

**COMMONWEALTH OF AUSTRALIA**

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AUSTRALIAN SPECIES OF SARGASSUM, SUBGENUS ARTHROPHYCUS

J. Agardh.

by H.B.S. Womersley,  
 Department of Botany, University of Adelaide.

The subgenus *Arthrophykus* of *Sargassum* is distinctive of the southern coast of Australia, where the species are frequently of considerable ecological importance in the upper sublittoral zone. Few species of *Arthrophykus* are known from other countries; 2 endemic species are known from South Africa (*S. heterophyllum* (Turner) J. Agardh and *S. incisifolium* (Turn.) J. Ag.), three species from New Zealand (*S. lacerifolium* (Turn.) C. Ag., *S. paradoxum* (R.Br. ex Turn.) H. & H. and *S. sinclairii* H. & H. (endemic) and two species endemic to Hong Kong (*S. mcclurei* Setchell and *S. herklotsii* Setchell) are referred to *Arthrophykus* by Setchell (1933). From southern and south-eastern Australia some 18 species have been described. This account, however, reduces them to about 9 "good" species with a very few other doubtful species.

Three subgenera of *Sargassum* occur on Australian coasts; *Phyllotrichia*, which has been discussed previously (Womersley 1954), *Arthrophykus*, and *Ensargassum*. (The southern Australian species of the latter subgenus will be described in a later account). Knowledge of *Sargassum* depends largely on the work of three authors — J. Agardh 1889 and earlier papers) who

established the subgenera, Grunow (1915, 1916), who largely followed J. Agardh, and Setchell (1931, 1933, 1935, 1936), who gives the most recent account of the genus, also largely following J. Agardh.

*Arthrophyucus* J. Agardh is characterised by simple, often large, and relatively thick, basal leaves, which are markedly distinct from the leaves of the upper fertile branches. The branch axes are usually robust and triquetrous (triangular in section), with the basal part of the laterals retroflexed (bent downwards). The receptacles are axillary, frequently simple but associated in groups, occasionally compound; they range in different species from terete to strikingly triquetrous with prominent marginal spines. Vesicles are usually present, often with a terminal awn or leaflet, indicating the origin of the vesicle from the lower part of a leaf.

While in general *Arthrophyucus* is a fairly well defined subgenus, some species are difficult to place, and it is doubtful whether the separation of the subgenera *Bactrophyucus* and *Arthrophyucus* can be maintained. J. Agardh (1899) separated these two genera on the receptacles; those of *Bactrophyucus* (from eastern Asiatic coasts) being simple while they are compound in *Arthrophyucus*. However in most of the Australian species placed under *Arthrophyucus* by J. Agardh, the receptacles are simple, even if grouped together owing to the dense fertile branch systems.

Variations between *Arthrophyucus* and subgenus *Eusargassum* are also found in some species. J. Agardh placed the Tasmanian *S. membranaceum* J. Ag. and the New Zealand *S. sinclairii* in a group of *Arthrophyucus* where the branch axes are obtusely angular below and terete above, the branches are scarcely retrofract, and the lower leaves are not very diverse from the upper ones. These characters are more those of *Eusargassum* than *Arthrophyucus*, and the above two species need detailed investigation to establish their position. Reasons are given below for regarding *S. membranaceum* J. Agardh as a nomen dubium. Several New South Wales species also appear to show characters intermediate between *Arthrophyucus* and *Eusargassum*. These need thorough study on the basis of field and seasonal knowledge and good ranges of fertile specimens; they are not included in the present account apart from notes on *S. globulariaefolium* J. Agardh and *S. erosum* J. Ag. which are fairly distinctive species of *Arthrophyucus*.

Most of our knowledge of *Sargassum* is due to J. Agardh, especially his 1889 monograph where numerous new species are described and all other known species described and illustrated. As has been stated before (Womersley 1954), it is disturbing to find that the specimens in the Agardh Herbarium in Lund are less impressive than J. Agardh's descriptions and figures. For instance, in several cases the basal leaves and upper branches

are not attached, and there seems no reason why they should definitely be associated. In other cases (e.g. Sp ensifolium (C. Ag.) J. Ag., J. Agardh has described receptacles for a species the type specimen of which is completely sterile. This is quite unjustified, and when the type of a species of Sargassum is sterile, it must undoubtedly be rejected as a nomen dubium.

