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The Genus *Pterocladia* in New Zealand.

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The genus *Pterocladia* has been widely collected over a long period by New Zealand algologists. Thanks to the generous co-operation of those responsible for the various herbaria, it had been possible to examine specimens from the following sources:—Herb. R. M. Laing (bequeathed to Canterbury College); Herb. W. A. Scarfe (presented to the Botany Division); Herb. V. W. Lindauer; Herb. Auckland Museum; Herb. Dominion Museum. The Auckland Museum collection, built up by Miss L. M. Cranwell, and the Laing Herbarium provide together a very useful set of examples from outside New Zealand. From this material, considered along with the fairly extensive series collected during a survey of seaweeds suitable for manufacture of agar in New Zealand (Moore, 1944), it appears that the characters of the genus have been rather narrowly limited, and that some points have been ignored altogether. The present paper offers supplementary data bearing on the broad question of generic diagnosis, and also attempts to state the conclusions reached about the relationships of the various New Zealand forms known to belong here. It is possible that, among our smaller plants at present attributed to the genus *Gelidium,* but not yet studied in detail, some may be found to be in fact *Pterocladia.*

The genus *Pterocladia* was set up by J. G. Agardh (1851, p. 482), based on the single species *Fucus lucidus R.Br.* (in Turner, 1819, p. 98, t. 238). The generic description, which is full and detailed, appears to have been drawn up, not from the original Australian specimens in the Brown Herbarium, but from later collected plants, which Agardh states did not agree in habit with the one Turnerian specimen he had seen. Agardh had descriptions subsequent to Turner's to draw upon, and probably had, among others, Hooker's New Zealand specimens under review when he set out his generic and specific characters. Thus, though the type specimen of *F. lucidus* must be one of Brown's Australian plants, the genus *Pterocladia* was based on other material.

The main diagnostic character of *Pterocladia* is the unilocular cystocarp with parietal placenta, and this was recognised by Bornet and Thuret (1876) in Gmelin's *Fucus capillaceus,* which had been merged in, or kept as a variety of, *Gelidium corneum.* Many features of *P. capillacea* do not fit into Agardh's detailed generic description of *Pterocladia,* based on *P. lucida* alone. More recently described species of *Pterocladia* include *P. pectinata* Lucas (1931), *P. nana* Okamura (1931), *P. tenuis* Okamura (1934), *P. densa* Okamura (1934), *Gelidium* (*Pterocladia*) *okamurai* Setchell and Gardner

(1937), *P. americana* Taylor (1943), and *P. bartlettii* Taylor (1943). In countries where only *P. capillacea* or near relatives grow, there has been a tendency to regard characters of the smaller *Pterocladia* as common to the genus, but this assumption is not always justified.

REPRODUCTIVE ORGANS.

In clearly defined margins of male sori, and in irregular disposition of tetrasporangia in their sori, New Zealand specimens agree with Feldmann and Hamel's account of the genus (1936, pp. 94–96). In some of the New Zealand material examined there was an indication of V-shaped series of tetrasporangia, but none were so obvious as those figured by Feldmann and Hamel in *Gelidium melanoideum* (*loc. cit.* Fig. 16) and the genus *Gelidiella*. Taylor (1943) records clear or obvious V-shaped rows in both *P. americana* and *P. bartletti*. The cystocarps examined showed some features of which no mention has been seen in the literature.

The Cystocarp.

Agardh pointed out in 1851 that while the cystocarp in *Gelidium* is double, projecting from both sides of the frond and with the placenta forming a wall between the two loculi, that in *Pterocladia* is single, projecting on one side only. He describes the liberation of the carpospores in *Gelidium*: " gemmidiis . . . demum de laceratione pericarpii a fronde liberatis "; in *Pterocladia*: " gemmidiis . . . per carpostomium demum emissis."

Harvey (1863, Pl. 248) says of *P. lucida* " conceptacles resemble semi-conceptacles of a *Gelidium*, as if one side only of the conceptacle were developed," but the carpostome of *Gelidium* is not described. Otherwise the dehiscence of *P. lucida* does not seem to be mentioned in the literature, and figures of sections of the cystocarp do not show any ostiole.

In *P. capillacea* the cystocarp is better known. Bornet's figure (1876) of a longitudinal section showing a single opening on a raised mound pointing towards the tip of the pinnule has been repeatedly reproduced. (Bornet's Pl. 20 shows also a T.S. of *Gelidium latifolium* with two opposite ostioles, not raised on special projections.) Feldmann and Hamel's Fig. 30B shows a twig of *P. capillacea* with numerous cystocarps in many of which the single ostiole can be seen at the top of a small projection. Of dehiscence in the family generally, these authors say only " Les carpostomes se percent." Okamura (1934) studying cystocarps of native Japanese species, describes the *Pterocladia* carpostome as " elevated more or less like a beak with a large and round opening, situated either vertically or a little obliquely towards the apex a little ahead of the middle of the median line." His Pl. 33 figures the cystocarps of his three Japanese species of *Pterocladia*, each with a single ostiole raised on a conical mound.

New Zealand specimens resembling *P. capillacea* in other respects have the characteristic conspicuous carpostome raised on a mound, often pointed and quite frequently directed rather towards the pinnule tip. Two, three, or occasionally as many as five carpostomes, all in the median line, may open from a single loculus (Pl. 45, Figs. 1–3), but usually there is only one.

