

## ***Gracilaria* and Related Genera (Gracilariales, Rhodophyta) from the Gulf of Thailand and Adjacent Waters**

Ryuta Terada<sup>1</sup>, Khanjanapaj Lewmanomont<sup>2</sup>, Anong Chirapart<sup>2</sup>, and Shigeo Kawaguchi<sup>3</sup>

<sup>1</sup> Faculty of Fisheries, Kagoshima University, Shimoarata, Kagoshima, 890-0056 Japan ,  
Tel. +81-99-286-4131, Fax. +81-99-286-4133  
E-mail address: terada@fish.kagoshima-u.ac.jp

<sup>2</sup> Faculty of Fisheries, Kasetsart University, Bangkok, 10900 Thailand

<sup>3</sup> Faculty of Agriculture, Kyushu University, Hakozaki, Fukuoka, 812-8581 Japan

The currently known 18 Thai species of *Gracilaria sensu lato* (*Gracilaria*, *Gracilariopsis* and *Hydropuntia*) were re-examined on the basis of the specimens housed in the herbaria of Kasetsart University (Thailand), Bishop Museum (USA), and Kagoshima University (Japan) and our recently collected material. Although *Gracilaria minuta* and *Gracilaria rhodymenioides* had been previously known only from the Gulf of Thailand (Western Pacific), they were collected also from the Andaman Sea (Indian Ocean). *Hydropuntia eucheumatoides*, previously collected only from the Andaman Sea, was found to grow in the Gulf of Thailand (Samui Island). Four of the 18 species (*Gracilaria irregularis*, *Gracilaria minuta*, *Hydropuntia fisheri*, *Hydropuntia percurrans*) are relatively described as endemic to Thailand, while others are commonly found in Southeast Asian waters.

**Keywords:** Algae, *Gracilaria*, *Gracilariopsis*, *Hydropuntia*, Rhodophyta, Seaweed, Taxonomy, Thailand

The species of *Gracilaria* and related genera (*Gracilaria sensu lato*) (Gracilariales, Rhodophyta) are well-known as economically important seaweeds in the Southeast Asian region as they are not only used for food (Tokuda *et al.*, 1988; Critchley and Ohno, 1998) or for feeding shellfish and others (Chiang, 1981; Critchley and Ohno, 1998), but also used as raw material for the extraction of the phycocolloid agar. Taxonomic studies of this group are, however, insufficient in this region and the specific diversity is not fully clarified.

In Thailand, Abbott (1988) first described 3 species and 1 variety of *Gracilaria* new to Thailand (*G. firma*, *G. irregularis*, *G. salicornia* and *G. tenuistipitata* var. *liui*) and 4 species of *Polycavernosa* (*P. changii*, *P. fastigiata*, *P. fisheri* and *P. percurrans*), of which 2 were described as new. The latter genus is now considered to be synonymous with *Hydropuntia*. Since then, several studies of *Gracilaria* have been made (Abbott *et al.*, 1991; Lewmanomont, 1994; 1995; Chirapart and Ruangchay, 1999; Chirapart and Lewmanomont, 2002; Lewmanomont and Chirapart, 2004) and until now 18 taxa have been recognized in Thailand.

In the present study, the currently known 18 taxa of *Gracilaria sensu lato* (*Gracilaria sensu stricto*, *Gracilariopsis*, and *Hydropuntia*), are re-examined on the basis of the specimens housed in the herbaria of Kasetsart University (Thailand), Bishop Museum (USA), and Kagoshima University (Japan), and our recently collected material. The taxonomic status of them is then discussed.

## MATERIALS AND METHODS

Field collections at three localities of southern Thailand, 1) Ma Kan Bay, Ko Libong (07°12.513'N 99°23.508'E), 2) Ko Petra, Satun (06°50.207'N 99°45.083'E), and 3) Ko Yo, Songkhla (07°09.342'N 100°31.942'E), were preserved in ca. 10% formalin/seawater. Small portions dissected from herbarium specimens were resoaked and prepared for microscopic observations. Sections were made with a freezing microtome and stained with 1% cotton blue in 50% glycerol/seawater.

