

Morphological study of the genus *Herposiphonia* (Rhodophyta, Rhodomelaceae) on the coast of eastern Guangdong, China, with a description of *H. pinnata* sp. nov.*

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Abstract We present a taxonomic study of taxa of the red algae genus *Herposiphonia* (Rhodophyta, Rhodomelaceae), collected from the coast of eastern Guangdong, China. We made detailed morphological studies and considered recent taxonomic criteria for species delimitation, and are making the first report of five different species on the coast of Guangdong, including a new species. The species identified were *H. caespitosa* Tseng, *H. hollenbergii* Dawson, *H. pecten-veneris* (Harvey) Falkenberg, *H. subdisticha* Okamura and *H. pinnata* Ding and Tan sp. nov. *H. pinnata* sp. nov. is characterized by bright green thalli; most parts of the feathery thalli are free of the substratum; determinate branches and indeterminate branches are arranged in a chaotic sequence; the primary axis has bare segments; the determinate branch has 9–11 periaxial cells per segment; vegetative trichoblasts are abundant; and tetrasporangia are formed on the middle of the determinate branch with 1–8 successive segments in a single rectilinear series. This paper is also the first record of sporophyte plants of *H. pecten-veneris*.

Keyword: new species; morphological taxonomy; Guangdong Province; biogeography distribution

1 INTRODUCTION

The genus *Herposiphonia* (Rhodophyta, Rhodomelaceae) was established by Nägeli based on *H. tenella* (Nägeli, 1846; Tseng et al., 2011) characterized by the following features: 1) having a dorsiventral habit, polysiphonous and uncorticated thalli; 2) determinate branches and indeterminate branches formed exogenously from a main prostrate axis usually arranged in a regular sequence; 3) apex of the young main axis usually rolled upward, and determinate branches rarely branched; 4) vegetative trichoblasts and reproductive structures formed on determinate branches (Hollenberg, 1968; Masuda et al., 2006).

Species discrimination within the genus *Herposiphonia* is usually difficult because of some classical vegetative features such as the numbers of segments, the numbers of periaxial cells produced by

each segment, branching patterns and the lengths of determinate branches, as these are variable in many species (Hollenberg, 1968; Masuda and Shimada, 2003). Other features, however, seem to be reliable for species diagnoses: 1) the shape of determinate branches (terete, compressed or clavate); 2) the 3-D dispositions of determinate branches on the primary axis; 3) the presence/absence of branching in determinate branches; 4) the numbers of periaxial cells in the basal segments; 5) the relative lengths of the suprabasal segments of determinate branches (conspicuously elongated or

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not); 6) the shapes of mature central axial cells and their sizes in relation to the surrounding periaxial cells; 7) the frequencies of vegetative trichoblasts (Masuda and Shimada, 2002, 2003). Reproductive characteristics are also critical taxonomic features for the genus *Herposiphonia*: 1) the presence of one or two tetrasporangia per segment and the position of the tetrasporangium chain (spiral or not) in the thalli (distal, middle or proximal); 2) the shapes, sizes and positions of the cystocarps (terminal, distal or proximal) and the development of the cystocarps; 3) the positions (distal or proximal) and arrangements (spiral or secund) of the spermatangial branches (Masuda and Shimada, 2002, 2003). The combination of vegetative and reproductive characteristics allow species discrimination within the genus *Herposiphonia* (Silva and Fujii, 2012).

At present, the genus *Herposiphonia* comprises about 54 species widely distributed throughout tropical and warm-temperate regions of the world (Guiry and Guiry, 2015). In China, 13 species including four new species and one new variety have been found in Xiamen, Hong Kong, the Xisha Islands and Fujian (Tseng, 1936, 1944; Chang and Xia, 1978; Zheng, 1990; Zheng and Chen, 1992) prior to our present research: *H. basilaris*, *H. caespitosa*, *H. delicatula*, *H. fissidentoides*, *H. fujianensis*, *H. hollenbergii*, *H. insidiosa*, *H. parca*, *H. pecten-veneris*, *H. ramosa*, *H. secunda*, *H. subdisticha*, *H. tenella* and *H. hollenbergii* var. *interrupta*.

The eastern area of Guangdong is in southern China, and is a transitional zone from a warm-temperate region to a tropical region. Until our research, no *Herposiphonia* species had been reported in this area. In the present study the authors investigated macroalgal diversity on Nan'ao Island, Shantou and Zhelang, Shanwei, on the eastern coast of Guangdong, China. More than 20 surveys were made during November 2011 and February 2014, and five *Herposiphonia* species were identified taxonomically. These results will add to information on biogeographical distribution, and enrich the diversity of *Herposiphonia* species.

2 MATERIAL AND METHOD

Specimens collected from Nan'ao Island, Shantou and Zhelang, Shanwei, during November 2011 and February 2014 were fixed in 5% formalin in seawater, and voucher specimens have been deposited in the herbarium at the Laboratory of Marine Algae, Shantou University, China. Sections for microscopic examination were cut into slices and stained with 1%

aceto carmine. The numbers of periaxial cells were determined in squash preparations as well as cut sections. Mounted slides were made with stained thalli or fragments. Photomicrographs were taken using a digital Olympus DP20 camera (Olympus, Tokyo, Japan).

3 RESULT

3.1 *Herposiphonia caespitosa* Tseng, 1944, p. 58–61, pl. I; Umezaki, 1967b, p. 285, f. 6; Zheng Yi, 2011, p. 23–25.

Type locality: Hong Kong, China.

