Distinctions between *Hypoglossum barbatum* Okamura, *H. minimum* Yamada and *H. simulans* sp. nov. (Delesseriaceae, Rhodophyta)

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Morphological criteria are provided to distinguish three superficially similar species of the genus *Hypoglossum* Kützing. *Hypoglossum barbatum* Okamura is known from the western Pacific (southern Japan, Korea, and the Palau Islands), and *H. minimum* Yamada is known only from Japan. A new species, *H. simulans*, is described, with a collection from Malendure, Guadeloupe, French West Indies, designated as holotype. The apical organization of the blades in the new species distinguishes it from the other two. In addition to its occurrence in the Caribbean, *H. simulans* is recorded from eastern Australia, the South Pacific, and Hawaii.

INTRODUCTION

Twenty-two species in the genus *Hypoglossum* Kützing are currently recognized worldwide, all from tropical and temperate seas. Six species have been attributed to the Japanese flora (Yoshida et al. 1985), six species have also been recognized in southern Australia (Womersley & Shepley 1982), and five species are known to occur in the tropical western Atlantic (Wynne & Ballantine 1986; Ballantine & Wynne 1988). In analysing collections of *Hypoglossum* from the Caribbean and the east coast of Australia, we became aware of possible confusion in the identification of some superficially similar taxa. In Puerto Rico and Guadeloupe we have collected at moderate depths co-occurring on sponge and coral reef substrata, three different species of *Hypoglossum*: *H. anomalum* Wynne & Ballantine, *H. rhizoporum* Ballantine & Wynne, and a third entity that appears to be undescribed. This third entity is easily separated from the other two co-occurring species but is superficially similar to two species known from the tropical western Pacific, namely, *H. barbatum* Okamura and *H. minimum* Yamada. The acquisition of additional collections of *Hypoglossum* from eastern Australia, Hawaii, and elsewhere in the South Pacific stimulated the present research and has resulted in the recognition of a new species, *H. simulans*, with a wide distribution in tropical waters. The objective of this research was to delineate these three superficially similar species of *Hypoglossum*.

MATERIALS AND METHODS

Almost all specimens have been collected using SCUBA and then either preserved in 5% formalin-seawater or dried on herbarium paper. Portions of the samples were stained on glass slides with 1% aniline blue acidified with dilute HCl. The mounts were then washed clean of excess stain, rinsed with liquid glucose (Karo Syrup), and allowed to solidify. A standard Zeiss research microscope was used to prepare the figures. A collection of *Hypoglossum barbatum* was provided by Mr M. Kajimura, and a collection of *H. minimum* was received from Dr T. Yoshida. Additional collections of *Hypoglossum* were obtained on loan from the University of Melbourne (MELU), Bernice P. Bishop Museum (BPBM), and the personal herbarium of Dr I.A. Abbott. Voucher specimens have been deposited in the herbaria of the University of Michigan (MICH), the Department of Marine Sciences,
University of Puerto Rico (MSM), James Cook University, Townsville (JCT), and the School of Botany, University of Melbourne (MELU). Herbarium abbreviations follow Holmgren et al. (1981).

RESULTS

Hypoglossum barbatum Okamura

Figs 1–6

HISTORICAL ACCOUNT: Okamura (1901) described Hypoglossum barbatum on the basis of a single specimen from ‘Hiuga’, now Miyazaki Prefecture in Kyushu, southern Japan. Okamura’s herbarium was originally housed in the Tokyo University of Fisheries (formerly the Imperial Fisheries Institute), where Okamura was Professor of Marine Botany. After his death, most of Okamura’s herbarium was moved to the Department of Botany, Hokkaido University, Sapporo (SAP), under the care of the late Professor Y. Yamada. Some specimens, however, remained in the Tokyo University of Fisheries. In an effort to locate the original specimen used by Okamura, we corresponded with Professor T. Yoshida (SAP) and Dr Y. Aruga, Tokyo University of Fisheries; neither was able to locate the original specimen. Dr Yoshida did indicate that Dr H. Mikami had examined specimens in SAP identified by Okamura as H. barbatum and found them to represent a mixture of ‘two or more taxa...’ In the absence of the original specimen, Okamura’s (1901) plate VII is designated as lectotype of Hypoglossum barbatum.