Unless otherwise indicated, the herbarium specimens with KL and SU numbers are housed in Kasetsart University, those with BISH, JRF and Abbott numbers in Bishop Museum with sheet numbers, and those with Terada numbers in Kagoshima University.

## RESULTS AND DISCUSSION

The two genera, *Gracilariopsis* Dawson and *Hydropuntia* Montagne (= *Polycavernosa* Chang et Xia), closest relatives to *Gracilaria*, have been variously discussed by many researchers (Dawson, 1949; Chang and Xia, 1963; Papenfuss, 1966; Yamamoto, 1978; Wynne, 1989; Fredericq and Hommersand, 1989; Abbott *et al.*, 1991; Steentoft *et al.*, 1995; Bird, 1995; Tseng and Xia, 1999; Gurgel *et al.*, 2003). In 1989, Fredericq and Hommersand supported the independence of the genus *Gracilariopsis* on the basis of reproductive features of *Gracilariopsis lemneiformis* (Bory) Dawson Acleto et Foldvik. Recently, Gurgel and Fredericq (2004) supported the independence of the genus *Hydropuntia* on the basis of plastid *rbcL* DNA sequence analyses. Therefore, here in this study, we treat 3 genera (*Gracilaria*, *Gracilariopsis* and *Hydropuntia*) under the family Gracilariaceae.



**Figure 1** *Gracilaria firma* Chang et Xia from Trat on June 24, 1986 (Abbott17975, Kasetsart).

**Figure 2** *Gracilaria irregularis* Abbott from Trat on Feb. 20, 1986 (BISH510495, Holotype).

**Figure 3** *Gracilaria longirostris* Zhang et Wang from Bang Gra Noi, Phetchaburi on Oct. 14, 2001 (Kasetsart).

### *Gracilaria* Greville, 1830

#### 1. *Gracilaria firma* Chang et Xia, 1976: 143

(Fig. 1)

Abbott, 1988; Lewmanomont, 1994.

**Specimens examined: Thailand:** Trat: Apr. 18, 1986 (KL5201), June 24, 1986 (Abbott17975, Kasetsart); Chonburi: March 2, 1989 (KL6402).

**Remarks:** This species was originally described by Chang and Xia (1976) from Guangdong Province, China, and has been characterized by small gonimoblast-cells, a few traversing filaments in the cystocarp and deep pot-shaped, *Verrucosa*-type spermatangial conceptacles (Chang and Xia, 1976; Yamamoto *et al.*, 1994; Terada *et al.*, 2000). It closely resembles *G. blodgettii* Harvey in gross morphology, but differs from the latter which has more abundant traversing filaments in the cystocarp and shallowly depressed, *Textorii*-type spermatangial conceptacles (Yamamoto, 1978; Fredericq and Norris, 1992). The greenish-brown color of *G. firma* also differs from the light pink or reddish brown of *G. blodgettii*. This species was first reported in Thailand by Abbott (1988) from Trat and Songkhla (the Gulf of Thailand). It was also reported from Vietnam (Yamamoto *et al.*, 1994; Ohno *et al.*, 1999), Malaysia (Phang, 1994; Terada *et al.*, 2000), and the Philippines (Abbott, 1994).

## 2. *Gracilaria irregularis* Abbott, 1988: 141

(Fig. 2)

Lewmanomont, 1994.

**Specimens examined: Thailand:** Trat: Feb. 20, 1986 (BISH510495, Holotype, BISH510749 and BISH510750, Isotype (all Abbott18003)), Jan. 30, 1988 (KL5612), Feb. 27, 1988 (KL5701), Apr. 11, 1989 (KL6526).

**Remarks:** This species was originally described by Abbott (1988) from Ao Len and Ao Cho, Trat (the Gulf of Thailand) and is endemic to Thailand. It has a succulent thallus with irregular secondary branching and has acute apices.