Thalli are delicate filaments, brown-red in color, clumped and attached to a rock. The prostrate indeterminate axes are terete, 80–190 µm in diameter, having segments almost 1 diameter long (Fig. 1a). Rhizoids are cut off from the distal end of ventral periaxial cells, 1–3 per segment (Fig. 1c). The axes bear either a determinate branch (d) or an indeterminate branch (i) on every segment in a regular sequence of three determinate branches followed by one indeterminate branch (d/d/d/i pattern) (Fig. 1a, b). Determinate branches are simple, terete, 60–90 µm in diameter, having 16–35 segments that are 1–2.5 diameters long, mostly with tapering apices (Fig. 1a). The segments of the determinate branches have 12–14 periaxial cells (Fig. 1h–j). Vegetative trichoblasts are formed on distal portion of determinate branches. Three trichoblasts are formed on each determinate lateral. The trichoblasts are pseudosubdichotomously and frequently branched, but short, being 21–50 µm long (Fig. 1e–j). Tetrasporangia are formed on the middle of the determinate branches with 22–30 successive segments arranged in a single spiral series. Mature tetrasporangia have tetrahedrally arranged spores and are swollen, globose, and up to 78 µm in diameter (Fig. 1b, k). Sexual plants are unknown.

Habitat: Thalli grow in the intertidal zone attached to rocks.

Domestic distribution: Hong Kong, Guangdong, Fujian.

Foreign distribution: Japan.

The species were collected on 27 April 2013 at Zhannan Ting, Nan'ao Island and Shantou City, China, by Tan Huaqiang and Sun Guodong.

3.2 *Herposiphonia hollenbergii* Dawson, 1963: 430–431, pl. 144 (19), Fig. 2–4; Abbott and Hollenberg, 1976: 715, Fig. 665; Zheng, 2011, p. 31–32.

Type locality: Oaxaca, Mexico.

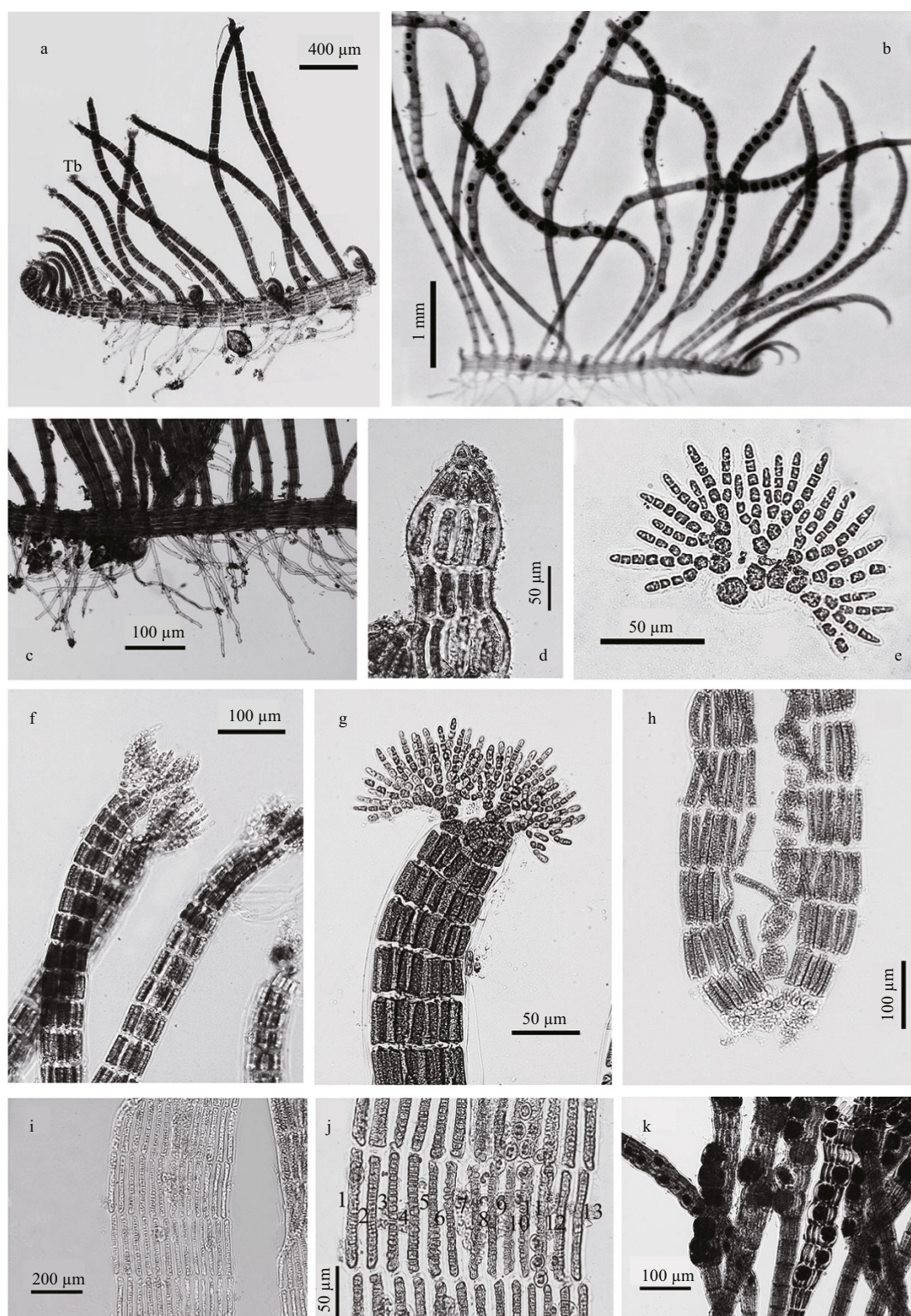


Fig.1 *Herposiphonia caespitosa*

Original figures had been uploaded into the websystem. a. the appearance of thalli, showing three determinate branches followed by one indeterminate branch (arrow) and trichoblasts formed on apices of young determinate branches (Tb: trichoblasts); b. the appearance of a sporophyte plant; c. rhizoids, 1–3 per segment; d. the tapered apex of a determinate branch; e. trichoblasts branched on one side; f–g. three vegetative trichoblasts formed on each determinate lateral; h. showing the number of periaxial cells in segments on the base of the determinate branches; i–j. showing the number of periaxial cells in segments on the middle and upper parts of the determinate branches; k. tetrasporangial branches (specimen No. 20130427023III).