J. Agardh was undoubtedly a "splitter" as far as Arthrophyucus is concerned. His emphasis on distinctions between the basal leaves of different species is in many cases impossible to uphold, and he had little appreciation of the age variation in the receptacles of each species. This lack of appreciation of specific variations was perhaps ~~fat~~ partly unavoidable with only dried specimens, often poor ones, available for study.

Since J. Agardh, the only account dealing extensively with Australian species of Sargassum is that of Grunow (1915). Grunow describes numerous varieties and some forms of the species of Arthrophyucus, but places these under J. Agardh's species. This work of Grunow's contributes virtually nothing to the taxonomy of Arthrophyucus, and the present author's field experience and studies of large ranges of good fertile specimens makes it abundantly clear (even though Grunow's specimens have not been seen) that nearly all, if not all of Grunow's varieties and forms within Arthrophyucus are only ecological or seasonal

variations and unworthy of recognition. Although references to Grunow's paper are given under the species below, his varieties and forms are not mentioned.

In studying *Arthrophycus*, the earliest described species have been studied in detail first, based on examination of the type specimens. Most of these species are well defined and the types fortunately are good fertile specimens usually with basal leaves. The earliest described species were those collected by R. Brown and described under Fucus by Turner (1811), viz. S. paradoxum (R. Br. ex Turn.) H. & H., S. lacerifolium (Turner) C. Ag. and S. vestitum (R. Br. ex Turn.) C. Agardh. These were followed by S. ensifolium C. Agardh in 1824, based on basal leaves only and therefore a nomen dubium. In 1845 Sonder described three more species, S. biforme, S. fallax and S. tristichum (the latter <sup>an</sup> nomen nudum of Greville and C. Agardh). Following this J. Agardh described several species, especially in his 1889 monograph.

The present study is based largely on extensive field knowledge and collections during all seasons by the author on various parts of the southern Australian coast. The collections in the Melbourne National Herbarium have also been examined. These include Sonder's type specimens, but most other specimens (many ex herb. J. Agardh) are sterile or too frag-

mentary to be of much value.

In collecting specimens of *Arthrophycus*, similar considerations apply as discussed previously for the species of *Phyllotrichia*. (Womersley, 1954). The specimens must be complete, with basal leaves and well developed upper fertile fronds; young or incomplete specimens are useless and should be discarded. Fertile specimens are usually found in late winter and early summer (September to January). After this period the fertile branches are usually lost, leaving only the basal leaves. Fertile fronds should be studied throughout this period to observe the variation in both receptacles (which often increase considerably in length as they age) and in vesicles. Vesicles are usually absent on young branches and develop at much the same time as the receptacles. Older fronds of some species may lose nearly all their vesicles and also the upper leaves are frequently largely or almost completely shed. (e.g. *S. tristichum*, *S. bracteolosum*). In some species (e.g. *S. vestigium*) vesicles are only rarely formed, though when they are they may be quite abundant.

Taxonomy within *Arthrophycus* must be based largely on the receptacles, which are reasonably characteristic for any species once their seasonal variation is known. The In most species the plant conceptacles appear to be bisexual, but in *S. paradoxum* the plants are usually dioecious, receptacles

of male plants being more<sup>or</sup> less terete while those of female plants <sup>are</sup> being flattened or even triquetrous in the upper part and bear a few coarse scattered spines. Basal leaves can only be used with caution, though they are more or less characteristic of certain species. In S. paradoxum they are strongly undulate, but flat and entire in S. vestitum and S. tristichum. The upper (and sometimes the basal) leaves of S. lacerifolium are deeply incised, thus separating this species from S. tristichum.

The extra- Australian species of *Arthrophycus* have not been studied, though detailed comparisons with them (especially the New Zealand species) would be of great interest. The only Australian species recorded from other countries are S. lacerifolium and S. undulatum (= S. paradoxum) from New Zealand (Lindauer 1947).

Many of the Australian species of *Arthrophycus* are distinctive of the upper sublittoral zone, especially just below low tide level or in low and deep rock pools. They usually extend into 10 or 20 or more feet of water, but some (e.g. S. paradoxum) seem to be characteristic of deeper rather than shallower water. Most species occur where wave action is moderate to strong.