In *P. lucida,* both New Zealand and Australian specimens, the surface of the cystocarp is smoothly rounded or vaguely cratered, without any conspicuous projection and no very obvious carpostome. (Pl. 45, Fig. 6). Slicing off the pericarp, of which Agardh (1851, p. 482) says " demum delabentia, excavationem in alterutera pagina reliquentia," and mounting it separately, shows clearly that each cystocarp has as a rule several carpostomes opening from one loculus. Each carpostome is slightly sunk below the general surface and is rimmed, though not so strongly as those of *P. capillacea,* with a clear structureless border. They are irregular in shape, from circular to slit-like, and disposed on the surface of the cystocarp without any uniform arrangement. On one frond different cystocarps may have one to six openings (Pl. 45, Fig. 7).

The appropriate part of the generic diagnosis should therefore read " cystocarp with one loculus opening to one or other surface of the frond by one or more ostioles."

Axis Structure as a Generic Character.

A characteristic feature of the family Gelidiaceae is the development, between the axis cells, of fine, non-septate, unbranched, thick-walled filaments, that are variously called rhizines, rhizoids, rhizoidal filaments, hyphae, or intercellular fibres.

Okamura (1934, p. 47) considers that " in the sterile state *Gelidium* is distinguished from *Pterocladia* by the difference of the arrangement of rhizoidal filaments. In the former they are, as a rule, thickly congested on the external side of the central tissue, and in that tissue few are scattered in younger parts of frond, becoming gradually denser as the part grows in age. On the contrary, in *Pterocladia* rhizoidal filaments are seen in the central tissue only, either densely or scatteringly. In both genera it is common to find a dense mass of rhizoids on both sides of branches, so that the cross section of branches shows densely congested rhizoids at both corners." He mentions as exceptions *G. vagum* and *G. pusillum,* which in some sections show a dense mass of rhizoids in the central tissue.

Feldmann and Hamel (*loc. cit.* p. 92) find that in *P. capillacea* " les rhizines sont localisées dans le tissu médullaire et font défaut dans l'écorce interne (Fig. 3, échantillon de Banyuls)". They use the rhizine grouping as a generic key character on page 97.

Setchell and Gardner (1937, p. 76) say " The presence of rhizoidal filaments in the centre of the medulla, as proposed by Okamura as a method of distinguishing the two genera, does not seem to hold in all cases."

Taylor (1943, p. 158), considering *P. capillacea* and *G. corneum,* remarks " The distribution of the rhizines in the stem is by no means clear-cut in many cases, and as a character must be used with caution."

In studying the structure of the frond Okamura took " for the sake of comparison, the sterile fronds of *Pterocladia lucida* and *P. capillaris* " (the latter presumably a misprint for *capillacea*) but he does not mention the source of this material.

Agardh's generic description, followed by Hooker, Harvey and later authors states: " Frons . . . stratis tribus contexta; fibris

interioribus longitudinalibus densissime intertextis, oblique in cellulas majores rotundatas excurrentibus, exterioribus cellulis minoribus, in fila moniliformia verticalia conjunctis." Thus one would expect *P. lucida* to conform to Okamura's scheme. Sections of Berggren's specimens from North Auckland, identified by J. Agardh as *P. lucida,* show, however, that this description applies only to older parts of the axes, and then only as long as it is understood that the region of larger rounded cells is rather inconspicuous, only about two cells wide and very near the surface. Younger portions of Berggren's specimens, and of a long series of matching cystocarpic plants from various parts of New Zealand show a well-defined region in the cortex where the rhizines are much more abundant than in the medulla; in fact the axis cross section before the midrib develops agrees better with Okamura's figures 5 and 7, Pl. 31, of two forms of *Gelidium amansii,* than with his figures of the Japanese species of *Pterocladia* closely related to *P. capillacea.*

P. pectinata, of which Lucas described a cystocarpic specimen (presumably unilocular) when he published the species (Lucas, 1931) is represented in the Laing Herbarium by a tetrasporic specimen (leg. Lucas). Cross sections of this would place it by Okamura's scheme definitely in *Gelidium;* indeed they agree quite well both with Okamura's description of those of *G. subcostatum* (1934, p. 52), and with sections made from a specimen of the same species, ex Herb. Michitaro Higashi, in the Laing Herbarium.

These observations indicate that the distribution of the rhizines in the axis is not a sufficient guide to the genus of a sterile specimen.

AXIS STRUCTURE AS A SPECIFIC CHARACTER.

Gardner (1927) recognised that this character might be important *within* the genus *Gelidium,* and he gives notes about the distribution of the rhizoidal filaments in seven out of the twelve entities he discusses. Feldmann and Hamel (*loc. cit.* p. 93) say, " Dans certains cas, la disposition des rhizines peut être utilisée pour la distinction des espèces," for example in *G. attenuatum* the rhizines completely fill the spaces between the medullary cells of the central tissue, while in the superficially similar *G. sesquipedale* the central area is quite without rhizines. In *G. crinale,* on the other hand, which, like the two preceding species, has many rhizines in the inner cortex, rhizines may be either present or absent in the medulla.

It is a general experience that there is a certain range of structure within a single plant, and it is not always safe to draw conclusions from a single section. The rhizine proportion usually increases with the age of the part, which does not always vary as its size (often a narrow old part bears a broad young tip). A few sections from the middle of penultimate pinnules not too near the tip are the best guide, especially if considered with one from a primary or stout secondary rhachis.

Taking the younger parts, sections of New Zealand plants made in the present project fall easily into two groups: one with rhizines concentrated in the medulla, and one where the bulk of the rhizines is in the inner cortex, with the number in the medulla small at first,

but increasing with the age of the part. These distinctive cross sections are correlated with constant morphological differences and seem too good a specific character to be ignored. Conversely, it should be fair to assume that, in plants having essentially similar tissue arrangements, morphological differences need to be very clear-cut in order to be accepted as reliable bases for segregating species.

Pterocladia capillacea IN NEW ZEALAND.