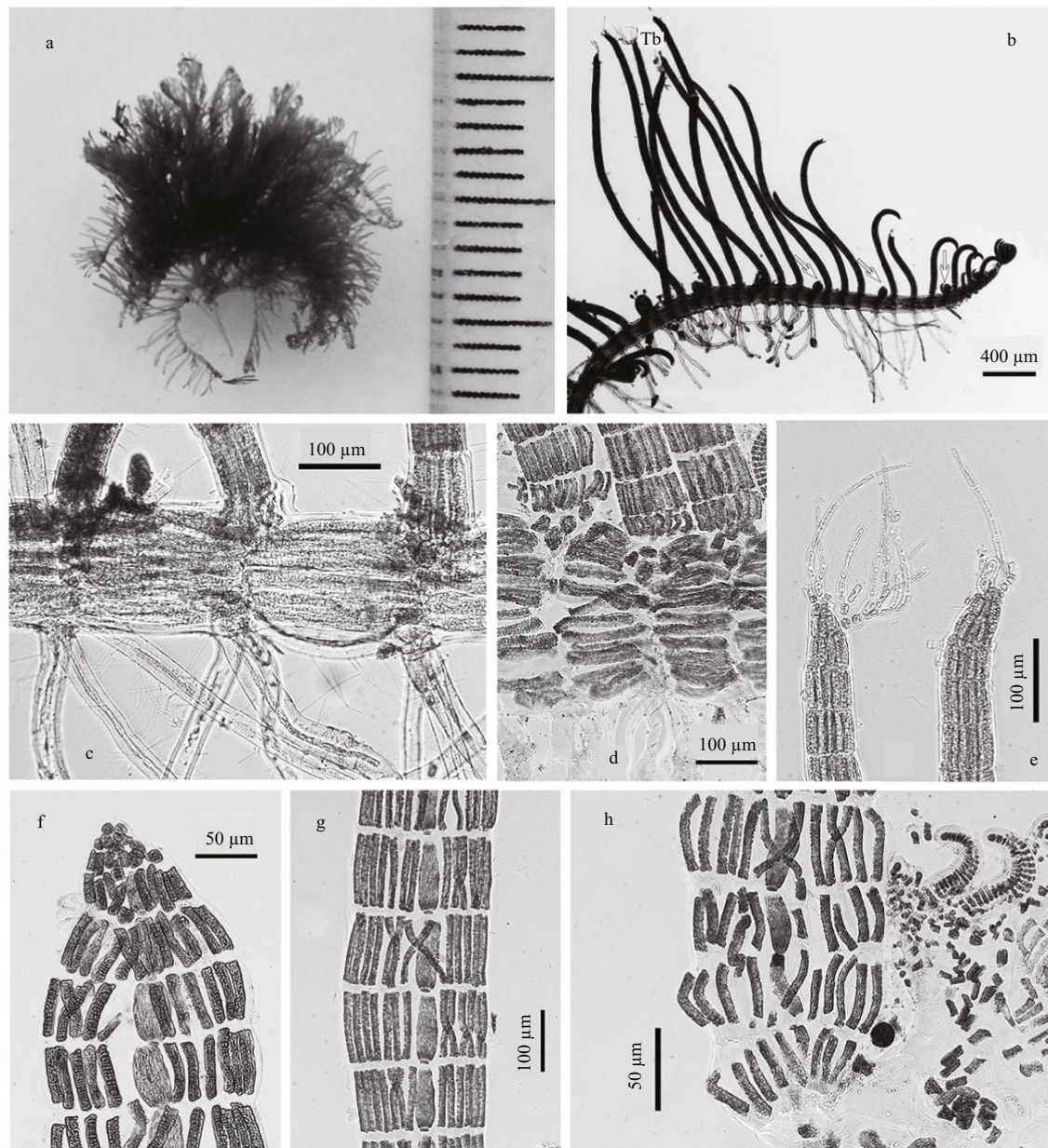


Fig.2 *Herposiphonia hollenbergii*

a. the appearance of thalli; b. the terminal of the prostrate indeterminate axes, showing three determinate branches followed by one indeterminate branch (arrow); c. rhizoids, 1–4 per segment; d. showing the numbers of periaxial cells in segments on prostrate indeterminate axes; e. vegetative trichoblasts borne on the apices of young determinate branches; f–h. showing the numbers of periaxial cells in segments on the upper, middle and base of the determinate branch (specimen No. 20130427024II).

Thalli are mulberry in color, attached to rocks by rhizoids with or without digitate tips. Parts of the thalli are free from the substratum (Fig.2a). The prostrate indeterminate axes are terete and 120–150 µm in diameter. They possess segments almost (0.9)–1–1.8 diameters long, which consist of a central cell and 11–12 periaxial cells (Fig.2b, c, d). Rhizoids are cut off from the distal end of ventral periaxial cells, 1–4 per segments, 25–28 µm in diameter (Fig.2c). The axes bear either a determinate branch

(d) or an indeterminate branch (i) on every segment in a regular sequence of three determinate branches followed by one indeterminate branch (d/d/d/i pattern), but the indeterminate branches degenerate to a primordial state (Note: right) (Fig.2b). The determinate branches are terete, greater than 1 mm and up to 4 mm, and possess 30–45 segments which are 0.7–1.7 diameters long (Fig.2b). The diameter of determinate branches thickens from bottom to top and the numbers of periaxial cells with segments also

vary; there are 9(10) periaxial cells at the base and 13(14) periaxial cells at the middle or upper portion (Fig.2f, g, h). Vegetative trichoblasts are rare, but occasionally three are formed on the distal portion of determinate branches. The trichoblasts are up to 230 μm long, branched 1–3 times (Fig.2e). Reproductive plants are unknown.

Habitat: Thalli grow on rocks in the intertidal zone.

Domestic distribution: Guangdong, Fujian.

Foreign distribution: California, USA; Oaxaca, Mexico.

The species was collected on 27 April 2013 at Zhannan Ting, Nan'ao Island and Shantou City, China, by Tan Huaqiang and Sun Guodong.

3.3 *Herposiphonia pecten-veneris* (Harvey) Falkenberg, 1901, p. 315; Tseng, 1944, p. 57; Zheng, 2011, p. 35.

Type locality: Florida, USA.

