gas-bladders in various state of development. (About $\frac{1}{6}$ magnified).

description of the leaves "lanceolato-linearibus" agrees best with *S. natans* of which the leaves are very narrow.

But here the Linnean Herbarium does render some assistance, since the finest specimen in his herbarium represents a form most closely approaching the figure given by TURNER (l. c.).

The writer takes the opportunity to thank most cordially Mr. DAYDON JACKSON, General Secretary of the Linnean Society, from whom were received excellent photos of the three specimens of *Sargassum natans* found in LINNÉ'S

¹⁾ LINNÉ was of the opinion that the vesicles were fruits!

"Flora Zeylanica" is the first quotation of LINNÉ. Here (p. 184) we find the following diagnosis: "Fucus caule tereti ramosissimo, frondibus lanceolato-linearibus serratis, fructificationibus globosis pedunculatis folioque umbilicatis," hence about the same as in "Species Plantarum". He quotes, also, "Hortus Cliffortianus", where on page 478 the same diagnosis as in "Flora Zeylanica" recurs. Besides LINNÉ does make some remarks upon its occurrence: "Crescit in omnibus fere rupibus aqua marina opertis circa Jamaicam, aliisque Americæ pluribus, unde a fluctibus abripitur, magnamque partem maris Americani borealis implet, ut pratum viride diceret spectator remotus.

From this it is clear that LINNÉ refers to the floating *Sargassum* in the Sargasso Sea, but whether LINNÉ wrote his diagnosis from specimen of *S. natans* or from *S. Hystrix* remains conjectural; it must be admitted, however, that the



Fig. 5. *Sargassum natans* (L.) var. *typica*. A somewhat broad-leaved form and with rather short-stalked vesicles. (About $\frac{1}{6}$ magnified.)

Herbarium, and upon which LINNÉ himself has written his determination. Of these I shall first mention the one (Fig. 3) which is much like TURNER'S figure, and quite agreeing with the material collected by myself. Regarding this specimen Mr. DAYDON JACKSON has given me the following information: "This specimen most resembles D. TURNER'S figure of *Fucus bacciferus*, Hist. Fucor., t. 47; at the base of the specimen we can read "Indica", and at the bottom of the sheet "natans 11" both in LINNÉ'S handwriting; at the right hand bottom corner occurs "*bacciferus* D. T." the initials of course of DAWSON TURNER; above this some unknown man has written "*Sargassum*".

As regards the next specimen, found in the Linnean Herbarium Mr. DAYDON JACKSON writes the following: "LINNÉ has written "11 ~~10~~ 7 natans" evidently doubting what to call it. DAWSON TURNER has inscribed it as "*bacciferus* β D. T."; on the base of the sheet LINNÉ has written: "Fanns i Inds . . . siöen, men rar" [I am not sure of Inds — it is so badly written]." This specimen which TURNER refers to his variety β about which he says "differs from α only in having its leaves oblong



Fig. 7. *Sargassum natans* (L.) var. *ciliata* nov. var. Part of Thallus with vesicles. (About $\frac{1}{6}$ magnified).



Fig. 6. *Sargassum natans* (L.). Intermediate form. Some of the vesicles with a short prolongation at their apex. (About $\frac{1}{6}$ magnified).

instead of linear, and two lines wide" appears to me to approach the pelagic form of *S. Hystrix* which will be described later on.

In respect to the third specimen finally Mr. DAYDON JACKSON informs me that we find "11 natans" in LINNÉ'S handwriting and further "right D. T." This specimen is not so well prepared, more clotted, and it is therefore more difficult to recognize from a photo but most probably it belongs to *Sargassum natans* as also determined by DAWSON TURNER.

From this it is clear that LINNÉ'S Herbarium

contains one well prepared and quite typical specimen; another poorly prepared specimen which most likely belongs to *Sargassum natans*; finally a third specimen which does not belong to this species and about which LINNÉ himself was in doubt. Therefore I think we are compelled to use LINNÉ's old name *natans* instead of *bacciferum* of TURNER.