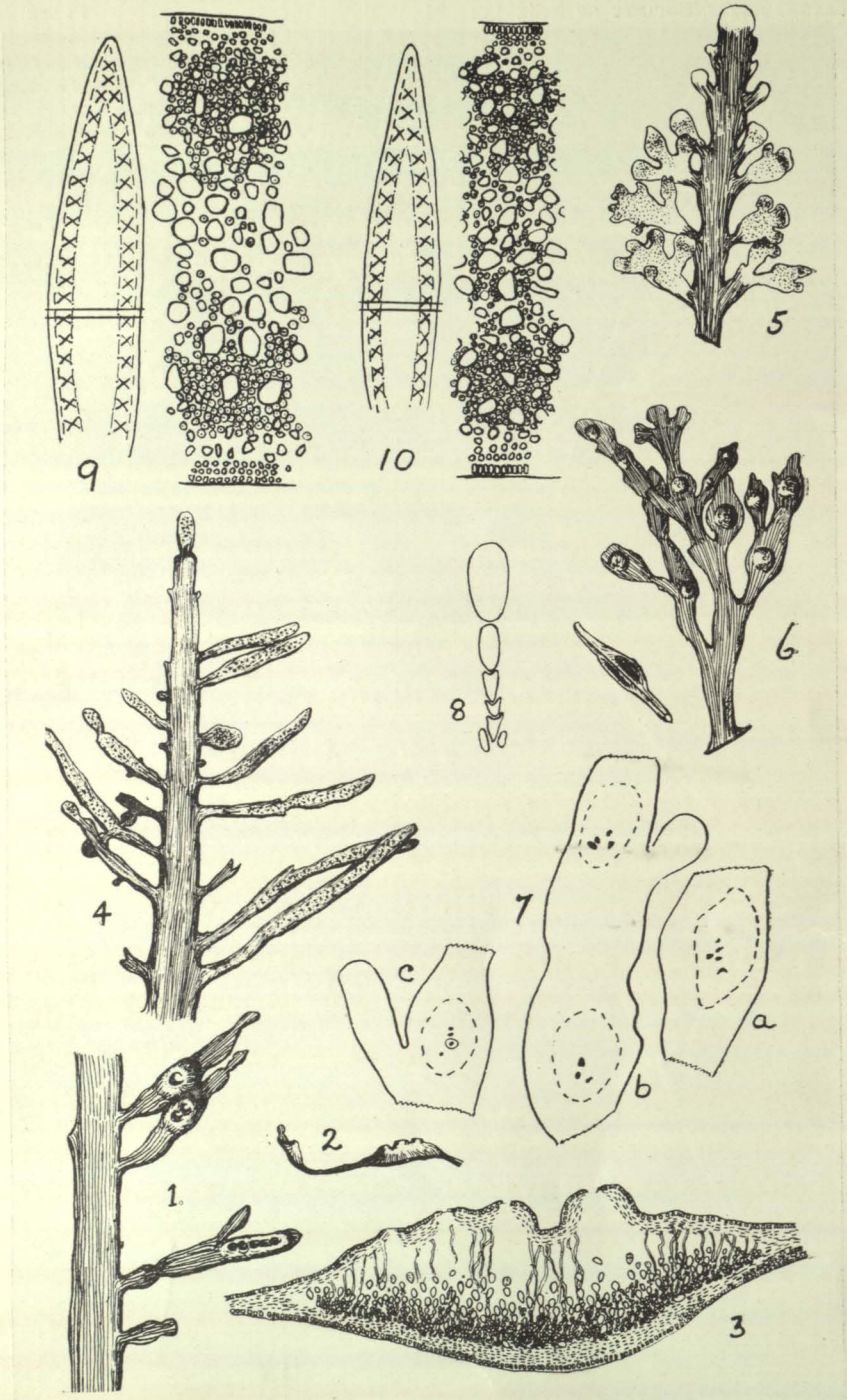
The New Zealand specimens examined can be divided without difficulty into two groups known commercially as *P. lucida* and *P. capillacea.*

The *P. capillacea* group is distinguished by small size (maximum about 30 cm. x 12 cm.), the cross section of the axis being oval in all parts except where it is occasionally almost circular, with the rhizines in young parts confined to the medullary region in the middle line (often forming a dumb-bell-shaped group in the whole T.S.), and, in the cystocarpic plant, by the usually single, strongly prominent, heavily rimmed carpostome.

To this group belong also *P. nana, P. tenuis,* and *P. densa* of Okamura, who gives no very convincing character separating these from *P. capillacea. P. capillacea* is stated to be (p. 63) " less broader, often more irregularly branched than *P. tenuis,* and not constricted always to have pyramidal outline."[1] Setchell and Gardner (1937) compare their very similar *G. (P.) okamuri* with *P. nana* but not with *P. capillacea.* Taylor's *P. americana* and *P. bartlettii,* which might otherwise be included in this group, are apparently distinct in that their tetrasporangial sori display clear V-shaped series.

In New Zealand material rather few plants are cystocarpic and this makes it difficult to eliminate the possibility that some might belong to species of *Gelidium* similar in form to *P. capillacea.* Among Okamura's illustrations, Pl. 16, Figs. 4 and 5 of *G. pacificum,* Pl. 19, Fig. 1 of *G. amansii* f. *typica,* Pl. 24, upper specimen of *G. subfastigiatum,* Pl. 28, Fig. 2 of *G. clavatum,* none of which represents a cystocarpic specimen, could all be fairly well matched among New Zealand *P. capillacea.* All New Zealand specimens sectioned, however, show in young parts rhizines more abundant in the medulla, with only an occasional one in the cortex, and therefore would be placed by Okamura in *Pterocladia.* It is perhaps worth noting that the rhizines are often very few; older parts of the axes are distinguished sometimes by the thickness of the cell walls, sometimes by an increase in number of rhizines, which in the main axes of the biggest plants may be evenly distributed throughout the whole cross section. The cells of the inner cortex are sometimes noticeably large and filled with floridean starch.