The distribution of the species along the southern Australian coast may be summarised as follows. The subgenus is essentially southern Australian (i.e. from south west Western Australia through to Victoria and Tasmania) with a few species characteristic of the New South Wales coast. None are known from northern Australia. Of the 7 fairly well defined species discussed below, S. biforme, S. fallax and S. tristichum are western species (extending into South Australia). S. paradoxum and S. vestitum are eastern species (also extending into South Australia) and S. bracteolosum and S. lacerifolium are found generally along southern Australia. All these species occur within the state of South Australia.

Previously (Womersley 1954) S. linearifolium (Turner) C. Ag. was removed from *Phyllotrichia*, and it was suggested that this species might belong to *ArthrophyCUS*. It is now clear that *S. linearifolium* should be referred to *Eusargassum* since the branch axes are more or less terete and the laterals not retrofract.

SYNOPSIS OF THE AUSTRALIAN SPECIES OF

ARTHROPHYCUS.

SOUTHERN AUSTRALIA.

"good" species

Synonyms previously  
regarded as good  
species.

Receptacles terete,  
not spinous.

? { S. paradoxum ♂  
S. bracteolosum } { S. undulatum, S. grande,  
S. fallax } S. gunnianum

Receptacles com-  
pressed, at least  
near the apex,  
with some spines

? S. paradoxum ♀  
S. vestitum - - - S. rhyncophorum  
S. biforme

Receptacles tri-  
quetrous, spiny.

S. tristichum  
S. lacerifolium

NOMEN DUBIA

S. ensifolium  
S. isophyllum  
S. laevigatum  
S. membranaceum.

NEW SOUTH WALES SPECIES

S. globulariaefodium - - - S. robustum  
S. erosum

KEY TO THE SOUTHERN AUSTRALIAN SPECIES OF ARTHROPHYCUS.

1. Receptacles terete (or older ones slightly compressed), without spines... .. 2
1. Receptacles usually flattened or triquetrous, with spines... .. 4
2. Receptacles large, 5-10 (-15) mm long and about 1 mm broad, in open panicles... S. paradoxum ♂
2. Receptacles smaller, 1-5 mm long, borne in large numbers on slender upper leaves... .. 3
3. Receptacles terete, older receptacles slightly compressed, without lateral awns; 1-2 mm long and 300-800  $\mu$  broad; upper subtending leaves narrow but flattened.. ... S. Allax
3. Receptacles terete, often bearing sterile awns; 2-5 mm long and 500-700  $\mu$  broad, upper subtending leaves terete or almost so.... .. S. bracteolosum
4. Receptacles flattened or occasionally somewhat triquetrous (may be terete when young), with odd spines especially on the upper part..... 5
4. Receptacles distinctly triquetrous, with prominent and regular spines along the edges..... .. 7

5. Receptacles large, 5-10 (-15) mm long and about 1 mm. broad, terete below, slightly flattened to somewhat triquetrous above, with occasional spines... .. S. paradoxum ♀
5. Receptacles small 1-2 (-4) mm long and  $\frac{1}{2}$ -1 mm broad, flattened with spines on the upper part... .. 6
6. Leaves entire, smooth. Receptacles flattened, occasionally somewhat triquetrous, with fairly prominent spines on the upper part... S. vestitum
6. Leaves undulate, crinkled when dry. Receptacles terete when young, flattened when mature, with odd blunt spines on the upper part... S. biforme
7. Leaves entire, usually smooth but lower leaves sometimes undulate. Fertile fronds tending to lose leaves... .. S. tristichum
7. Leaves deeply incised, especially those above the basal leaves. Fertile fronds tending to retain their leaves... .. S. lacerifolium

Sargassum paradoxum (R. Br. ex Turner) Hooker and Harvey  
 1847: 413. J. Agardh 1848: 302; 1872: 66; 1889: 68, pl.  
 20 (II) De Toni 1895: 29. Grunow 1915: 358. Harvey  
 1860: 282. May 1939: 202? Sonder 1852: 672; 1853: 512.

## PLATE I.

Fucus paradoxus R. Br. ex Turner 1811, pl. 156.

Mertens 1819: 181.