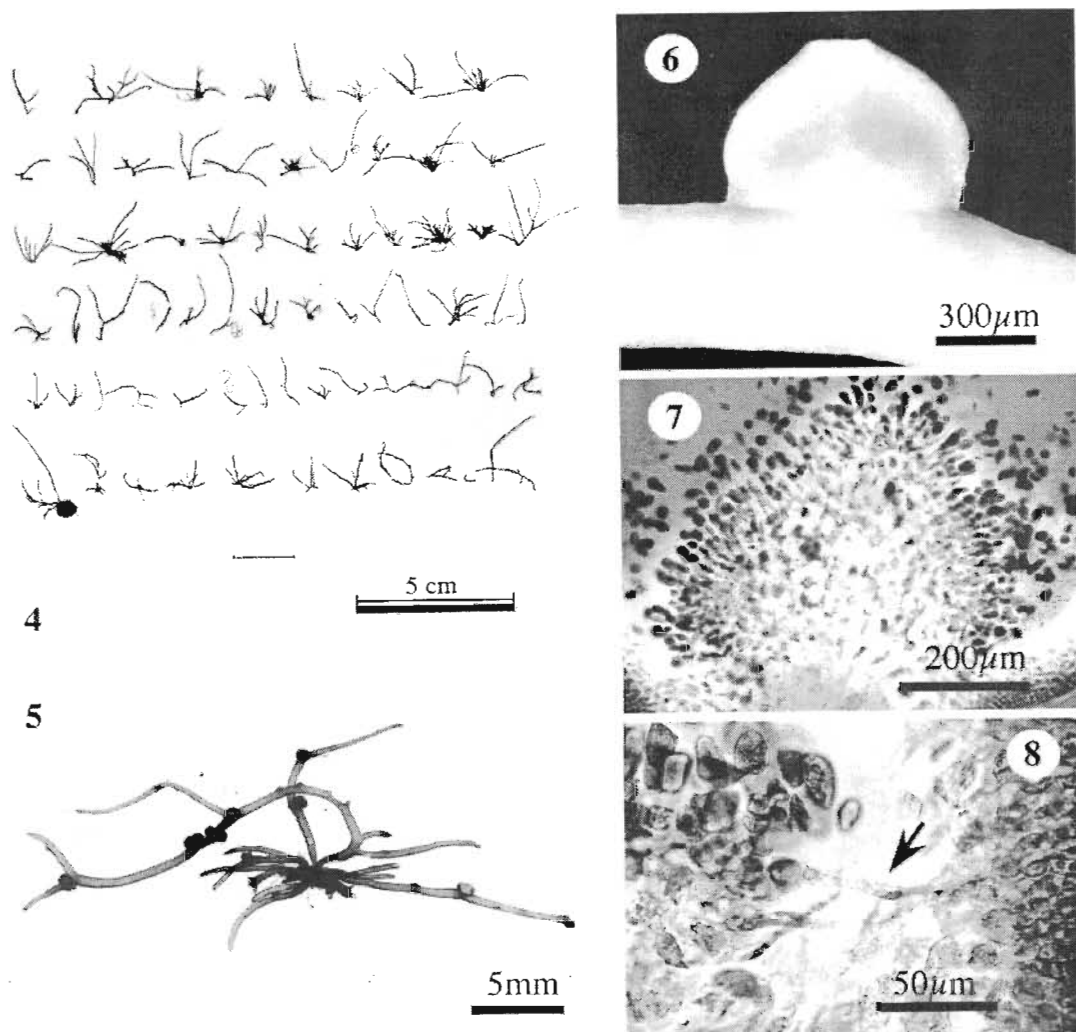
## 3. *Gracilaria longirostris* Zhang et Wang, 1995: 197

(Fig. 3)

Lewmanomont and Chirapart, 2004.

**Specimens examined: Thailand:** Bang Gra Noi, Phetchaburi, Oct. 14, 2001 (Kasetsart).

**Remarks:** This species was originally described by Zhang and Wang (in Zhang *et al.*, 1995) from Guangdong Province, China. The long rostrate ostiole on the cystocarp of this alga is very distinctive, resembling no other species of *Gracilaria*. It was recently reported by Lewmanomont and Chirapart (2004) from Bang Gra Noi, Phetchaburi (the Gulf of Thailand) as a first record from Thailand. No spermatangial plants have been reported.