In respect to the reason why TURNER did not accept the Linnean name, the following quotation is of interest ("Fuci", p. 107):

"It has been observed, and, I must own, not without an appearance of justice, that, instead of giving the name of *F. natans* to the preceding species¹⁾, it would have been better to have applied it to the one here figured, which has never yet been found except swimming about, in which state it appears certain that it continues to live and increase, thus affording the strongest argument in favour of the opinion of those who maintain that the roots of Fuci are not organs of nourishment. This observation unfortunately did not reach me till, for reasons already mentioned under the preceding species, I had done other-wise; and I know too well how much botany has suffered from the multiplication and constant confusion of its synonymy, ever to change without the most decisive cause a name already known and established. It is certainly extraordinary that *F. bacciferus* should never have been seen with either root or fructification, especially as its congeners seem by no means unwilling to produce their fruit. The species may possibly be regarded as in some degree unsettled till this is discovered, but I at the same time feel no doubt in giving it as my opinion, that it is essentially distinct from all others, differing in its mode of growth and general habit, and still more in its texture, and cylindrical stem and petioli."



Fig. 8. *Sargassum Hystrix* var. *fluitans* nov. var. Part of thallus with vesicles. (About $\frac{1}{6}$ magnified).

And in respect to this question I, also, wish to point out what C. AGARDH has to say in "Species Algarum", p. 4. Having given his reason, why he appends to TURNER's *Fucus natans* the name *vulgare*, he adds: "Verus *F. natans* Linnæi est sequens species²⁾, cujus tamen nomen mutare superfluum fuit, cum nihil contineat erronei & jam omnibus notum."

Moreover HARVEY in "Phycologia Britannica", 1846—51, pl. 109, writes: "it is therefore unfortunate that the ancient name *natans*, has not been preserved for this species, to which it is most applicable."

¹⁾ The preceding species is *Sargassum vulgare* which TURNER calls *Fucus natans*.

²⁾ *Sargassum bacciferum*.

Two forms may be referred to this species:

var. *typica*. Figs. 3—5.

Fucus bacciferus Turner, l. c., pl. 47.

To this variety belongs the forms with globular vesicles with no appendages as shown in the typical specimen from the Linnean Herbarium. This variety is nicely pictured in TURNER, Fuci, l. c.

var. *ciliata* n. var. Fig. 7.

HARVEY, Phycologia Britannica, Pl. 109.

KÜTZING, Tabulæ Phycologicæ, vol. XI, pl. 11, fig. II.

While the typical form as described above has globular vesicles without any prolongations at their apex, another form is often found in which the vesicles have shorter or longer filiform appendages at their top (Figs. 6 and 7). Otherwise it seems to agree with the typical form. I do not think that this form can be kept separate from the above mentioned, typical form, with good justice; specimens occur in which some of the vesicles have prolongations, while others have not (comp. Fig. 6 and HARVEY, l. c. pl. 109) and in some of these the length of the prolongations is much variable. In this connection I also want to point out that, as stated above, the vesicles of *S. vulgare* may occur with a leaf-like prolongation. I therefore consider it to represent a variety to which I propose the name given above.

2. *S. Hystrix* J. Ag. (compare p. 5).

var. *fluitans* nov. var. Fig. 8.

This is the second species which I have collected in the Sargasso-Sea. It is larger and coarser than *S. natans*; the leaves are broader, linear-lanceolate with serrate margins, the single tooth being proportionally broader and shorter than in *S. natans*. The midrib is distinct, and cryptostomata are commonly found scattered on both sides of the midrib; in some of the leaves they are almost absent.

The vesicles are very numerous; they are about as large as a common pea; they are spherical with no prolongations and borne on very short stalks. They are placed in the axils of the leaves, solitary as a rule, but sometimes two vesicles are developed. The stem is provided with short spinules.

I have considered this form as a variety of *Sargassum Hystrix* as it seems to me to be very much like the figure of J. AGARDH in "Species Sargassorum Australiæ", tab. VII, fig. 1. J. AGARDH mentions also, that this species is found floating in the Atlantic Sea; he writes (l. c., p. 91): "nunc in Atlantico circumvaga et sæpissime sterilis."

These are the forms which I have found in the Sargasso-Sea; that other forms may occur there, is very likely, but those described above are nevertheless the most common.

B. Remarks upon the biology, affinities and origin of the Gulfweed.

The Sargasso floats frequently so near the surface that tips of the leaves become emerged when moved by the sea.

The colour of the floating form is light, lighter than that of the attached, varying from brown to olive-green, or often nearly ochreous; this applies especially to the young parts of the plants while the older are darker coloured.

The Gulfweed is nearly always found in long narrow rows arranged in the direction of the wind, and at a right angle to the moving of the sea. Only more seldom larger areas are found, sometimes reaching extensions of considerable width.¹⁾

Common to the different forms of Gulfweed may be pointed out that they are always sterile and, furthermore, that they usually appear of continuous growth.