Mr M. Kajimura kindly sent a tetrasporangiate specimen that he collected and identified as Hypoglossum barbatum (Kajimura 1987) and which agrees in essential characteristics with Okamura’s original description. We concur with his identification. Kajimura’s material was collected off Tsudo, Oki Islands, Shimane Prefecture, Japan, 7.vii.1986, at 40 m depth, growing on a hydrozoan. This specimen has been deposited in MICH. The following account is based upon this Kajimura collection.

VEGETATIVE STRUCTURE: The thallus consists of a small tuft of narrow, branching blades with a loosely sprawling habit, attached secondarily along the blade margins and at some blade apices. The thallus reaches about 2 cm in overall length. Individual blades reach about 1.0 cm in length and usually 0.8–1.0 mm in width (although one primary blade was 3.0 mm in maximum width), and typically have an attenuate apex (Fig. 1). Apical organization (Fig. 2) is like that of the type of the genus, H. hypoglossoides (Stackhouse) Collins & Hervey (Kylin 1923, as H. woodwardii Kützing), in that all cells of the second-order rows bear third-order rows (Type 1, Table 1). Vegetative blades are monostromatic, except in the midrib region where the formation of transverse pericentral cells results in three cell layers. The midrib is not corticated. Fully expanded lateral pericentral cells are 250–285–(315) μm in length and 24–28–(32) μm in width. Thallus branches arise singly from the axial row of a parent blade and are endogenous in origin, as is typical for the genus. More than one lateral branch may be produced from a parent blade, and these branches arise irregularly along the midrib of the parent blade. Some of the primary laterals form secondary laterals, which arise either from the basal segment of the parent blade (Fig. 3) or, occasionally, from a segment higher up. Both unicellular and multicellular rhizoids are produced singly and in tufts from the blade margins and at apices (Fig. 4), apparently where decumbent blades contact the substratum.

REPRODUCTION: Tetrasporangial sori (Fig. 5) occur on ultimate and penultimate orders of branches. Neither transverse nor lateral pericentral cells participate in the production of tetrasporangia, but other second-order cells and also some third-order cells as well as cortical cells produce tetrasporangia, resulting in a ‘twinn’ multilayered tetrasporangial sori running along both sides of the midrib of the fertile blade (Fig. 6). A mature sorus measures about 650 μm in width. Mature tetrasporangia are about 74–80 μm in diameter and are tetrahedrally divided.

COMMENTS: Similarities to the type illustration are sufficient to permit us to confirm this recent collection of Kajimura as H. barbatum. Okamura (1901) emphasized several characteristics of H. barbatum as distinctive. He stated that the general shape of the blade of H. barbatum was linear–lanceolate and that lateral veins were absent. He also referred to the presence of ‘marginal root-like fibres’ from the blade, leading to secondary attachments and resulting in a decumbent habit. The epithet ‘barbatum’ alludes to the bearded aspect of the fronds because of their marginal rhizoids. The midrib of the blade, according to Okamura, was ecoricate and made up of elongate cells. The tetrasporangial sori were
described as oblong and borne over the midrib. This is in contrast to the 'twin' sori observed in the Kajimura specimen.

Finally, Okamura stated that the branching in *H. barbatum* was usually alternate from the midrib of blade surfaces but sometimes appeared to be opposite. The apparently opposite arrangement of branches, however, was actually due to the production of a higher-order branch from the very base of the parent branch, as Okamura (1901, pl. VII, figs 2 and 5) clearly illustrated. This unusual mode of branching, with a higher-order blade arising from the basal segment of the parent blade, is regarded as an important feature of Okamura’s description of *H. barbatum* and also of Kajimura’s collection.