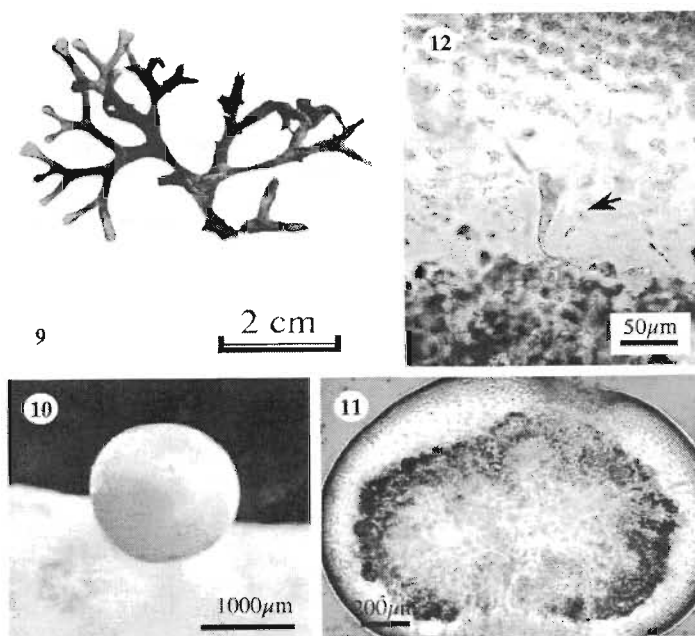


- Figures 4-8** *Gracilaria minuta* Lewmanomont.  
**Figure 4** Holotype from Trat on Jan. 30, 1988 (KL5616).  
**Figures 5-8** Material from Ko Libong on September 23, 2003 (Terada1584).  
**Figure 5** Natural habit.  
**Figure 6** Cystocarp, showing slightly rostrate ostiole and slightly constricted base.  
**Figure 7** Vertical section of the cystocarp, showing large gonimoblast cells.  
**Figure 8** Close up of the traversing filament (arrow) present between gonimoblast and pericarp.

**4. *Gracilaria minuta* Lewmanomont, 1994: 145**  
**(Figs. 4-8)**

**Specimens examined: Thailand:** Trat: Jan. 30, 1988 (KL5616, Holotype); Ko Libong: Sept. 23, 2003 (Terada1583, 1584).

**Remarks:** This species was originally described by Lewmanomont (1994) from Trat (the Gulf of Thailand). In this study, we collected a cystocarpic plant from Ko Libong (Fig. 5), a first record of this species from the coast of the Andaman Sea. It is closely similar to *G. tenuistipitata* in external and internal appearances, but is different from the latter in its much smaller size and the presence of a traversing filament between the pericarp and the gonimoblast (Figs. 6-8, arrow). This species is endemic to Thailand.



**Figures 9-12** *Gracilaria rhodymenioides* Millar from Satun on Sept. 24, 2003 (Terada1581)

**Figure 9** Natural habit.

**Figure 10** Cystocarp, showing abruptly constricted base.

**Figure 11** Vertical section of the cystocarp, showing large gonimoblast cells.

**Figure 12** Close up of the traversing filament (arrow) present between gonimoblast and pericarp.

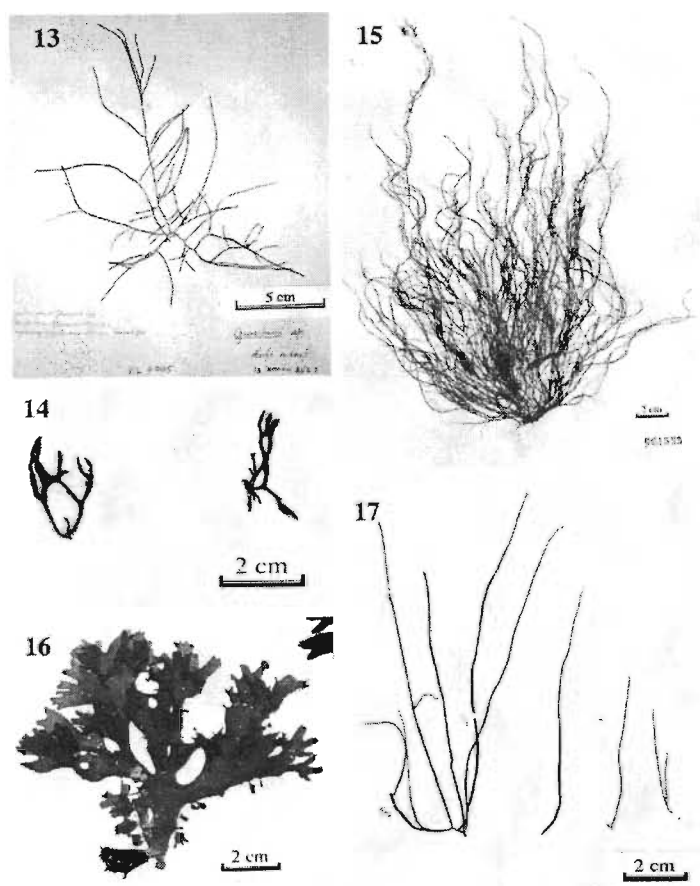
##### 5. *Gracilaria rhodymenioides* Millar, 1997: 114