As to the first point, the lack of receptacles this is in accordance with the well-known fact that floating and not attached algæ on the whole nearly always are sterile; that it also is so is actually pointed out by numerous investigators, for instance TURNER²⁾, C. AGARDH³⁾, MEYEN⁴⁾, ROBERT BROWN⁵⁾, G. VON MARTENS⁶⁾, GRUNOW⁷⁾, BOUVIER⁸⁾, SAUVAGEAU⁹⁾, GRAN¹⁰⁾ and several others.

However some few authors have expressed opposite views. In "Species Sargassorum Australiæ", p. 106, J. AGARDH writes: "radice instructam et fructiferam ad oras Americæ foederatæ lectam habui, in rupibus extra New Foundland"¹¹⁾ and on the same page "In paucissimis speciminibus natantibus receptacula obvenire, certum videtur". O. KUNTZE, in his very unfortunate "Revision von Sargassum und das sogenannte Sargasso-Meer", says, p. 197, that he has found "verschiedene Exemplare auch mit Receptakel vom hohen Ocean". To this I wish to point out, that it may happen that specimens with receptacles are found floating out at sea, but these are not *S. natans*, but other forms, newly detached from the shores and carried out at sea. Some few examples will be mentioned in the subsequent pages.

¹⁾ Compare different works of O. KRÜMMEL quoted below, and also HOLGER LASSEN in "Geografisk Tidsskrift", Bd. 12, Hefte 3/4.

²⁾ TURNER, D., Fuci, 1808, p. 103.

³⁾ AGARDH, C., Species Algarum, 1823, p. 7.

⁴⁾ MEYEN, I. J. F., Reise um die Erde, 1. Theil, 1834, p. 38.

⁵⁾ In Proceedings of the Linnean Soc. of London, vol. II, 1848—1855, p. 77.

⁶⁾ G. VON MARTENS, Die Tange (in "Die Preussische Expedition nach Ost-Asien", 1876 p. 7).

⁷⁾ In ASKENASY, Algen (Forschungsreise S. M. S. "Gazelle", IV Theil, Botanik, p. 29).

⁸⁾ In Bulletin de l'Institut Océanograph., Monaco, 1907, No. 93, p. 35.

⁹⁾ In Comptes rendus des séances de la Société de Biologie, t. 62, p. 1082.

¹⁰⁾ In "The Depths of the Ocean", 1912, p. 336.

¹¹⁾ That the plant should have been found "radice instructam" i. e. attached near New Foundland seems so unlikely that I deem it unworthy of consideration.

In regard to the other fact that the floating *Sargassum* always seems to be in continuous growth (at least from Nov.—April, according to the writers observation), this problem depends on it being a perennial. I feel confident that the *Sargassum* lives and is capable of vegetative reproduction out at sea.

If we examine a specimen of the floating *Sargassum* we will always observe that all the uppermost ends of the branches have quite young leaves and bladders, these being smaller, more delicate and of a brighter colour towards the top (compare the figs. 4—8). Here also the Bryozoa etc. are wanting; it will be remembered that Bryozoa, Zoophytes etc. frequently cover the older parts of the plants¹⁾ On the other hand the alga dies away from behind, and in this way the branches gradually become separated and independent individuals.

As we know from the literature the floating Sargasso has usually, at least recently, been supposed to have its origin from specimens, torn loose from the shores and carried out at sea by means of currents and the wind; here it should float for some time, gradually die off and sink to the bottom, but by steady new supply become renewed²⁾. I cannot agree with this supposition.

¹⁾ The most common forms occurring upon my collection are *Membranipora tuberculata* Busk. and *Campanularia (Clytra) simplex* Crougdon on *Sargassum natans* and *Aglaophenia late-carinata* Allm. together with *M. tuberculata* on *S. Hystrix*, var. *fluitans*. For the determination of the Bryozoa I am indebted to Inspector LEVENSEN of the Zoological Museum, Copenhagen, while Mr. KRAMP has determined the Zoophytes. In G. v. MARTENS, "Die Preussische Expedition nach Ost-Asien", Bot. Theil, 1866, a list of the animals living upon and among the Gulfweed is found.

²⁾ The citations as follow, though taken at random, may illustrate this point.