In addition to its presence in southern and central Japan, *Hypoglossum barbatum* has been reported from the Palau Islands (Tsuda & Wray 1977) and from Korea (Lee & Kang 1986). These
Table 1. Apical organization in species of Hypoglossum

<table>
<thead>
<tr>
<th>Type 1 (all cells of 2nd-order rows bear 3rd-order rows)</th>
<th>Type 2 (only some cells of 2nd-order rows bear 3rd-order rows)</th>
<th>Uncertain status</th>
</tr>
</thead>
<tbody>
<tr>
<td>H. anomalum Wynne &amp; Ballant.⁹</td>
<td>H. dendroides (Hav.) J. Ag.⁸</td>
<td>H. guineense Laws. &amp; John</td>
</tr>
<tr>
<td>H. armatum (J. Ag.) J. Ag.⁸</td>
<td>H. protendens (J. Ag.) J. Ag.⁸</td>
<td>H. nipponicum Yamada</td>
</tr>
<tr>
<td>H. barbatum Okamura¹²</td>
<td>H. simulans sp. nov.¹²</td>
<td></td>
</tr>
<tr>
<td>H. caloglossoides Wynne &amp; Kraft¹⁰</td>
<td>H. tenuifolium (Hav.) J. Ag.⁹</td>
<td></td>
</tr>
<tr>
<td>H. geminatum Okamura¹¹</td>
<td></td>
<td></td>
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<tr>
<td>H. harveyanum (J. Ag.) Womers. &amp; Shepl.⁸</td>
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<tr>
<td>H. heterocystideum (J. Ag.) J. Ag.⁸</td>
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<tr>
<td>H. hypoglossoides (Stackh.) Coll. &amp; Herv.⁴</td>
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<tr>
<td>H. involvens (Hav.) J. Ag.⁹</td>
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<tr>
<td>H. minimum Yamada¹¹</td>
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<tr>
<td>H. parvulum Levr.⁵</td>
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<tr>
<td>H. revolutum (Hav.) J. Ag.⁸</td>
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<td></td>
</tr>
<tr>
<td>H. rhizophorum Ballant. &amp; Wynne¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. serratifolium Okamura⁸</td>
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</tbody>
</table>


records have not been confirmed in the present study.

Hypoglossum minimum Yamada

Figs 7–11

HISTORICAL ACCOUNT: This species was described by Yamada (1936) from a collection made at Naha, Okinawa Prefecture, southern Japan, and has also been recorded from central and northern Japan (Konno & Noda 1980). According to Yoshida & Mikami (1986), four microscope mounts prepared by Yamada are now housed in SAP. The lectotype specimen, which was selected from among the material on these four slides, is a tetrasporophyte 2 mm long and 0.4 mm wide. A further collection, which was made by T. Yoshida on 26.xi.1984, at Ichise, Wakayama Prefecture, central Japan, was kindly loaned to us. The following account is based upon Yoshida & Mikami (1986) and our own observations.

VEGETATIVE STRUCTURE: Blades are erect (i.e. there are never any marginal tufts of rhizoids), up to 9 mm in length, and usually simple, arising in a cluster from a small discoid holdfast (Fig. 7). Blade apices are broad and obtuse (Fig. 8). The midrib of the blade is three cells thick. The apical organization is Type 1 (Table 1), with all cells of second-order rows producing third-order rows.

REPRODUCTIVE STRUCTURE: On male plants the spermatangial sori form somewhat oblique, parallel patches separated by sterile areas (Fig. 9). In female plants, usually a single cystocarp develops on the midrib of the distal portion of a blade. Tetrasporangia are cut off from lateral pericentral cells and later from additional second- and third-order cells (Fig. 10), but not from transverse pericentral cells. Although Yoshida & Mikami (1986) stated that the tetrasporangia are cut off only from primary cells of the blade, we observed the cutting off of sporangia also from cortical cells of the sorus, resulting in sporangia that lie in more than one plane of the blade. The mature sorus forms a discrete ovate region on the midrib of the blade (Fig. 11).

COMMENTS: Hypoglossum minimum can be distinguished from H. barbatum by the different habits (a tuft of simple erect blades arising from a discoid holdfast in the former vs. branching decumbent blades attached by marginally produced rhizoids in the latter) and by the participation in tetrasporangia production of lateral pericentral cells in H. minimum but not in H. barbatum.

Hypoglossum simulans sp. nov.