Thalli are delicate filaments, pink in color, epiphytic on *Corallina* spp. or other macroalgae, and most free from the substratum. Prostrate indeterminate axes are terete, 100–185 μm in diameter, and possess segments 0.7–2 diameters long, which consist of a central cell and 9–11 periaxial cells (Fig.3b–e). Rhizoids are cut off from the distal end of ventral periaxial cells, and only one found per segment (Note: it indicates there is one rhizoid produced from single segment) (Fig.3b, c). The axes bear either a determinate branch (d) or an indeterminate branch (i) on every segment in a regular sequence of three determinate branches followed by one indeterminate branch (d/d/d/i pattern) (Fig.3b, c). The terminal of the indeterminate axes is incurved to a large extent (Fig.3b). The determinate branches are simple, terete, 62–100 μm in diameter, with a blunt apical cell, and possess 12–14 segments almost 1 diameter long (Fig.3b, c). The height of determinate branches is less than 1 mm. The basal segments of the determinate branches possess seven periaxial cells, the middle segments having 8 periaxial cells, and the top segments having 8 or 9 periaxial cells (Fig.3f–j). Vegetative trichoblasts are absent. Reproductive plants are rare. Tetrasporangia are formed on the middle of the determinate branch with 1–4 successive segments arranged in a single spiral series. Mature tetrasporangia have tetrahedrally arranged spores and are swollen and global, being 55–58 μm in diameter (Fig.3k). Sexual plants are unknown.

Habitat: Thalli are attached to *Corallina* spp. or other macroalgae.

Domestic distribution: Hong Kong, Guangdong,

Fujian.

Foreign distribution: California, USA; Oaxaca, Mexico.

The species were collected on 25 January 2014 at Shen'ao Bay, Nan'ao Island and Shantou City, China, by Tan Huaqiang and Zhang Quanliang.

3.4 *Herposiphonia subdisticha* Okamura, 1899, p. 37, pl. 1, Fig. 12–14; Hollenberg, 1968, p. 554–555, Fig. 11; Zheng, 2011, p. 38–40.

Type locality: Chiba, Japan.

Thalli are brown-red in color, attached to rocks or other macroalgae. Most of the feathery thalli are free from the substratum (Fig.4a). The prostrate indeterminate axes are terete, 120–160 μm in diameter, and possess segments 0.4–1.2 diameters long (Fig.4a, b). The axes bear either a determinate branch (d) or an indeterminate branch (i) on every segment in a regular sequence of three determinate branches followed by one indeterminate branch (d/d/d/i pattern), and have distichous or nearly distichous branches (Fig.4a, b, c). Rhizoids are cut off from the distal end of the ventral periaxial cells, and only one is found per segment (Fig.4d). The terminal of the indeterminate axes does not bend (Fig.4a, e). The determinate branches are terete, 70–120 μm in diameter, mostly with blunt apices and narrowed at the base, slightly to strongly curved toward the tip of the bearing branch, and often slightly curved toward the substratum; they have 8–21 segments almost 1 diameter long at the base and are mostly shorter than they are broad at the mid- or upper parts. The basal segments of the determinate branches have 8 periaxial cells, the mid segments have 11–12 periaxial cells, and the top segments have 9 or 10 periaxial cells (Fig.4c, f–h). Vegetative trichoblasts are absent. Prostrate indeterminate axes in the substratum lack distichous branches, and determinate branches and indeterminate branches are arranged in a chaotic sequence (Fig.4d). Tetrasporangia are in a straight series of 2–7 in swollen segments of determinate branches borne on short indeterminate laterals, not in the determinate branches of main axes (Fig.4e). Sexual plants are unknown.

Habitat: Thalli are attached to rocks and *Polysiphonia* spp. in the intertidal zone.

Domestic distribution: Guangdong, Fujian.

Foreign distribution: California, USA; Oaxaca, Mexico.

The species were collected on 26 May 2013 at Zhannan Ting, Nan'ao Island and Shantou City,