So writes MANGIN in "Bulletin du Musée Océanographique de Monaco", No. 82, 1906, p. 21: "Toutes les fois que la mer est grosse dans le golfe du Mexique, les vagues arrachent des sargasses qui couvrent les côtes et les débris sont entraînés par les courants qui en dispersent une grande partie dans l'Atlantique, mais qui ramènent beaucoup de fragments dans la zone des calmes. La mer des Sargasses n'est donc pas d'autre chose qu'un amas de débris végétaux formés par les Fucacées ou dominant les sargasses; celles-ci continuent à végéter faiblement sans pouvoir se multiplier et, lorsque la vie les abandonne, elles plongent lentement; de nouveaux débris viennent les remplacer qui maintiennent à peu près en état la mer des Sargasses." And in KRÜMMEL, "Handbuch der Ozeanographie", 2te Aufl., Bd. II, 1911, p. 588 we notice: "Diese Fucoideen (die Ansammlungen treibender Tange, die der Sargassosee ihren Namen gegeben haben¹⁾), insbesondere *Sargassum bacciferum* oder Beerentange, mit zahlreichen nahe verwandten Arten (*S. vulgare*, *ilicifolium*, *latifolium*, *obtusatum* u. a. m.) sind Strandpflanzen, die im warmen Wasser entlang den amerikanischen Küsten bis zum Kap Cod hinauf, insbesondere aber an den westindischen Felsgestaden wachsen und von der hier mächtig brandenden Dünung oder von den Wogen der Tropenorkane abgerissen ein Spiel der Meeresströmung werden. Besonders reichlich sind diese treibenden olivgrünen Büschel im Floridastrom zu finden, der sie aus seinem westindischen Ursprungsgebiete her stetig neu ergänzt und über den ganzen Nordatlantischen Ozean verstreut, daher die deutschen Seeleute sehr bezeichnend vom „Golfkraut“ sprechen. So hatte schon KOLUMBUS diese Tange bei seinen früheren Seereisen kennen gelernt und . . ."

Compare also the quotation from BOUVIER, p. 17.

¹⁾ Vergl. meine (KRÜMMEL) Ausführungen in Pet. Mitt. 1891, S. 129 f. (mit Karte) und in der Reisebeschreibung der Planktonexpedition, Kiel 1892, S. 117 f., auch im oben S. 581 Anm. 1 erwähnten Vortrag.

The following objections may be raised to this supposition.

Let us consider at once the enormous quantity in which the Sargasso occurs. It would seem strange if these masses of floating Sargasso were originally torn and washed away from the shore, when we remember how proportionally few algæ are met with floating in the northern seas, where the fucaceous alga-vegetation is so much more luxuriant. If really the littoral, fixed types were the ones that were represented at sea, the matter would not be difficult to explain, but it is not so. Once in a while, and mostly near the coast, forms approaching the attached ones may be met with; and moreover *Ascophyllum* from the coasts of the North Atlantic is said to have been observed together with these¹⁾. However the occurrence of these forms does not seem to be of much importance since specimens of these algæ are scarcely more common in the Sargasso Sea than detached specimens of *Fucus*, *Ascophyllum* etc. in the northern seas.

If we accept the explanation that the *Sargassum* in the Sargasso Sea had been torn loose from the shores, it must also be admitted that the constant absence of the attachment-discs seems most remarkable, since *Fucus*-specimens found floating in northern seas are not unfrequently disc-bearing.

As a support of this viewpoint I wish, furthermore, to emphasize the fact that specimens torn loose from the shores are not in the same active state as the floating ones. These specimens are for the most part old, and ready to die away²⁾.

¹⁾ Compare E. L. BOUVIER in "Bull. de l'Institut Océanographique", No. 93, 1907, p. 36 and H. H. GRAN, in "The Depths of the Ocean", 1912, p. 335. Professor GRAN has most kindly communicated me that *Ascophyllum* was found in the northern part of the Sargasso Sea, and rather abundantly.

²⁾ Having made no observations myself as to the life history of the attached *Sargassum*, I have consulted Professor YENDO who has followed the development of *Sargassum* in Japan in many details, for many years. And Professor YENDO has most kindly communicated me the following interesting remarks with the permission of communicating these as follow. He writes: "From December till March the *Sargassums* are discharging the spores. Little difference of time may be found according to the species. The spores become anchored. Young fronds with large basal leaves are found in Aug.—Oct. They have no axillary, lateral branches.

From the beginning of winter they grow up quickly giving rise to lateral branches, minor branchlets etc., etc. untill the vegetation is at the highest vigorosity in April—May. They are yet sterile. The basal leaves and the fulcrant leaves are all in a healthy condition.