Gelidium corneum (Huds.) Lmx. has been recorded for New Zealand (see Laing, 1939, p. 141), and a number of specimens in the herbaria examined bear this name. None of the local specimens shows any good character to differentiate it from *P. capillacea.* Setchell (1931) published a photograph of what he considered to be the type specimen of *Fucus corneus* Huds., and concluded that *G. corneum* (Huds.) Lmx. in a strict sense was what Thuret later called *G. ses-*



P. capillacea. Figs. 1–3 from Waiotemarama, June, 1944, No. 44818.
FIG. 1.—Twig with cystocarps showing 1, 2 and 5 ostioles.
FIG. 2.—Profile of pinnule with two cystocarps, one with one ostiole, one with three.
FIG. 3.—L.S. of cystocarp with 4 ostioles opening from one loculus.
FIG. 4.—From Opape, Bay of Plenty, February, 1941, No. 34054. Twig with tetrasporic sori.
P. lucida.—Figs. 5 and 6 from Aohanga, April, 1943. Fig. 5, twig with tetrasporic sori.
FIG. 6.—Twig with cystocarps; profile of one cystocarp.
FIG. 7.—Camera lucida outlines showing positions of ostioles on cystocarps; a and b from same plant, No. 28562, from O'Neill's Pt. Auck. W. coast, c from Geraldton, W. Australia.
FIG. 8.—Carpospore "chaplet" from 7c.
FIGS. 9 and 10.—T. S. pinnule, camera lucida outline and detail of median part. Fig. 9 from No. 38565. Fig. 10 from No. 42986.