Figs 12–26

Thallus decumbens, usque ad 15 mm longum, e lamellis 1.5–1.7(–2.5) mm latis, angustis lanceolatis compositus; apices acuti, saepe secundaris affixi per rhizoidea de marginibus et de extremitatis lamellarum; rami laterales plurumque adaxi-
Figs 7–11. Hypoglossum minimum.
Fig. 7. Tuft of simple blades arising from discoid base.
Fig. 8. Blade apex.
Fig. 9. Blade with spermangial sori.
Fig. 10. Immature tetrascorpanial sorus.
Fig. 11. Mature tetrascorpanial sorus.

ales, secus costam singulatim exorientes, et ramos ordinis superioris e segmento basali saepe efferentes; solum cellularae interiores serierum secundii ordinis producunt series cellularum tertii ordinis; lamellae vegetativae monostromaticae, costa excepta quae crassa cellularae tres et incorticata est; lamellae femininae in costa cystocarpia efferentes; cystocarpia hemisphaerica, ostiolata, 480–650 μm diametro; plantae tetrascorpii praedae unum aut plures soros elongatos circum costam efferentes; tetrascop-

rangia, per cellulas laterales pericentralesque, per cellulas contiguas secundii et tertii ordinis, per cellulas corticales, facta sunt; sori tetrascorpiiales 1400–1700 μm longi et 390–625 μm lati; tetrascorpiangia matura 40–75 μm diametro.

HOLOTPUS: legit D.L. Ballantine 2490 (cystocarpic), deposited in MICH. Collected 24.ii.1987, at 30 m, reef slope, off Tiet de Pigeon,
Fig. 16. Blade apex showing that only inner cells of second-order rows bear third-order rows.
Fig. 17. Blade showing with marginal rhizoids.
Fig. 18. Midrib of blade with endogenously arising lateral branch.
Fig. 19. Mature blade with cells in parallel arrangement.
Fig. 20. Blade with branches of two orders.
Malendure, west side of Basse-Terre, Guadeloupe, French West Indies.

**Isotype Collections** (*D. Ballantine 2490 = M. Wynne 8328*): some containing tetrasioporangiate plants, have been deposited in JCT, MELU, MICH, MSM, and US.

**Etymology**: 'simulans' (L., imitating, resembling) alludes to the general similarity of the new species to *H. barbatum*.

**Vegetative Structure**: The blades are narrow and lanceolate, to 12 mm in length, 1.5–1.7(–2.5) mm in width, and usually taper at their apices. The thallus usually has a spreading, decumbent habit (Fig. 21). In the Guadeloupe collection thalli were attached often at several points to the substratum (coral, sponge, or other algae). These secondary attachments, as in *H. barbatum*, are established by the frequent production
of rhizoids, both from blade margins (Figs 12, 17) and blade apices (Fig. 13), singly, in sporadic groups, or in fairly extensive series along blade margins. The rhizoids are uni- or multicellular; they may become branched and have elaborate discoid tips. Thalli frequently tore apart when one attempted to disengage them from their substrate.

Blades bear a variable number of lateral branches, and these arise singly and endogenously from central cells of the midrib. They may arise from both blade surfaces but are more often adaxial. At times branching appears opposite, but this again is a result of the distinctive method of branching described above for *H. barbatum*, in which a branch arises from the basal segment of the parent blade (Figs 14, 20). Two branches of different order may thus arise in close proximity, giving the appearance of a pair of branches of the same order (Fig. 15). This method of branching is easily recognized at an early stage (Fig. 14) but is not obvious when branches are well developed (Fig. 15).

Blade apices are acute (Fig. 16) or somewhat rounded (Fig. 19). The lateral pericentral cells cut off second-order cell rows, but usually only the innermost cells of the rows bear third-order rows (Fig. 16) (Type 2 of Table 1). The initials of third-order rows reach the blade margin, as is characteristic of the genus *Hypoglossum* and other genera of the *Hypoglossum* Group. The blade is monostromatic throughout except for the midrib (Fig. 18), which is three cells thick, and for fertile regions, such as tetrasporangial sori.

Mature lateral pericentral cells are 115–240 μm in length and 44–50 μm in width. Blade cells near the midrib are subrectangular or polygonal, up to 46 μm in length and 28 μm in width, and often arranged in distinct longitudinal rows (Figs 19, 24). Cells near the blade margin are much smaller than other cells of the blade (Fig. 17).