In summer time, in many species, the fulcrant leaves and the basal leaves which come out in the first year drop away. In autumn the lateral branches develop further, forming receptacles. The receptacles mature in winter between Dec.—April. Then the whole plant is uprooted and is washed away. This takes place usually in the spring. There are certain fluctuations according to species but in general this statement holds good for all species of Japan".

I take for good that this observation holds good also with the development of the *Sargassum* in the West Indies and elsewhere. Consequently the majority of the detached *Sargassum* represents old individuals soon to die. That part of the detached *Sargassum*, nevertheless, may be able to reach the Sargasso Sea is not impossible; nor is it absolutely excluded that some of the algæ may have the strength to remain active, and continue their growth. We

Be it considered, at last, that the floating *Sargassum* as mentioned above is as it seems always in active growth, I take it for granted that the Gulfweed is perennial, that it lives and dies out at the Sea.

That this explanation is not entirely new, may be seen from HARVEY'S "Nereis Boreali-Americana", part I, 1851, p. 54, where the illustrious English algologist has expressed the same opinion; the observation of this author containing so much of interest in this respect and being seemingly not much known, I take the opportunity to give the quotation as follows:

"Naturalists have been puzzled to account for the origin of the Gulfweed, and formerly it was supposed to be altogether derived from the Gulf of Mexico; being torn off the shores of the Florida reefs and keys, and carried to sea with the great current. It is possible (and indeed probable) that the origin of the present floating banks may have been partly of this nature, but it is most certain that the great masses of the weed that are at present found floating have had no such immediate parentage, but are produced on the surface of the ocean on which they float. Whoever has picked up the plant at sea, on any genuine portion of the bank, must have seen that it was in a perfectly fresh and growing state, and if he have looked at his specimen carefully, he will probably have observed, that different parts of the same specimen were of very different ages; that though there was no apparent root, yet that toward the centre of the mass a small portion of stem was of a much darker colour than the rest, and possibly covered by parasitic incrustations; and that all the branches springing from this central piece were successively more and more delicate and of paler colour, and evidently in a young and sprouting state. Such a Specimen is clearly in vigorous life, yet it has no root. But the absence of root is a matter of very trivial moment in a seaweed; for we must bear in mind that the roots of Algæ are merely holdfasts, intended to keep them from being washed off the rocks on which they grow. And in a plant capable of enduring extensive change of place, like this *Sargassum*, the root is the part which may be most readily expensed with. No doubt the specimen under examination originated in a little branch accidentally broken from a neighbouring mass, and which being thus cast adrift, continued to push out new branches and leaves. In this manner, by the continual breaking up of old fronds and the continued growth of their broken parts, the floating masses spread over the surface of the sea.

In this floating state the species never forms proper fructification. There is, therefore, no growth from spores. The supply of plants is consequently kept up and extended by the constant development of buds or *gemmæ*, originating in broken fragments of branches. I have taken some pains to examine numerous specimens, picked up on various parts of the bank, while fresh from sea, and have in general been able to convince myself that the tuft under examination had originated in a fragment of an older tuft.

This process of growth by breakage must have gone on for ages; from that early time when the first individuals were brought from some unknown rocks by the currents of the ocean. Humboldt indeed conjectures that between the parallels of 20° and 45° there is an

know, at least, that other algæ in a more or less fragmentary condition, and occurring as loose masses are able to persist by means of vegetative reproduction. A fuller account concerning this matter will be given in the subsequent pages.

immense bank from which the supply of *Sargassum* is constantly derived; but such a bank, if covered by only as much water as the greatest depth at which any Fucaceous plant is known to grow, could scarcely have escaped the notice of voyagers. And the aspect of this *Sargassum*, with its innumerable floating-bladders, shews that it was not intended to vegetate at any great depth; for we invariably find the air-vessels most numerous in species which rise to the surface, and altogether absent in those which are deeply submerged."

As may be seen from this quotation, HARVEY gives a very clear representation of the mode of living and of the origin of the *Sargassum*, at the same time as he protests against the supposition of ALEX. VON HUMBOLDT¹⁾ that the Gulfweed should originate from immense submersed banks.

Earlier than HARVEY various authors have expressed the same opinion. MEYEN in *Reise um die Erde, 1ster Theil*, p. 39 says: "Nach unserer Meinung schwimmen sie (the Gulfweed) an dem Orte ihres Vorkommens vielleicht schon seit Tausenden von Jahren." Moreover ROBERT BROWN²⁾ referring especially to MEYEN's observations expresses his view in the same way:

"That the Gulfweed of the great band is propagated solely by lateral or axillary ramification, and that in this way it may have extended over the immense space it now occupies, is highly probable, and perhaps may be affirmed absolutely without involving the question of origin, which I consider as still doubtful."