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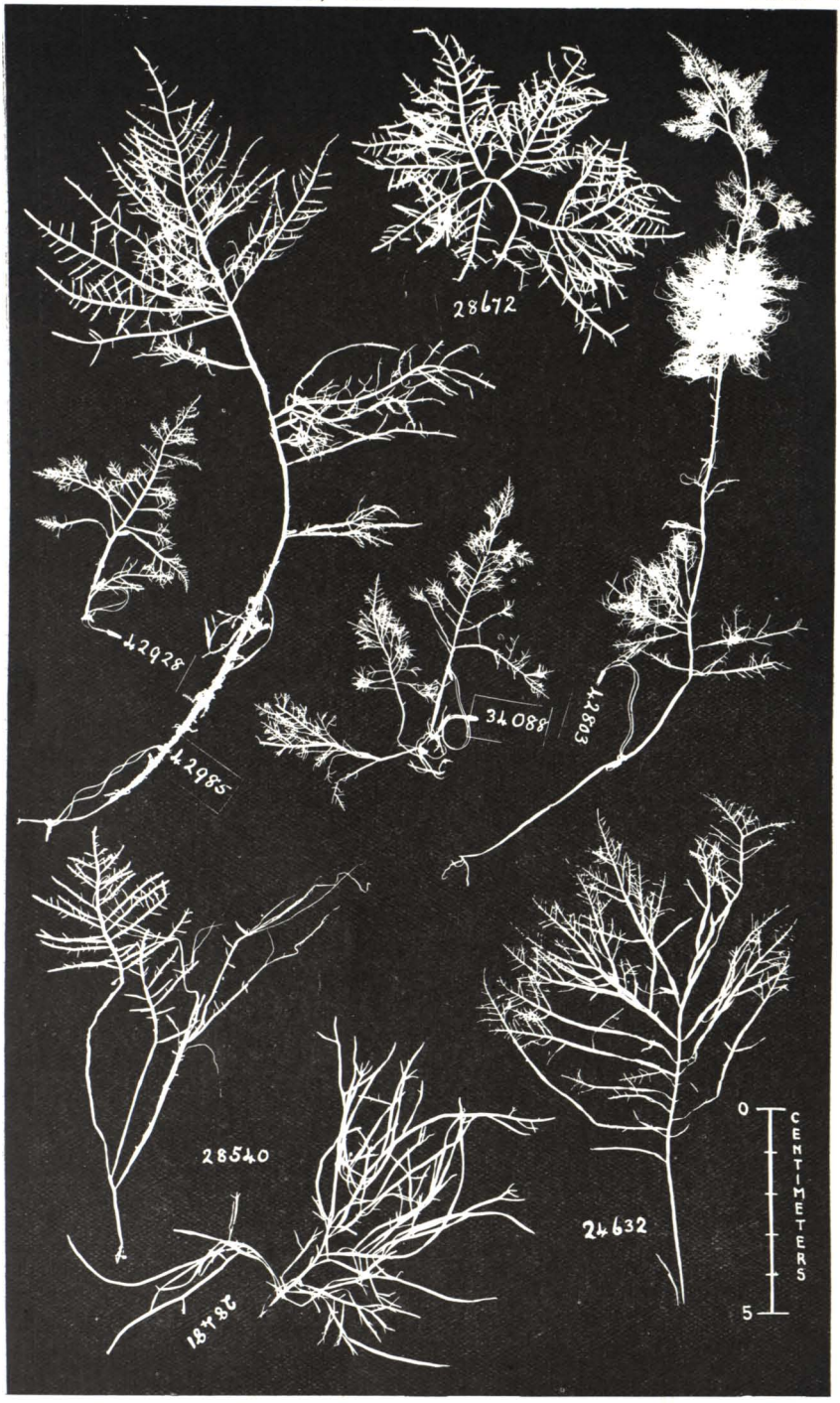
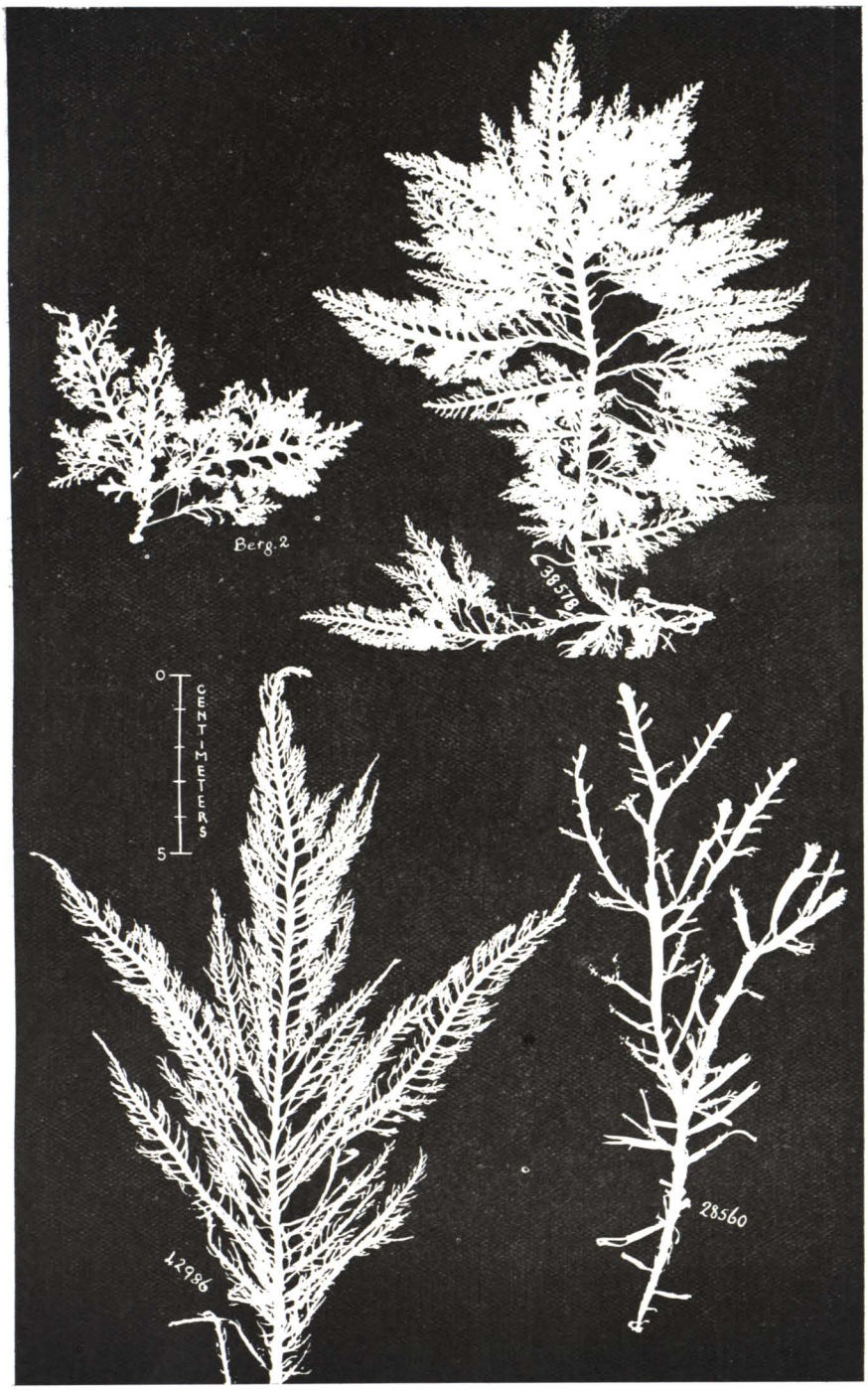


Specimens of *P. capillacea*.

No. 24632.—Waima Flat Reef, Tokomaru Bay, March, 1943, leg. Mrs. Tamati ♀.
No. 28481.—Takapuna, October, 1940, leg. L. B. Moore. "Pool form" sterile.
No. 28540.—The Mount, Tauranga (west end), October, 1940, leg. L. B. Moore. Deep high-level pool, sterile.
No. 28672.—Oharīu Bay, Wellington, November, 1940, leg. R. Mason, sterile.
No. 34088.—Te Kaha, Bay of Plenty, March, 1941, leg. L. B. Moore, ⊕.
No. 42803.—Campbell's Beach, Pihama, Taranaki, January, 1944, leg. L. B. Moore, sterile.
No. 42928.—Oeo Beach, Taranaki, January, 1944, leg. L. B. Moore, ♀.
No. 42985.—Ohiro Bay, Wellington, March, 1940, leg. L. B. Moore, ⊕.



Specimens of "robust" *P. lucida*. (See text.)

Specimens of several forms of *P. lucida*. (See text.)

Tetrasporic twigs of *P. lucida*, leg. Berggren, det. J. Agardh. Sori shown black.
FIG. 11.—"Littoralis" form from Hokianga, in Herb. Auck. Mus. (Berg. 1).
FIG. 12.—"Robust" form from Bay of Islands, in Herb. Dom. Mus. (Berg. 2).

[*To follow Plate 48.*]

quipedale. Feldmann and Hamel say (p. 127) "le *G. sesquipedale* ne contient de rhizines que dans la partie externe de la région médullaire; elles font totalement défaut au centre." No *Gelidium corneum*-like plant with that axis structure has been seen here, and it seems safe to conclude that *G. corneum* in that restricted sense at least is absent.