Cystoseira paradoxa (R.Br.) G. Agardh 1821: 75;

1824: 289.

Blossevillea paradoxa (R.Br.) Kuetzing 1849: 630;

1860, pl. 88.

Sargassum grande J. Agardh 1889: 72, pl. 22 (I).

De Toni 1895: 32. Grunow 1915: 360.

Sargassum gunnianum J. Agardh 1889: 71, pl. 21 (III).

De Toni, 1895: 32. Grunow 1915: 359.

Sargassum undulatum J. Agardh 1872: 67; 1889: 73,

pl. 22 (II). De Toni 1895: 33. Grunow 1915: 360.

Lindauer 1947: 562?

Plant dioecious, (largely if not entirely). Stem terete, to  
 4 cm long, from a conical holdfast. Basal leaves to 10 cm.  
 (or more) long, 2-3 cm. broad, margins strongly undulate, more  
 or less entire to spinous. Branch axes robust, triquetrous,  
 branches retroflex. Branches to 1 meter long. Upper leaves to

5 cm long and 1 cm broad, smooth (not undulate), margin entire or spinous to fairly deeply incised. Vesicles abundant on older fertile fronds, shortly petiolate, spherical, 5-10 mm diameter, mucronate to aristate. Receptacles 5-10 (-15) mm long, about 1 mm broad; on male plants receptacles more or less terete with few if any spines; on female plants receptacles terete below, flattened or even somewhat triquetrous in upper parts, with scattered spines.

Type Locality: "Southern coast of Australia". Type: BM

Distribution: From Kangaroo Island and Spencer Gulf in South Australia to St. Kilda, Victoria and around Tasmania.

Hooker and Harvey (1847) first stated that the female receptacles were three angled, with conical protuberances, and the male receptacles cylindrical and smooth, larger than the female. J. Agardh (1889) considered this view mistaken, and described those specimens with somewhat triquetrous, irregularly spiny receptacles as S. grande. An extensive collection of S. paradoxum from Marino, South Australia (AD, A 23,969) shows clearly that Hooker and Harvey were correct, and the species is dioecious with differing receptacles. Other collections support this, though in a few cases there is some doubt whether bisexual conceptacles may not occur. In other features the male and female plants are identical.

S. undulatum J. Agardh (Type Locality: Tasmania (Gunn);  
 Lectotype: Herb. Agardh, LD, No. 2154 (lower left)) is  
 represented by only one good fertile specimen in Herb. Agardh,  
 that of Gunn. J. Agardh's specimen from southern Australia  
 (Hobsons Bay, Watts) consists of basal leaves only and must be  
 disregarded. The receptacles illustrated by J. Agardh are  
 young ones, older ones being more elongate (2-5 mm long). J.  
 Agardh (1889: 73) described the receptacles as "obovato-  
 clavatis angulatis et denticulis obsoletioribus obsitis", and  
 compared them to both S. paradoxum and S. biforme. It is clear  
 that S. undulatum represents only a female plant of S.  
paradoxum.

S. grande J. Agardh, from "Tasmania and southern  
 Australia", (Lectotype: Herb. Agardh, LD, No. 2147) is also  
 identical with S. paradoxum, the type having fairly mature  
 receptacles. The parts from which J. Agardh described and  
 figured S. grande are separate, and there is no authentic  
 specimen in Herb. Agardh with both upper and basal parts  
 attached. The upper parts (No. 2147) with receptacles are  
 selected as the lectotype, and the basal parts (No. 2141) must  
 be regarded with doubt.

S. gunnianum J. Agardh is founded mainly on 7 specimens of R. Gunn, from Tasmania, in Herb. Agardh. These all appear to be the same species, and one of the best (No. 2132) is selected as the lectotype. However, there are no basal leaves in the folder of S. gunnianum in Herb. Agardh, so J. Agardh's drawing of basal leaves must be disregarded. A specimen of Gunn's in MEL, ex Herb. Agardh, is probably type material. The receptacles of the lectotype are fairly young, those of the MEL specimen more mature, and I have little hesitation in referring them to S. paradoxum.

S. paradoxum is found fertile in late winter and early summer; the receptacles reach their full size in December, and then or soon after the vesicles are lost and later the whole fertile fronds.