But, as already mentioned, the bulk of recent literature³⁾ treats the floating *Sargassum* as an alga torn loose from the coasts of the West Indies and America, a conclusion that has probably been reached through the discussion of OTTO KUNTZE⁴⁾.

¹⁾ ALEX. VON HUMBOLDT und A. BONPLANDT, *Reise in die Aequinoctial-Gegenden des neuen Continents, 1ster Theil*, 1815, p. 305.

²⁾ ROBERT BROWN, *On the Origin and Mode of Propagation of the Gulf-weed* in "Proceedings of the Linnean Society of London", Vol. II, 1855, p. 77.

³⁾ Besides the works already quoted compare also:

THOULET, I., *l'Océan, ses lois et ses problèmes*, Paris 1904, p. 367.

OLTMANN, F., *Morphologie und Biologie der Algen*, 2ter Bd., 1905, p. 171.

SCHOTT, G., *Geographie des Atlantischen Ozeans*, 1912, p. 268 (concerning the *Sargassum* in the Sargasso Sea is said here: "Hier mögen sie mehrere Jahre sich halten, ehe sie allmählich absterbend zur Tiefe sinken").

NEGER, FR. W., *Biologie der Pflanzen*, 1913, p. 277.

SCHENCK, H., in the newest editions of "Lehrbuch der Botanik" on the other hand supports the view of SAUVAGEAU (l. c.).

⁴⁾ The paper of KUNTZE (in Engler's *Bot. Jahrbücher*, vol. 1, 1881) intends to show that *Sargassum natans* is no valid species and that the Sargasso Sea is a mere myth. In reference to this I can not abstain from reprinting some of his assertions viz.: "Der name *natans* schliesst nun bereits einen Irrthum in sich; leider glaubte LINNÉ den herrschenden Ansichten und unwissenschaftlichen Berichten früherer Seefahrer mehr, als den exacten Beobachtungen des ehrwürdigen Botanikers RUMPHIUS". TURNER is claimed to be: "Der eigentliche Begründer dieser vermeintlicher Art". And about the floating Gulfweed is said: "Aber sowie man einen ins Wasserglas gestellten, kurze Zeit weiter vegetirenden Blumenzweig nicht eine Wasserpflanze nennt,

Nevertheless, there are some few statements to the effect, that growth of the floating Sargasso does take place. So for instance KRÜMMEL writes (Peterm. Mitt., 37. Bd., 1891, p. 135): "Unser Botaniker (of the German Plankton-Expedition), Hr. Dr. F. SCHÜTT, stellte fest, das die Pflanze lebten und überdies ein gewisses, wenn auch geringes Wachstum zeigten." And BOUVIER (Bulletin de l'Institut Océanographique, Monaco, 1907, No. 93, p. 35) says:

"On sait que les Sargasses à flotteurs (*Sargassum bacciferum*) végètent au voisinage des côtes américaines tropicales à la manière de nos Fucus, et que les portions détachées de leurs thalles, entraînées par les courants, viennent se réunir dans un vaste espace de 200,000 kilomètres carrés, compris entre le Gulf-Stream et le courant équatorial. A lui seul, cet apport serait insuffisant pour peupler d'Algues une étendue aussi vaste; mais, si les Sargasses flottantes ne forment aucun élément reproducteur, elles végètent parfaitement à la surface des flots, y poussent des rameaux, des expansions foliacées et des flotteurs, sans doute également s'y divisent sous l'influence des vagues, chacune de leurs branches détachées donnant naissance à une touffe nouvelle."

GRAN in "The Depths of the Ocean", 1912, p. 336, writes: "The Sargasso weed continues to grow as it drifts, but the gas-bladders are not formed in the same proportion as on the ordinary branches . . ." To this last remark I may point out, that in my material, I have found quite as many gas-bladders in development in the young parts of the branches as in the older parts; moreover, in this connection, may be stated that the gas-bladders "in-toto" are proportionally much more numerous in the pelagic floating forms than in the attached forms at the shores.

A second question, and of no small importance is: where did the floating Sargasso originate?