A small *Gelidium* from Bay of Islands has recently been distributed from the Herbarium of Victor W. Lindauer as No. 137 Algae Nova-Zelandicae Exsiccatae under the name *G. setchellii* Lindauer sp. nov., accompanied by a description. This seems to be quite distinct from the Californian *G. setchellii* Gardner published in 1927. It is of the same order of size as the local *P. capillacea*, but even without cystocarps it has clear differences in habit, in the vertically elongated holdfast with numerous irregularly-produced stolons, and in the cross section showing rhizines scattered through the medulla and densely crowded in a conspicuous cortical region.

Within a wide range of frond form, the axis structure of local *P. capillacea* is fairly uniform, and the cystocarps, wherever they turn up, are typically *Pterocladia*. Cystocarps have not been noticed strictly basal on a pinnule, but on some specimens an occasional one is terminal. Tetrasporic sori are usually much longer than wide (Pl. 45, Fig. 4) with young and old sporangia mixed; even in the young apical part there is no clear V-shaped series; dehiscence is acropetal, but not at all regular.

Though the forms of *P. capillacea*, here as elsewhere, are legion, it has proved beyond the powers of the present writer to sort them into definable groups. In fact, it seems unlikely that any two people (or even the same person at two different times) would make the same dispositions if asked to separate the several hundred specimens in the Botany Division Herbarium into matching lots, without leaving any over. The range of form and size is illustrated (Pl. 46) and the figures show also the typical, rather wide-angle branching, often regular and strictly pinnate to tri-pinnate, with well-defined smooth primary and secondary axes, the former often devoid of branches basally, and with pinnae and pinnules constricted near the point of insertion. Our specimens seem to have much in common with those examined from England, France (Bairritz, 9 Juillet, 1868, Bornet, ex Farlow Herbarium), Australia, Sandwich Is., Lord Howe Is., Norfolk Is., and Kermadec Is., and show no striking difference from a Japanese specimen ex Herb. Michitaro Higashi, Inatori, Izu, May, 1928, labelled *P. capillacea*, presumably the *P. tenuis* of Okamura. As Nos. 28540 and 42803* (Pl. 46) show, even parts of a single frond can exhibit contrasting shape, size, and habit of branching, demonstrating how unreliable these features are for systematic purposes. No more trustworthy basis for splitting has been found, and all the small *Pterocladia* of New Zealand with oval transverse section and predominantly medullary rhizines is regarded as belonging to one entity, presumably *P. capillacea* (Gmel.) Bornet et Thuret.

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* Unless otherwise stated numbers are those assigned to specimens in the herbarium of the Botany Division, Plant Research Bureau, Wellington.

Pterocladia lucida IN NEW ZEALAND.

The *P. lucida* group is distinguished by large size, ancipitous T.S. of all parts, with rhizines scattered or thickly clustered throughout the medulla but always more densely developed and straighter in the inner cortex (Pl. 45, Figs. 9 and 10); there is usually a strong midrib in older axes; the carpostomes are slightly sunken, never raised on a projection, faintly rimmed, and usually multiple in each cystocarp with no regular arrangement; tetrasporangia often show a V-arrangement near the retuse apex of the growing sorus. The complex holdfast, described and figured by Moore (1944) seems to be a very stable character, contrasting strongly with the very simple attachment organs of *P. capillacea.*

The material examined exhibiting these common features falls into several sets, linked by intermediates, and all obviously much more closely related to one another than any of them is to *P. capillacea* or to the Australian *P. pectinata.*

Harvey (1863), in discussing the variability of *P. lucida,* suggests the possibility of difference between Australian and New Zealand specimens, but the few Australian plants available here show a range of forms similar to ours, though sections were inconclusive. The point can be decided only when more information is available about the genus in Australia.

Mrs. Valerie May Jones, of the Fisheries Section of the Australian Council of Scientific and Industrial Research, mentions in a letter (5th May, 1944) a specimen in the Sydney Herbarium called *P. pectinata* from East Cape, New Zealand. The present writer has made collections from within a few miles of East Cape, on either side, and has met with nothing to correspond either with the Lucas *P. pectinata* specimen in the Laing Herbarium, or with Mrs. Jones's brief description of the New Zealand specimen in the Sydney Herbarium.

Agardh (1876, p. 545) proposed two rather ill-defined varieties, α and β, of *P. lucida,* but did not quote specimens or localities for either. He had probably by this time seen Berggren's specimens collected in New Zealand in 1874–75, amongst the fragments of which that have returned to New Zealand herbaria there are several forms represented, but it is not easy to relate the varietal diagnoses to these.

Laing (1939) says " apparently common in at least two forms." Their status is of economic importance in that they behave rather differently in agar processing. It would be interesting to see to what extent such differences depend on proportion of rhizine to cellular tissue, a ratio which varies from part to part of one plant but is apparently higher in the more robust forms.

Two difficulties arise—(1) that of defining sharp limits between forms, and (2) that of deciding to which the name *lucida* really belongs if there are two or more species involved. The only feasible course seems to be to illustrate the chief New Zealand forms (this has not hitherto been done for *P. lucida* in any part of its range) and to distinguish, as a matter of convenience, those kinds which, though of uncertain status, have some practical significance.

P. lucida Forms.

Robust Form (Pl. 47).

No. 38578. From near Table Cape, Mahia Peninsula, leg. L. B. Moore, December, 1942. Tetrasporic.