Sargassum fallax Sonder 1845: 52; 1846: 164. J. Agardh 1848: 297; 1872: 66; 1889: 68, pl. 20 (Ip. De Toni 1895: 29. Grunow 1915: 357. May 1939: 202?

PLATE 2.

Blossevillea fallax (Sonder) Kuetzing 1849: 631; 1860: pl. 87.



Stem terete, short. Basal leaves to 10 cm long,  $\frac{1}{2}$  -  $1\frac{1}{2}$  cm broad, margins more or less entire, smooth. Branch axes robust, triquetrous, branches retroflex. Branches to  $\frac{1}{2}$  m (or more) long. Lower leaves grading to upper ones; smallest leaves 1-2 cm long and  $\frac{1}{2}$  - 1 mm broad, flattened; intermediate leaves several cm long, 5-10 mm broad, margins entire to fairly deeply incised. Vesicles fairly abundant, petiolate, spherical, 5-10 mm diameter with a leafy awn to 1 cm (or more) long. Receptacles terete, smooth, without awns, older ones slightly compressed, 1-2 mm long and 300-800  $\mu$  broad, conceptacles bisexual (?).

Type Locality: Western Australia (Preiss). Type: MEL.

Distribution: Definitely known from the type, a probable specimen from Champion Bay, Western Australia, and a specimen from Rocky Point, Kangaroo Island, South Australia (A 13,320). The type material in MEL consists of two sheets, one with 5 separate fragments, all fertile, the other with 4 fragments, one of which comprises largely basal leaves, another the upper sterile parts, and the other two are smaller fertile branches. All the fertile species are similar. The type sheet is illustrated in Plate 2. The type material - or similar Preiss material - has been illustrated by Kuetzing (1860, pl. 87).

Relationships between S. fallax and S. bracteolosum are discussed under the latter species.

Sargassum bracteolosum J. Agardh 1889: 67, pls. 4, 19 (II).

De Toni 1895: 28. Grunow 1915: 355. Lucas 1936: 66. Womersley 1950: 161.

PDATE 3.

Stem terete, to 4 cm long, from a conical holdfast. Basal leaves to 12 cm long, 1-2 cm broad, generally smooth, margins entire in rough water forms to entire or sometimes spinous in calmer water forms. Branch axes robust, triquetrous, branches retroflex. Branches to  $\frac{1}{2}$  m long. Upper leaves usually sharply distinguished from lower leaves, but showing gradation on young branches; uppermost leaves terete or almost so, slender, to 3 cm. long and less than  $\frac{1}{2}$  mm broad. Vesicles varying from absent to abundant, not present on young fronds and lost from older fertile fronds; petiolate, spherical (sometimes ovate when young), 4-8 mm diameter, mucronate or with a leafy awn to 1 cm long. Receptacles terete, often bearing sterile awns, similar to the upper terete leaves, from part way up the receptacle; receptacles borne 1 or 2 in axils of terete leaves; receptacles 2-5 mm long (longer ones often curved) 500-700  $\mu$  broad; conceptacles usually bisexual.

Type Locality: Tasmania.

Lectotype: Herb. Agardh, LD, No. 2044.

Distribution: From Euela (probably further west) in Western Australia to Robe in South Australia and probably in Victoria; Tasmania.

The lectotype chosen in Herb. Agardh is the best specimen, with upper and basal parts attached, from Tasmania and matches J. Agardh's figures best of all his specimens.

This is a common species along the South Australian coast in particular, extending into Victoria and Tasmania. In the latter two States it is largely replaced by S. vestitum, both species occurring just below low tide level. The type locality (Tasmania) appears at present to be rather outside the main distribution of S. bracteolosum.

The differences between S. bracteolosum and S. fallax need further study, and they may prove to be forms of the one species. The receptacles are very similar apart from the lateral sterile awns in S. bracteolosum and slightly compressed receptacles in S. fallax; but only a few specimens classed as S. fallax, not showing such awns, have been examined. Otherwise the receptacles of S. bracteolosum tend to be longer, the upper leaves are terete whereas they are flattened in S. fallax, and the latter species appears to retain the upper and medium leaves in older fertile fronds more so than in S. bracteolosum. These differences, however, are not always consistent and may prove to be only ecological variations.