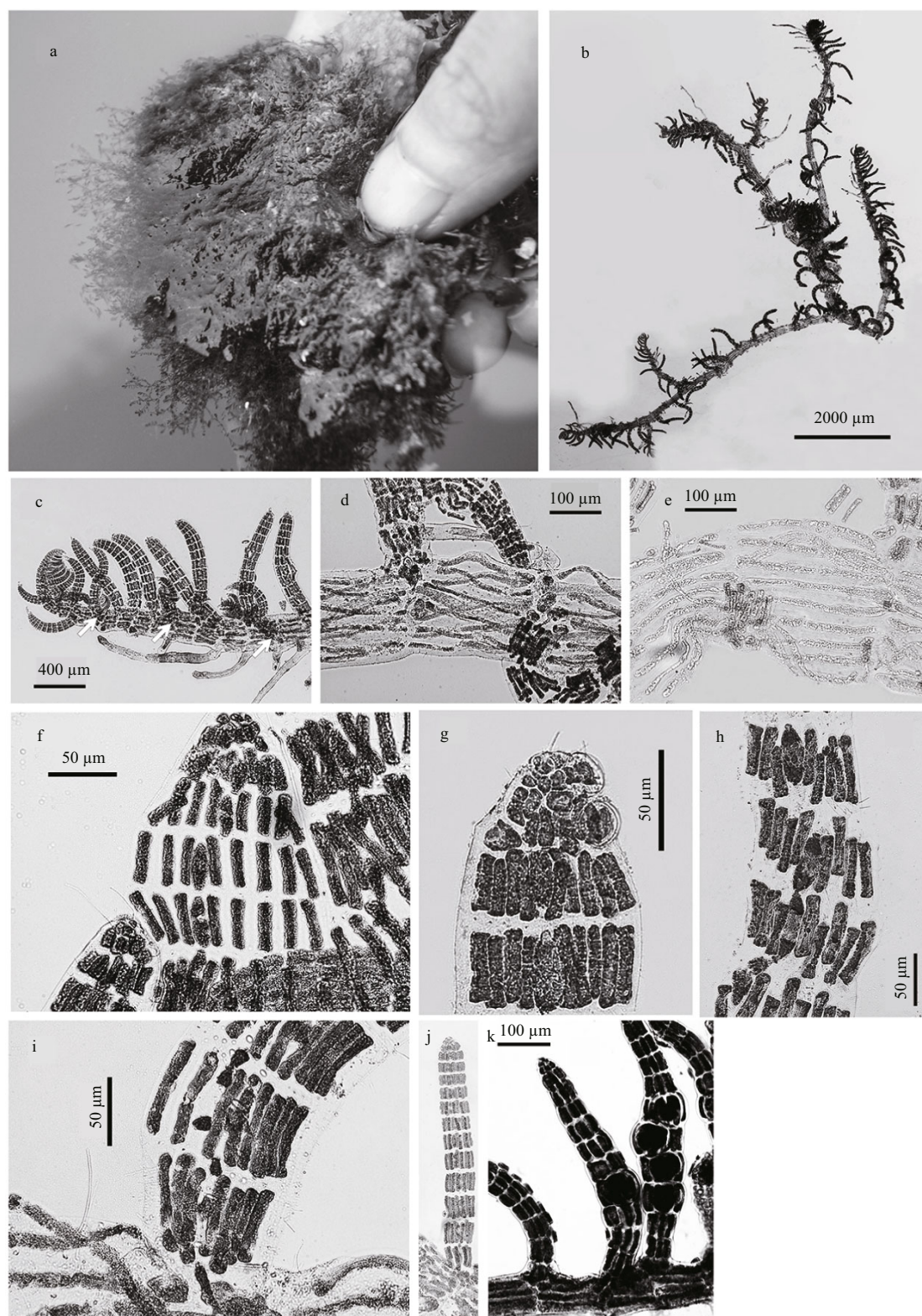


Fig.3 *Herposiphonia pecten-veneris*

a. the appearance of thalli; b. the microscopic appearance of thalli; c. the terminal of the prostrate indeterminate axes, showing three determinate branches followed by one indeterminate branch; d–e. showing the numbers of periaxial cells in segments on prostrate indeterminate branch; f–i. showing the numbers of periaxial cells in segments on the upper, middle and base of the determinate branch; j. showing the numbers of periaxial cells in segments of an entire determinate branch; k. tetrasporangial branches (specimen No. 20140125029III).

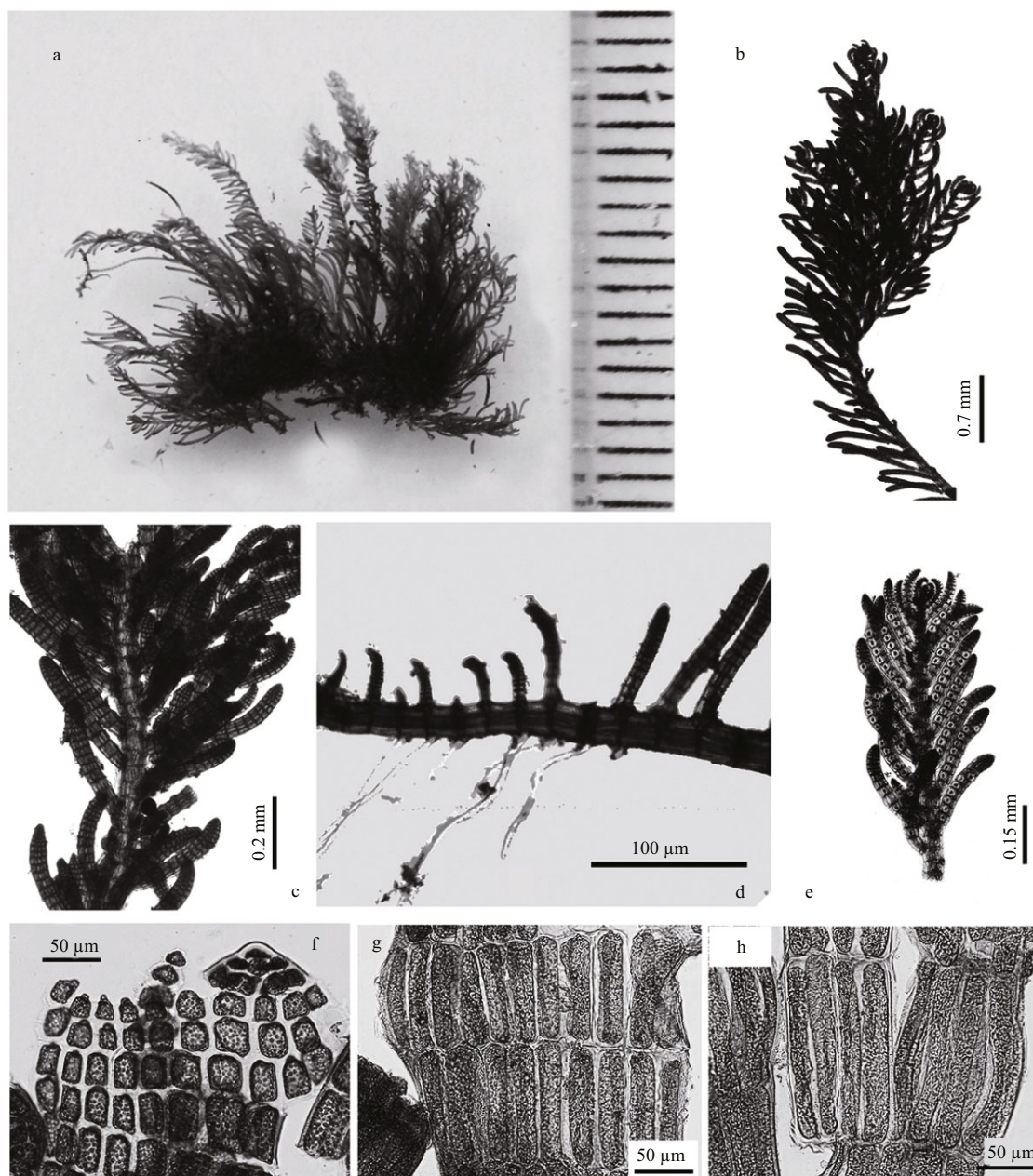


Fig.4 *Herposiphonia subdisticha*

a. the appearance of thalli; b. the microscopic appearance of thalli; c. prostrate indeterminate axes with distichous or nearly distichous branches; d. prostrate indeterminate axes in the substratum, showing determinate branch and indeterminate branch arranged in a chaotic sequence; e. tetrasporangial branches; f-h. showing the numbers of periaxial cells in segments on the upper, middle and base of the determinate branch (specimen No. 20130526022II).