**REPRODUCTION:** Female plants bear cystocarps on the midrib (Figs 21, 22). The cystocarps are hemispherical, ostiolate, and 480–625 μm in diameter. Carposporangia are teardrop-shaped, 75–95 μm long and 38–50 μm broad. Male plants (based on observations of Australian collections) bear spermatangia in small, discrete sori, 70–150(–250) μm long, of variable shape, scattered over both blade surfaces (Fig. 23). Tetrasporangial plants produce the sporangia in elongate sori (1400–1700 μm long, 390–625 μm wide) around the midrib (Fig. 24). More than one sorus may be formed on a single blade. Tetrasporangia are produced by the lateral pericentral cells (but not the transverse pericentral cells), as well as by additional second- and some third-order cells close to the midrib, resulting in a characteristically narrow sorus (Figs 24, 25). Tetrasporangia are also formed by cortical cells, and thus the mature sorus contains sporangia loosely scattered at various levels (Fig. 26). In the young sorus the sporangia lie in regular lines parallel to the midrib, but at maturity the arrangement is less regular. Mature tetrasporangia are tetrahedrally divided and are 44–50 μm in diameter.

**DISTRIBUTION OF HYPOGLOSSUM SIMULANS:** In addition to our determinations of the new species as occurring in northeastern Australia and the Caribbean, we have established its presence in Hawaii and other areas of the South Pacific. Collections from Enewetak, Marshall Islands, identified as *Hypoglossum minimum* by Dawson (1957), conform to *H. simulans*. Dawson (1957, fig. 30c) illustrated his No. 13704 as having a creeping habit, with branching from the midrib, frequent tufts of rhizoids from the blade margin, and separate tetrasporangial sori on a single blade—all characteristics of *H. simulans* rather than *H. minimum*. We were able to examine three of the four Dawson collections (now in BPBM) identified as *H. minimum*, and these three collections can all be assigned to *H. simulans*. Likewise, the specimens (now in MICH) assigned to *Caloglossa leprieurii* (Mont.) J. Ag. by Taylor (1950) from Bikini Atoll, Northern Marshall Islands, have been examined and determined to be *H. simulans*. The median tetrasporangial sori are typical of *Hypoglossum* rather than *Caloglossa*, and other features permit us to assign these several collections to *H. simulans*. Dawson's (1954) record of *H. attenuatum* Gardn. from Vietnam is suspected to be *H. simulans* on the basis of its small size and the creeping habit figured by Dawson (his fig. 58c), but it was not possible to locate Dawson's collection.

The figure of tetrasporic *Hypoglossum tenuifolium* in Wynne & Ballantine (1986, fig. 22) has now been recognized as *H. simulans*. The arrangement of the inner cells of the blade in parallel longitudinal rows is a feature of *H. simulans* but not of *H. tenuifolium* (compare figs 22 and 23 in Wynne & Ballantine 1986). The similar apical organization in these two species led to the initial misidentification. Figure 22 of Wynne & Ballantine (1986) is from a collection of Ballantine #1783.
**Table 2. Comparative characteristics of* Hypoglossum barbatum*, *H. minimum*, and *H. similans***

<table>
<thead>
<tr>
<th>Species</th>
<th>Habitat and attachment</th>
<th>Branching</th>
<th>Tetrasporangia from lateral pericentral cells</th>
<th>Apical organization (see Table 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>H. barbatum</em> (based on Kajimura coll., Oki Is., and literature)</td>
<td>Decumbent, with frequent secondary attachments by marginal rhizoids</td>
<td>Frequent, alternate, often with branchlet from basal segment of lateral blade</td>
<td>Type 1</td>
<td>No</td>
</tr>
<tr>
<td><em>H. minimum</em> (based on Yoshida coll., Ichiyoe, and literature)</td>
<td>Erect, attached by single discoid holdfast</td>
<td>Blades usually simple</td>
<td>Type 1</td>
<td>Yes</td>
</tr>
<tr>
<td><em>H. similans</em> (based on holotype and isotypes)</td>
<td>Decumbent, with frequent secondary attachments by marginal rhizoids</td>
<td>Frequent, alternate, often with branchlet from basal segment of lateral blade</td>
<td>Type 2</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**ADDITIONAL SPECIMENS EXAMINED:**

PUERTO RICO, USA. La Parguera, D. Ballantine 1783, 16.i.1985, 66 m, tetrasporic, MSM. Margarita Reef, D. Ballantine 67, 6.iv.1978, 30 m, female and tetrasporic, MICH.