Although the present writer agrees in all respects with HARVEY (comp. p. 15), that the Sargasso has lived for ages in the Sargasso Sea, yet it seems possible that the floating Sargasso was originally derived from detached forms; furthermore I venture, to express the opinion that renewed increase in this way may take place the day to day.¹⁾

But the question about the origin is however difficult to settle, and before I make any attempt to solve the problem, I wish to give some introductory remarks upon *Sargassum natans* and detached algæ on the whole.

ebenso darf man die auf hoher See schwimmenden *Sargassum*-Fragmente nicht pelagische Pflanzen bezeichnen". By means of seven "reasons" this author, at last, reduces the floating *Sargassum* in the Sargasso Sea to "schwimmenden *Sargassum*-Fragmente". Compare also KUNTZE in his *Revisio generum plantarum*, Part II, 1891, p. 915.

However OTTO KUNTZE does deserve credit for having compiled a good deal of the very comprehensive literature upon this subject.

¹⁾ The supposition offered by PICCONE, according to FORBES, that the Sargasso constitutes a proof of the sunk Atlantis (fide SAUVAGEAU, l. c.) appears to me much too hazardous.

At first I wish to repeat here again the statement that a form exactly agreeing with *S. natans* and its varieties has never been found at any shore, nor do I believe that such form will be found. It is namely a well known fact that loose and floating algæ gradually change their appearance; they grow as if without regulation, getting a quite differing shape, often with numerous proliferations, and being sometimes quite deformed. I need only to refer to the highly different and peculiar appearance of the loose-lying forma *scorpioides* of *Ascophyllum nodosum*¹⁾, in comparison with the typical form, as already pointed out by REINKE²⁾. Unless the development was known, it would be impossible to imagine the fact that these two forms actually belong to the same species. ROSENVINGE³⁾ mentions the difference in habit of several algæ occurring in his "loose-lying Algæ-formation" as compared with the attached forms; in my treatise on the algal vegetation of the Færøese coasts⁴⁾ I have pointed out that many algæ, in sheltered places, and most often loose-lying, have quite a different appearance from the specimens attached and growing in more open localities. And in regard to loose-lying algæ from the Adriatic Sea SCHILLER⁵⁾ in an interesting paper writes p. 64:

"Durch oftmalige und durch mehrere Jahre fortgesetzte Beobachtungen konnte ich mich überzeugen, das diese Algen wachsen, niemals fruktifizieren, sich lediglich vegetativ vermehren und starken morphologischen und physiologischen Veränderungen unterliegen."

and in a special part: "Morphologische und habituelle Veränderungen der Migrationsalgen" very detailed descriptions are given of the great change in habit of the loose-lying algæ as compared with the fixed forms.

Owing to these facts I feel convinced that the floating Gulfweed has an appearance very distinct from the original, attached form.

¹⁾ This form is destitute of vesicles and lies on the bottom; detached *Ascophyllum* carried out at sea sinks therefore most probably soon.

²⁾ REINKE, J., Algenflora der westlichen Ostsee deutschen Antheils. Kiel 1889, p. 33—34.

³⁾ ROSENVINGE, L. KOLDERUP, Om Algevegetationen ved Grønlands Kyster. Meddelelser om Grønland, XX, 1898, p. 218—220.

⁴⁾ BØRGESEN, F., The Algæ-vegetation of the Færøese coasts (Botany of the Færøes, Part III, 1905, p. 697).

⁵⁾ SCHILLER, I., Über Algentransport und Migrationsformationen im Meere (Internationale Revue der gesammten Hydrobiologie und Hydrographie, Bd. II, 1909). When SCHILLER calls the loose-lying algæ-formation "Wanderformation" or "Migrationsformation" and the loose-lying algæ "Migrationsalgen" I do not think that these names are very successfully chosen. Certainly the algæ do become dispersed by currents or by wind, carried to sheltered places, far away from their original stations, but this way of transportation is of course purely mechanical, thus by no means intimating "migration". When arrived to such sheltered places the Algæ remain there, and gradually acquire the different aspect. Finally when SCHILLER at the same time considers the Gulfweed in the Sargasso Sea to represent a Migrationsformation, I can not agree with him since the Gulfweed, as I have pointed out above, propagates by vegetative division in the Sargasso Sea itself, where it rests for the balance of its life.

Naturally this circumstance is a serious obstacle in respect to settling the question of origin, or better the original home of the floating *Sargassum*, inasmuch as there is some possibility of the *Sargassum* descending from forms that are inhabitants of other coasts of the Atlantic ocean than just the West Indian. However, in favour of the West Indies with adjoining shores being the original home of the floating *Sargassum*, is the fact, that the importation seems more possible from there, besides that certain species of *Sargassum* occur there, which do resemble the floating forms.