China, by Tan Huaqiang and Zeng Lingzhao.

3.5 *Herposiphonia pinnata* Ding and Tan sp. nov.

Holotype: Zhelang, Shanwei city, China, collected on 22 April 2014 by Tan Huaqiang and Zhang Quanliang. Voucher specimen 20140422012I has been deposited in the Laboratory of Marine Algal Research of Shantou University, Shantou, China.

Other specimens examined: Tetrasporangial plant, Zhelang, Shanwei City, China, collected on 22 April

2014 by Tan Huaqiang and Zhang Quanliang, 20140422012I; and Zhelang, Shanwei City, China, collected on 21 June 2014 by Tan Huaqiang and Zeng Lingzhao, 20140621011I. Vegetative plant: Zhelang, Shanwei City, China, collected on 22 April 2014 by Tan Huaqiang and Zhang Quanliang, 20140422012II; Zhelang, Shanwei City, China, collected by on 21 June 2014 by Tan Huaqiang and Zeng Lingzhao, 20140621011II.

Diagnosis: Thalli are delicate, bright green

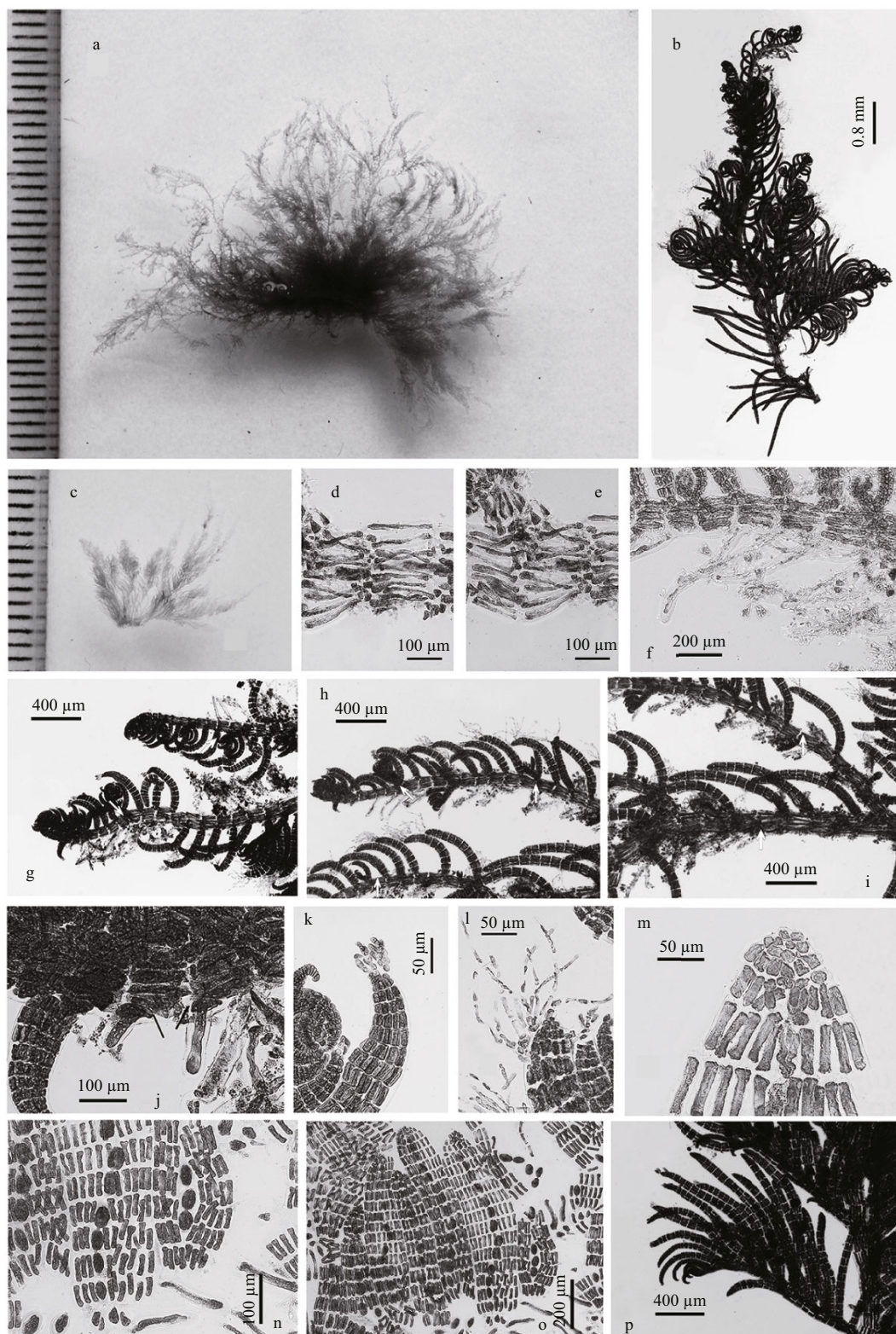


Fig.5 *Herposiphonia pinnata*

a. the appearance of thalli; b-c. feathery thalli; d-e. showing the numbers of periaxial cells in segments on prostrate indeterminate axes; f. a segment of prostrate indeterminate axes with 1-3 rhizoids; g-i. determinate branch and indeterminate branch arranged in a chaotic sequence with axes having bare segments; j. rhizoids are cut off from the distal end of ventral periaxial cells; k-l. three (occasionally two or four) trichoblasts formed on each determinate lateral; m. showing the numbers of periaxial cells in segments on the upper, middle and base of the determinate branch; o. showing the number of periaxial cells with segments of an entire determinate branch; p. tetrasporangial branches (specimen No. 20140422012I).