This broad, robust form, often more richly branched than in this specimen, is the commonest east coast form, growing in rough places and to a depth of some feet below low tide mark. Similar specimens have been received from Chatham Is. The frond shape matches fairly well that shown in Turner's figure (t. 238) of *Fucus lucidus*. The tetrasporic sori (Pl. 45, Fig. 5) are on distinct reproductive branchlets, broad in comparison to length, and often lobed like those figured by Turner. The biggest plant seen is well over a metre long.

Specimens from Maroubra Bay, N.S.W. ⊕ (Laing Herb., leg. Lucas), from Port Phillip, Australia (leg. F. von Müller, ex Herb. W. G. Farlow), and from Lord Howe Is. ⊕ (Auck. Mus. Herb., leg. J. D. McComish) are similar to this form except that they are of more membranous texture.

A series of odd little plants under collecting No. 312, Herb. V. W. Lindauer, grew epiphytically on Durvillea holdfast or on barnacles at the base of the holdfast, through holes in the upper surface of which they protruded. Several have standard *P. lucida* cystocarps and the T.S. of the axis shows nothing novel. Branching is almost inhibited in some cases, but in others it is of a pattern that can be matched on larger and more " normal " looking plants from other places. In my opinion these are just plants of the robust form modified by their strange growing place.

Berg. 2. From Bay of Islands, leg. Berggren, Dominion Museum Herbarium. Tetrasporic. This fragment agrees well with No. 38578. Details are shown in a sketch (Pl. 49, Fig. 12).

No. 42986. From Cape Turnagain, leg. U. and P. Herrick, 1930, Auck. Mus. Herb. Cystocarpic.

Fronds with short, regular fine pinnules have come also from Anaura Bay (No. 38591 ⊕) further north on the east coast, and others, not quite so regular, from a number of localities. Though these look rather distinct, they are probably just a casual aspect of the common robust form. The typical *P. lucida* T.S. (Pl. 45, Fig. 10) distinguishes this from *P. pectinata*. No tetrasporangial branchlets like the sharply-differentiated, often terminal ones in the Lucas specimen of *P. pectinata* have been seen here.

No. 28560. From O'Neill's Pt., Te Henga, Auckland West Coast, leg. L. B. Moore, October, 1940. Tetrasporic.

A small plant of a stout, elongated kind, sparsely and strictly branched, with main axes broad throughout, and with clearly-defined tetrasporic pinnules often, but not uniformly in all parts of one plant, in regular lateral rows.

Plants of this shape, which are found almost exclusively on the very exposed rocks of the west coast, appear to be simply rougher water representatives of the common robust form; plants like No. 38578 grow nearby in more sheltered spots.

" Littoralis " Form (Pl. 48).

No. 38565. From Waihau Bay, Cape Runaway, leg. P. Hauraki, November, 1942. Tetrasporic. (Pl. 45, Fig. 9).

This finely branched form has been called *" littoralis "* (Moore, 1944). It is characterised by the narrowness of the pinnules which frequently break off leaving ragged stumps. Adventitious haptera on ultimate pinnules are not uncommon. The tetrasporic sori are typically very narrow-linear, not lobed, and not on clearly-differentiated tetrasporic pinnules.

This form is widely distributed on the east coast, and has been found in pools growing alongside the robust form, so that the two are perhaps unlikely to be habitat forms only. It comes up freely in the drift. Localities where it is abundant or even predominant in collections are Aohanga, Wellington, Kaikoura, and occasionally in the Bay of Plenty. These fine fronds introduce difficulties in processing, and the resultant agar differs from that from stouter plants.

Berg. 1. From Hokianga, leg. Berggren, det. J. Agardh, Auck. Mus. Herb., ex Herb. Bot. Garden, Gothenburg. Labelled *"Pterocladia lucida* (Fl. Nov. Zel.) " Tetrasporic.

This fragment and also a whole plant in Herb. Dominion Museum, collected at Bay of Islands by Berggren are of the *" littoralis "* kind. Pl. 49, Fig. 11 shows the slender tetrasporic sori for comparison with the broad ones of the robust form. Two Australian specimens in the Laing Herbarium might be grouped here, one, cystocarpic, from Geraldton, W.A., and one, sterile, from Investigator Strait. Nos. 234, 690, 1004 and 1139, Herb. V. W. Linduaer, all from Bay of Islands, belong here. An extremely attenuated state is seen in a specimen from Kennedy Bay, Coromandel, in the Auckland Museum Herbarium. A similar one from Lyall Bay, No. 785, Herb. R. M. Laing, has many haptera near pinnule tips.

Delicate Form (Pl. 48).

No. 24633. From Omapere, Hokianga, leg. Mrs. Caddell, August, 1942. Antheridial.

A similar deltoid fine-textured frond with main axes broad to the tips is an antheridial one, also from Hokianga, leg. Berggren (Auckland Museum Herbarium), and this form is represented by a considerable suite of specimens from Hokianga in the Botany Division Herbarium. A sterile specimen from Norfolk Is. (No. 39267) with a *P. lucida* T.S. matches No. 24633 except that it is much smaller.

This comparatively delicate form shows considerable range of shape, the whole frond sometimes being quite narrow like one of the pinnules of No. 24633. The tetrasporic sorus is usually three to four times as long as wide, mostly simple, but it may be lobed. The plant is flaccid and almost clinging when wet, and has a different " handle " from any other kind; no corresponding difference in the tissues or their arrangement could be traced, the T.S. showing all the essential features of *P. lucida.*

It grows in large quantities inside the Hokianga Harbour, which forms an exception to the rule that in New Zealand *Pterocladia* nearly always grows on an open coast. Here, on gently sloping papa rock, *Pterocladia* beds extend as far as Pakanae, about five miles in from the Heads along the southern shore of the harbour. In one year some

11,000lb of dry *Pterocladia* was sold from this Pakanae-Opononi-Omapere district, and the greater part of this would be of the delicate form.