QUINTANA ROO, MEXICO. Puerto Morelos, D. Ballantine 1023, 28.iv.1982, 18 m, MSM.

BELIZE, CENTRAL AMERICA. Long Cay, D. Ballantine 379, 27.vi.1979, MSM.

AUSTRALIA. South Passage, Lord Howe Island, NSW, J. Huisman, 31.i.1982, 13 m, female, MELU-A035957. Ned’s Beach, Lord Howe Island, NSW, A. Millar & R. Green, 16.xi.1985, 1–2 m, male and tetrasporic, MELU; G. Kraft 9064, 1.iii.1976, 1 m, tetrasporic, MELU-A035962, -3, -6, 70, -1, -3, Signal Point, Far Rooks, Lord Howe Island, NSW, G. Kraft, 3.x.1976, 0.5–1.5 m, tetrasporic, MELU; G. Kraft & J. Lewis, 5.iii.1976, 0.5–1.5 m, tetrasporic, MELU-A03596, -69.


**DISCUSSION**

In their study of southern Australian species of *Hypoglossum*, Womersley & Shepley (1982) pointed out that some of the Australian species had an apical organization like that of the type of the genus, in which all cells of second-order rows produced third-order rows. Two of the Australian species, however, had blades in which only the inner second-order cells produced third-order rows. Wynne & Ballantine (1986) also applied this criterion in separating *H. tenuifolium* (Harvey) J. Agardh from several other species in the tropical western Atlantic. The type of apical organization in most species of *Hypoglossum* is given in Table 1; for some species this information is not yet known. Both types of apical organization are also recognized in the related genus *Branchioglossum* (Ballantine & Wynne 1987).

Early Caribbean collections of *Hypoglossum similans* were recognized to agree with *H. tenuifolium* in regard to apical organization but to differ in their decumbent habit, relatively small
size, and more sparsely branched nature. These latter features were also observed in specimens collected from tropical Australian waters. A survey of the literature on Hypoglossum, particularly in the South Pacific and southern Japan, showed that two other species, *H. barbatum* and *H. minimum*, shared some characteristics, such as small size and lack of midrib cortication, with the taxon now described as *H. simulans*. However, important differences have been established that necessitate the recognition of three separate species. A summary of the most important criteria separating these three species is given in Table 2.

*Hypoglossum simulans* resembles *H. barbatum* in the frequent, alternate branching, a branchlet often arising endogenously from the basal segment of the lateral blade. *Hypoglossum minimum*, in contrast, typically has unbranched blades and is attached by a single discoid holdfast. *Hypoglossum simulans* and *H. barbatum* are both decumbent in habit, form many secondary attachments by means of marginal rhizoids, and can produce tetrasporangia from the cortical cells of the sorus as well as from primary cells. *Hypoglossum simulans* is distinguishable from *H. barbatum* in the apical organization, as all second-order cells bear third-order cell rows in *H. barbatum*, but only the innermost second-order cells bear third-order rows in *H. simulans*. Furthermore, tetrasporangia are cut off from lateral pericentral cells in *H. simulans* but not in *H. barbatum*. *Hypoglossum simulans* can be separated from *H. minimum* on the basis of their different apical organization and different habit.

Recently Mikami (1987) has shown that in *Hypoglossum sagamianum* Yamada intercalary cell divisions occur in second-order cell rows, which results in a Type 2 apical organization (Table 1). But the manner in which that pattern is derived in this species differs from that of other species, which lack intercalary divisions. *Hypoglossum sagamianum* also differs from *H. simulans* in the restriction of tetrasporangial sori to small ultimate bladelets and the absence of third-order cell rows within the sori.

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**REFERENCES**


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