(Figs. 9-12)

Lewmanomont and Chirapart, 2004.

**Specimens examined: Thailand:** Prachuap Khiri Khan: Sept. 2, 2001 (Kasetsart); Satun: Sept. 24, 2003 (Terada1580-1582).

**Remarks:** This species was originally described by Millar (1997) on material collected from New South Wales, Australia. It was also reported from Norfolk Island by Millar and Xia (1999). It has a terete stipe with foliose, dichotomously or trichotomously branched blades (Fig. 9), large gonimoblast-cells (Fig. 11), and traversing filaments in the cystocarp (Fig. 12). It resembles *Rhodymenia* species in gross morphology, but differs from the latter in having a gonimoblast with traversing filaments. Lewmanomont and Chirapart (2004) report this alga from Ta Mong Lai, Prachuap Khiri Khan (the Gulf of Thailand) as a first record from Thailand. In this study, we collected it from Satun (the Andaman Sea). Lewmanomont and Chirapart (2004) report the *Textorii*-type spermatangial conceptacle in their material, but no spermatangia were found in Australian material.



**Figure 13** *Gracilaria rubra* Chang et Xia from Sri Racha, Chonburi: Jan. 13, 1989 (KL6005).

**Figure 14** *Gracilaria salicornia* (C. Agardh) Dawson from Satun on Sept. 24, 2003 (Terada1589).

**Figure 15** *Gracilaria tenuistipitata* Chang et Xia from Songkhla on Sept. 28, 2003 (Terada1585).

**Figure 16** *Gracilaria textorii* (Suringar) Hariot from Kantang, Trang on June 24, 1990 (Kasetsart).

**Figure 17** *Gracilariopsis lemaneiformis* (Bory) Dawson, Acleto et Foldvik from Trang on Sept. 19, 1988 (SU0086).

#### 6. *Gracilaria rubra* Chang et Xia, 1976: 160

(Fig. 13)

Chirapart and Ruangchaay, 1999.

**Specimens examined: Thailand:** Sri Racha, Chonburi: Jan. 13, 1989 (KL6002, KL6005).

**Remarks:** This species was originally described by Chang and Xia (1976) from Hainan Island, Guangdong Province, China. It resembles *G. tenuistipitata* in gross morphology, but is different from the latter species in having *Verrucosa*-type spermatangial conceptacles instead of the *Textorii*-type. It was first reported in Thailand by Chirapart and Ruangchaay (1999) from Sri Racha, Chonburi (the Gulf of Thailand), and Haad Toong Nang Dam, Ranong (the Andaman Sea).

**7. *Gracilaria salicornia* (C. Agardh) Dawson, 1954: 4****(Fig. 14)**

Chang and Xia, 1976; Yamamoto, 1978; Xia, 1986; Lewmanomont, 1994.