filaments. Most of the feathery thalli are free from the substratum. The prostrate indeterminate axes are terete, without distichous branches, possessing segments with 9–10 periaxial cells, having a terminal curved to the dorsal side. The axes bear a determinate branch (d) or an indeterminate branch (i) on segments, but sometimes have bare segments. Determinate branches and indeterminate branches are arranged in a chaotic sequence. Determinate branches are up to 1.2 mm high, and have 15–20 segments 0.8–1.8 diameters long. The segments of the determinate branches have 9–11 periaxial cells. Vegetative trichoblasts are formed on distal portions of determinate branches. Three (occasionally two or four) trichoblasts are formed on each determinate lateral. The trichoblasts are up to 150 μm long, pseudodichotomously divided five to seven times. Tetrasporangia are formed on the middle of the determinate branch with 1–8 successive segments arranged in a single straight series.

Description: Thalli are delicate filaments, bright green, attached to rocks and other macroalgae. Most of the feathery thalli are free from the substratum (Fig.5a, b, c). Rhizoids are cut off from the distal end of ventral periaxial cells, with 1–3 per segment (Fig.5f). Prostrate indeterminate axes are terete, 60–152 μm in diameter, and possess segments 0.6–1.8 diameters long, which consist of a central cell and 9–10 periaxial cells (Fig.5d, e, f). The axes bear a determinate branch (d) or an indeterminate branch (i) on the segment, but sometimes have bare segments (Fig.5g, h, i). Determinate branches and indeterminate branches are arranged in a chaotic sequence (Fig.5g, h, i). The terminal of the axes is curved to the dorsal side. Determinate branches are terete, up to 1.2 mm high, 48–80 μm in diameter, mostly with blunt apices, having 15–20 segments 0.8–1.8 diameters long (Fig.5g, h, i). The segments of the determinate branches possess 9→10→11→10→9 periaxial cells from bottom to top (Fig.5m–o). Vegetative trichoblasts are formed on distal portions of the determinate branches. Three (occasionally two or four) trichoblasts are formed on each determinate lateral. The trichoblasts are up to 150 μm long, pseudodichotomously divided five to seven times (Fig.5k–l). Tetrasporangia are formed on the middle of the determinate branch with 1–8 successive segments arranged in a single straight series. Mature tetrasporangia have tetrahedrally arranged spores and are swollen, globose and 60–69 μm in diameter (Fig.5p). Sexual plants are unknown.

Habit: Thalli are attached on rocks and other

macroalgae in the intertidal zone.

Domestic distribution: Guangdong, Fujian.

Foreign distribution: California, America; Oaxaca, Mexico.

4 DISCUSSION

The genus *Herposiphonia* is widely distributed throughout tropical and warm-temperate regions of the world (Masuda and Kogame, 2000). In China, four new species and one new varieties have been reported: *H. caespitosa* and *H. ramosa* from Hong Kong, and *H. basilaris*, *H. fujianensis* and *H. hollenbergii* var. *interrupta* from Fujian (Tseng, 1936, 1944; Zhang and Xia, 1978; Zheng, 1990; Zheng and Chen, 1992). The eastern area of Guangdong is also a transitional zone from a warm-temperate region to a tropical region, but prior to our research no *Herposiphonia* species had been reported. For the past 2 years, the authors investigated macroalgal diversity along the coast of the eastern region of Guangdong, and found five *Herposiphonia* species.

The type locality of *H. caespitosa* is Hong Kong, China (Tseng, 1944). The basic morphological characteristics from its type specimen described by Tseng and Zheng (Tseng, 1944; Tseng et al., 2011) are similar to those of our specimens collected at Nan'ao Island, Shantou, from January to May as follows: 1) the thalli clump; 2) the axes with a branching pattern of three determinate branches followed by one indeterminate branch; 3) the segments of main axes are wider than long and have 1–3 rhizoids; 4) the segments of the determinate branches have 12–14 periaxial cells (according with the species reported from Fujian); 5) three vegetative trichoblasts are formed on each determinate lateral. Some characteristics vary, however, such as the number with segments of determinate branches from our specimens is 16–35, whereas the type specimen is 16–30. Masuda and Shimada (2003) felt that the lengths of determinate branches are variable in many species and the numbers with segments of determinate branches are not a stable characteristic, so the variation of numbers is likely due to diversity of biogeography.

H. hollenbergii was reported to lack vegetative trichoblasts. The species has two other important characteristics: the diameter of the determinate branches thicken from bottom to top and the numbers of periaxial cells are also variable from bottom to top (Tseng, 1944; Dawson, 1963; Stegenga et al., 1997; Masuda and Shimada, 2003; Tseng et al., 2011). Our specimens collected at Nan'ao Island, Shantou, from

March to May have all the above characteristics, so we regard the specimens as *H. hollenbergii*.

H. pecten-veneris is a controversial species. It closely resembles *H. tenella*. Børgesen suggests that *H. pecten-veneris* is a synonym of *H. tenella* (Børgesen, 1920). However, Tseng (1944) examined specimens from Hong Kong, and suggested that *H. pecten-veneris* is an independent species because of its prostrate axes with a relatively incurved terminal and the numbers of segments with determinate branches being fewer than 14 (Tseng, 1944). Zheng checked it and made a detailed comparison with the specimens from Fujian, and found the characteristics supposed by Tseng were stable (Tseng et al., 2011). Masuda and Kogame (2000) found that *H. pecten-veneris* had more thalli free from the substratum. Silva and Fujii (2012) checked specimens from Brazil and found that *H. tenella* had vegetative trichoblasts, whereas *H. pecten-veneris* had none. The characteristics of our specimens collected from October to May at Nan'ao Island, Shantou, are in conformity with *H. pecten-veneris*. They are clearly distinguished from *H. tenella* by holding a relatively incurved terminal, more thalli free from the substratum, fewer than 14 segments of determinate branches and lack of vegetative trichoblasts in the former. There is strong evidence to recognize *H. pecten-veneris* as an independent species.