Tetrasporic plants from Great Barrier Is. are intermediate between this and "*littoralis*," as are both antheridial and cystocarpic plants from Cook Strait and from Tauranga.

Indeterminate Forms (Pl. 48).

No. 42987. From Kaikoura, drift, leg. L. B. Moore, August, 1943. Tetrasporic.

This form, abundant at Kaikoura and Wellington and probably elsewhere, is one of the many intermediates between "*littoralis*" and the common robust form, and illustrates the difficulty in finding a sharp dividing line between these two that, in the extreme case, look so different. One such plant, from Lyall Bay, leg. Berggren, is in the Dominion Museum Herbarium.

Poor Knights Form (Pl. 48).

No. 41, Auckland Museum Herbarium. From northern island of Poor Knights group, leg. L. M. Cranwell and L. B. Moore, February, 1937. Tetrasporic.

This form is perhaps deserving of varietal rank, since it differs widely from the robust form that grows abundantly around this small island. A good and fairly uniform series was collected (Sheets 34–41, 64, 174, Herb. Auck. Mus.), sufficient to show that this is not a chance abnormality. At its best development there this plant has long primary axes and is more closely and bi- to tri-pinnately branched distally than is this medium-sized specimen. The sides of the flat axes are not lacerated; the holdfast and T.S. are of the *P. lucida* pattern. All the herbarium specimens are tetrasporic with broad, delicate blunt-ended sori like those of robust *P. lucida*. In the absence of cystocarps this may be a *Gelidium*, but the resemblances to *P. lucida* are strong.

Conclusions about P. lucida.

It will be seen that of the five forms distinguished here, all but the Poor Knights one are represented in Berggren's collection, probably all identified by J. Agardh, while three of Berggren's four can be matched outside New Zealand. The robust form predominates greatly in most commercial collections, and is preferred by agar manufacturers. Several points indicate that "*littoralis*" may be genetically distinct, but the intermediates are an obstacle to describing it as a variety.

The ability of a single plant to produce new branchlets from broken surfaces, the inconstancy of size and branching characters within one individual, the occurrence of certain forms only in certain types of habitat, all suggest that epharmonic response is highly developed. The features in which these plants differ from *P. capillacea*, seen in holdfast, carpostome, outline of cross section and arrangement of rhizines are just those that remain uniform throughout the long series of specimens examined. They are regarded as indicating genetically distinct entities. On the other hand, there is no obvious anatomical or morphological feature that would make it impossible for, for instance, a West Coast plant to produce twigs

of the Omapere form, or vice versa, if the appropriate transplants were made. The differences are not greater than those between the limicolous form of *Fucus vesiculosus* and saxicolous plants of which pieces were shown by Baker and Bohling (1916) to be capable of sprouting vegetatively when pinned down in the marsh.

On the available evidence it seems advisable to retain all these forms under the one species, and this is considered to be *P. lucida* (R.Br.) J.Ag., on the assumption that Agardh's description of the internal structure applied to older parts of axes only. It is hoped that this account of the common features and differences may be of use in placing new variants that may turn up, and also that the discussion may facilitate the comparison of our plants with those of Australia and the South-West Pacific generally.

Literature Cited.

Agardh, J. G., 1851. *Species, genera et ordines Algarum*, vol. ii, pt. 1. Lund.

——— 1876. Ibid., vol. iii, *Epicrisis Systematis Floridearum.*

Baker, S. M., and Bohling, M. H., 1916. On the Brown Seaweeds of the Salt Marsh. *Linn. Soc. Jour. Bot.*, vol. xliii, pp. 325–380.

Bornet, E., et Thuret, G., 1876. *Notes Algologiques*, Fasc. 1, Paris.

Feldmann, J., et Hamel, G., 1936. Floridées de France VII. Gélidiales. *Rev. Alg.*, tome ix, pp. 85–140.

Gardner, N. L., 1927. New Species of *Gelidium* on the Pacific Coast of North America. *Univ. Cal. Publ. Bot.*, vol. xiii, pp. 273–318.

Harvey, W. H., 1863. *Phycologia Australica*, vol. v. London.

Laing, R. M., 1939. New Zealand Seaweeds—Reference List No. II. *Trans. Roy. Soc. N.Z.*, vol. lxix, pp. 134–164.

Lucas, A. H. S., 1931. Notes on Australian Marine Algae VI. *Proc. Linn. Soc. N.S.W.*, vol. lvi, pp. 407–411.

Moore, L. B., 1944. New Zealand Seaweed for Agar-manufacture. *N.Z. Jour. Sci. and Tech.*, vol. xxv (B), pp. 183–209.

Okamura, K., 1931. *Icones of the Japanese Algae*, vol. vi, p. 57. Tokyo.

——— 1934. On *Gelidium* and *Pterocladia* of Japan. *Jour. Imp. Fish. Inst.*, vol. xxix, pp. 47–67.

Setchell, W. A., 1931. Some Early Algal Confusions. *Univ. Cal. Publ. Bot.*, vol. xvi, pp. 351–366.

Setchell, W. A. and Gardner, N. L., 1937. A Preliminary Report on the Algae of the Templeton Crocker Expedition. *Proc. Cal. Acad. Sci.* 4th Ser., vol. xxii, pp. 65–98.

Taylor, W. Randolph, 1943. Marine Algae from Haiti Collected by H. H. Bartlett in 1941. *Papers of Mich. Acad. Sci. Arts and Lett.*, vol. xxviii (for 1942), pp. 143–163.

Turner, D., 1819. *Fuci, sive plantarum Fucorum generi a botanicis ascriptarum icones, descriptiones et historia*, vol. iv. London.