**Basionym:** *Sphaerococcus salicornia* C. Agardh, 1820, 302.**Synonyms:** See Xia, 1986, 103.**Specimens examined: Thailand:** Rayong: Jan. 2, 1996 (Terada278-292, 500); Satun: Sept. 24, 2003 (Terada1587-1590).**Remarks:** Xia (1986) merged 4 related taxa, *G. cacalia*, *G. opuntia*, *G. minor* and *G. canaliculata* (= *G. crassa*) into *G. salicornia* since the degree of constrictions was not distinguishable among them. The articulated and constricted segments of this alga are very distinctive when present, resembling no other species of *Gracilaria*. This species was first reported from Thailand by Dawson (1954) from Saen Soek (the Gulf of Thailand) as *G. cacalia*. It is common in Southeast Asian waters.**8. *Gracilaria tenuistipitata* Chang et Xia, 1976: 102****(Fig. 15)**

Zhang and Xia, 1988; Abbott, 1988; Lewmanomont, 1994.

**Specimens examined: Thailand:** Songkhla: Feb. 13, 1985 (Kasetsart), Sept. 28, 2003 (Terada1585, 1586); Pattani: Jan. 21, Oct. 30, 1990 (Kasetsart), Dec. 28, 1995 (Terada44, 45, 193-197).**Remarks:** Two varieties are recognized in this species: var. *tenuistipitata* Chang et Xia, and var. *liui* Zhang et Xia. Both varieties were originally described from Hainan Island, Guangdong Province, China by Chang and Xia (1976) and Zhang and Xia (1988), respectively. This species is terete throughout with densely and irregularly arranged branches, and shallow, *Textorii*-type spermatangial conceptacles. It resembles *G. vermiculophylla* (Ohmi) Papenfuss in gross morphology, but differs from the latter which has deep, pot-shaped *Verrucosa*-type spermatangial conceptacles. This species (as var. *liui*) was first reported in Thailand by Zhang and Xia (1988) and Abbott (1988) from Pattani (the Gulf of Thailand). Lewmanomont (1994) also reported var. *tenuistipitata* and var. *liui* from Thailand. The species was reported from Vietnam (Nguyen, 1992; Ohno *et al.* 1999) and Malaysia (Terada *et al.*, 2000).**9. *Gracilaria textorii* (Suringar) De Toni, 1895 : 27****(Fig. 16)**

Lewmanomont, 1994.

**Basionym:** *Sphaerococcus textorii* Suringar 1867, 259.**Specimens examined: Thailand:** Kantang, Trang: June 24 and 26, 1990 (Kasetsart).**Remarks:** This species was originally described from Japan (Japan Sea) by Suringar (1867). Later, it was reported from Malaysia (Doty and Fisher, 1987), Philippines (Trono, 1997), China (Chang and Xia, 1976) and temperate and subtropical region of Northeast Pacific (Norris, 1984; Abbott, 1984). This species has dichotomously or trichotomously branched foliar blades and shallowly depressed, *Textorii*-type spermatangial conceptacles. It closely resembles *G. sublittoralis* Segawa et Yamada in gross morphology, but differs in showing deep, pot-shaped *Verrucosa*-type spermatangial conceptacles. It is also similar to *G. vieillardii* Silva, but is different from the latter in lacking dentate spines at the margin of the blade. Lewmanomont (1994) reported this species from Trang (the Andaman Sea).