H. subdisticha has an important characteristic in that thalli have terete and distichous branches. This type of arrangement is known for the following species: *H. heringii* (Harvey) Falkenberg (1901), *H. plumula* (J. Agardh) Falkenberg ex De Toni (Dawson, 1963, as *H. subdisticha*), *H. verticillata* (Harvey) Kylin (Dawson, 1963) and *H. calva* Millar (1990). *H. subdisticha* is distinguished from all of these by having determinate branches narrowed at the base, three alternating determinate branches between two successive alternating indeterminate branches, and with vegetative trichoblasts rarely present. The characteristics of our specimens collected from April to June at Nan'ao Island, Shantou, are in conformity with the description of *H. subdisticha* by Zheng (Tseng et al., 2011) based on the distichous branches, determinate branches narrowed at the base and absence of vegetative trichoblasts. Some characteristics vary, however, such as the prostrate indeterminate axes in the substratum in our specimens are without distichous branches, and the determinate branch and indeterminate branch are arranged in a chaotic sequence. In addition, tetrasporangia are in a straight series of 2–7, whereas, in

some previous reports, tetrasporangia were recorded as straight series of 3–4 (Hollenberg, 1968; Tseng et al., 2011). Despite the different characteristics, it is doubtful that these specimens from Shantou can be regarded as an independent new species. The different characteristics are not main characteristics, and phenotypic variations are generally existing on different distribution, so this species from Shantou is still regarded as *H. subdisticha*.

H. pinnata sp. nov., collected from April to July at Shanwei, China, is newly described based on morphological evidence. It is recognized by bright green thalli having terete branches, with most parts of the feathery thalli free from the substratum, having determinate branches and indeterminate branches arranged in a chaotic sequence, non-distichous branches, the primary axis having bare segments, determinate branches having 9–11 periaxial cells per segment, having well-developed vegetative trichoblasts in abundance and tetrasporangia formed on the middle of the determinate branch with 1–8 successive segments arranged in a single rectilinear series.

Thirteen *Herposiphonia* species and one variety have been reported from China, but most of these have a regular sequence of three determinate branches followed by one indeterminate branch, and only *H. secunda* and *H. delicatula* have bare segments at the main axis. *H. secunda* differs from *H. pinnata* in its lack of vegetative trichoblasts and the degeneration of indeterminate branches. *H. delicatula* clearly differs from *H. pinnata* in that the segments of the determinate branches have 8(9) periaxial cells (Tseng et al., 2011).

H. pinnata sp. nov. resembles seven *Herposiphonia* species found worldwide (Hollenberg, 1968; Abbott, 1999; Millar, 1999; Schneider, 2004; De Ramon N'Yeurt and Payri, 2011; Tseng et al., 2011) by having terete branches, very narrow angles between the left and right rows of branches, determinate branches and indeterminate branches arranged in a chaotic sequence and bare nodes. The frequency of vegetative trichoblasts are a significant taxonomic feature (Hollenberg, 1968): (1) absent; (2) infrequent and very rudimentary; (3) frequent but in a restricted number (two to four) and poorly or well developed; and (4) frequent, abundant and mostly well developed. In the seven similar species, the vegetative trichoblasts of *H. dubia*, *H. obscura* and *H. secunda* are absent (Hollenberg, 1968; Abbott, 1999), and in *H. delicatula* and *H. dendroidea* are infrequent and very rudimentary (Hollenberg, 1968; De Ramon N'Yeurt and Payri, 2011; Tseng et al., 2011). Only in *H. arcuata* and *H. variabilis* are they

frequently found, and in this they are similar to *H. pinnata* (Hollenberg, 1968; Millar, 1999; Schneider, 2004). However, *H. arcuata* is distinguished from *H. pinnata* by the vegetative trichoblasts poorly developed in the former (Hollenberg, 1968), and *H. variabilis* is distinguished from *H. pinnata* by the unrestricted numbers and frequent appearance of the vegetative trichoblasts in the former in (Hollenberg, 1968; Schneider, 2004). In addition, some combined characteristics, such as diameter of main axes, length of segments of indeterminate axes and determinate branches, and frequency of vegetative trichoblasts, can further distinguish between *H. pinnata* and similar species (see the key) (Hollenberg, 1968; Abbott, 1999; Millar, 1999; Schneider, 2004; De Ramon N'Yeurt and Payri, 2011; Tseng et al., 2011). Furthermore, the thalli of *H. pinnata* are bright green with most erect parts of the feathery texture free from the substratum. These features are rarely recorded in past reports. We therefore suggest that the species from Shanwei, China, is a new species: *H. pinnata* Ding and Tan sp. nov.

5 CONCLUSION

Five *Herposiphonia* species collected from the eastern coast of Guangdong were identified morphologically, including a new species from Eastern Guangdong, China. The results add some new information on their biogeographical distribution and diversity along the coast of this district.

Key to *Herposiphonia pinnata* sp. nov. and seven similar species

1. Diameter of main axes mostly more than 50 μm 2
 1. Diameter of main axes mostly less than 50 μm ...
..... *H. delicatula*
 2. Length of segments of indeterminate axes mostly less than 1.....3
 2. Length of segments of indeterminate axes mostly more than 1.....5
 3. Numbers of segments of determinate branches less than 10..... *H. dendroidea*
 3. Numbers of segments of determinate branches more than 10.....4
 4. Numbers of periaxial cell per segment on determinate branches less than 10..... *H. obscura*
 4. Numbers of periaxial cell per segment on determinate branches more than 10..... *H. dubia*
 5. Length of segments of determinate branches mostly more than 1.....6
 5. Length of segments of determinate branches mostly less than 1..... *H. secunda*

6. Vegetative trichoblasts in an unrestricted number
..... *H. variabilis*
6. Vegetative trichoblasts in a restricted number.....7
 7. Vegetative trichoblasts poorly developed.....
..... *H. arcuata*
 7. Vegetative trichoblasts well developed.....
..... *H. pinnata* sp. nov.

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