The species which, according to my opinion, are the most obvious as to the origin of *S. natans* are: *Sargassum vulgare* and *Sargassum Filipendula*; both show much likeness with *Sargassum natans* and both are common along the shores of the West Indies, and warmer parts of the American coast.

In the following I shall try to explain my reasons for entertaining this view.

In the collection of the Botanical Museum at Copenhagen a large specimen of a *Sargassum* is found taken by Capt. A. ANDREA in the Atlantic upon 28° lat. N. and 81° lat. W., consequently quite near the shore of Florida. J. AGARDH has determined this specimen as *S. affine*, a form belonging to *S. Filipendula*. This specimen was interesting in several respects. Judging from its appearance it has evidently been floating already for some length of time, but nevertheless it is fertile. The respectacles are very thin, cylindric and much ramified; the leaves are narrow, nearly linear, with serrate margin, and have a distinct midrib, but no cryptostomata; the vesicles are large, spherical. It can not be denied that this specimen resembles much *Sargassum natans*; the shape of the leaves is proportionally a little broader than in *Sargassum natans*, but the cryptostomata are wanting as is the case with *S. natans*. Furthermore the vesicles are perhaps a little larger in this specimen than in *S. natans*, but taken altogether, the differences are not great. As mentioned above (p. 12) some few specimens of fruiting floating *Sargassum* have been recorded; upon such specimens recently detached, and yet fertile are based, I presume, these statements.

But even if this form of Capt. ANDREA approaches *S. natans* it appears to me that *S. natans* may also have descended from *S. vulgare*. Narrow leaved forms of this species occur (comp. f. i. KÜTZING's figure in "Tab. Phycol.", vol. XI., pl. 23, fig. II) and these forms agree very much with *S. natans*. In some of my attached specimens from the Danish West Indies, I have, now and then, found leaves without cryptostomata. And in regard to the flagellate prolongation known from var. *ciliata* of *S. natans* I may point out that I have often found a shorter or longer, frequently leaflike prolongation upon the top of the vesicles. And taking into consideration the above mentioned tendency to proliferations in loose-lying algæ the frequency of these ciliate prolongations in the floating seems very natural.

In respect to the second, coarser form which I have found in the Sargasso Sea this reminds very much of *Sargassum Hystrix* which is said to be widely dispersed along the shores of the West Indies and America. As I have pointed out above, the figure of the sterile plant in J. AGARDH'S "Species Sargassorum Austr.", pl. 1, fig. 1 agrees very well with the floating form; only the leaves in the floating form are commonly somewhat smaller, and proportionally more serrate, and so along their whole length, moreover the vesicles are very numerous. In the collections of the Botanical Museum, Copenhagen, some specimens were found, collected floating by Capt. ANDREA in the Old Bahama Channel, 1/VIII 1870 and by J. AGARDH referred to this species. These specimens agree also very much with my specimens from the Sargasso Sea. Therefore I feel quite convinced that this form has its origin from *Sargassum Hystrix* being a floating form to which I have proposed the name var. *fluitans*.

The results of the present investigation are in brief:

- 1) The floating *Sargassum* in the Sargasso Sea consists of two species: *Sargassum natans* (L.) (the most common) and *S. Hystrix* J. Ag. var. *fluitans*.
- 2) The Gulfweed is a true pelagic alga; it is a perennial, lives and dies out at the sea.
- 3) As to the origin of the Gulfweed, I presume, it most probably has descended from forms living at the shores of the West Indies and surrounding coast of America.

It is, thus, of great interest that we have before us an instance of floating, pelagic species of such a high alga-type as *Sargassum*. Because, as is well-known, the higher types of algæ are as a rule attached, at least normally, and if detached they perish sooner or later.

Finally I wish to point out that the amount of organic detritus which the floating pelagic *Sargassum* produces surely may be of high importance to the economy of the sea, and so much the more to the tropical sea, where the Plankton is more scant¹⁾.

Since the printing of this paper was nearly ended Mr. WINGE has published a small note on the Gulfweed in the last number of the "Botanisk Tidsskrift", vol. 33, Heft. 4, p. 269. Having not seen the Sargasso Sea himself, Mr. WINGE'S observation is not based upon material collected by himself. His results are: 1) The Gulfweed essentially consists of two species: *Sargassum bacciferum* and *S. vulgare*, 2) The *Sargassum* can surely float for some time and reproduce vegetatively. Finally some information is given about the location of the Sargasso Sea.

¹⁾ Compare H. H. GRAN, l. c. p. 366.