**Gracilariopsis Dawson 1949**

**10. Gracilariopsis lemaneiformis (Bory) Dawson, Acleto et Foldvik, 1964: 59 (Fig. 17)**

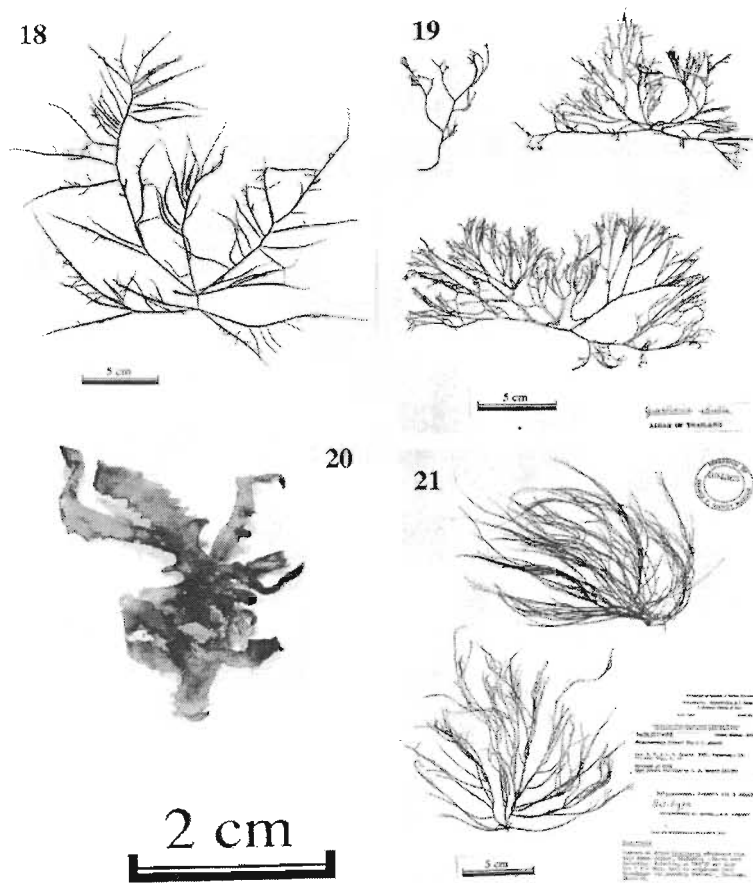
Lewmanomont, 1994 (as *Gracilaria lemaneiformis*).

**Basionym:** *Gigartina lemaneiformis* Bory, 1828, 151.

**Synonym:** *Gracilaria lemaneiformis* (Bory) Greville, 1830, Synopsis LIV.

**Specimens examined: Thailand:** Trang: Sept. 19, 1988 (SU0086).

**Remarks:** This species was originally described by Bory (in Duperrey 1828) from Peru, it was also reported from China (Xia, 1985), Philippines (Abbott, 1994) and Japan (Yoshida, 1998). In Thailand, this alga was reported by Lewmanomont (1994) from Trang (the Andaman Sea). Gurgel *et al.* (2003) suggested that on a molecular basis genuine *Gracilariopsis lemaneiformis* from Peru and East Asian material from China and Japan are specifically different. The re-examination of Southeast Asian material of *G. lemaneiformis* is needed. The Thai material is terete throughout with a few to several long branches, and small gonimoblast cells with the absence of traversing filaments in the cystocarp.



**Figure 18** *Hydropuntia changii* (Xia et Abbott) Wynne from Chonburi on Mar. 2, 1989 (KL6403).

**Figure 19** *Hydropuntia edulis* (Gmelin) Gurgel et Fredericq from Trat on Apr. 11, 1989 (KL6521).

**Figure 20** *Hydropuntia eucheumatoides* (Harvey) Gurgel et Fredericq from Ko Samui (Terada1595).

**Figure 21** *Hydropuntia fisheri* (Xia et Abbott) Wynne from Pattani on June 28, 1983 (BISH504365 (JRF#1087), Holotype).



***Hydropuntia* Montagne 1842****11. *Hydropuntia changii* (Xia et Abbott) Wynne, 1989: 477****(Fig. 18)**Lewmanomont, 1994 (as *Gracilaria changii*).**Basionym:** *Polycavernosa changii* Xia et Abbott, 1987, 407.**Synonym:** *Gracilaria changii* (Xia et Abbott) Abbott, Zhang et Xia, 1991, 23.**Specimens examined: Thailand:** Trat: Feb. 22, 1987 (KL5420), Jan. 30, 1988 (KL5613), Feb. 27, 1988 (KL5703), Apr. 11, 1989 (KL6525); Chonburi: Mar. 2, 1989 (KL6403). **Malaysia:** Penang: Mar. 10, 1983 (BISH504364 (JRF#1022), Holotype).**Remarks:** This species was originally described by Xia and Abbott (1987) from Penang, Malaysia (as *Polycavernosa changii*). This species is distributed in Thailand, Malaysia, Myanmar and the Philippines (Xia and Abbott, 1987). Wynne (1989) transferred it to *Hydropuntia*, and Abbott *et al.* (1991) again transferred it to *Gracilaria*. In their paper, the specimen from Ao Len, Trat (the Gulf of Thailand) was also described as a first record from Thailand. In the present study, we treated it as *Hydropuntia changii* because Gurgel and Fredericq (2004) supported the independence of the genus *Hydropuntia*. This species is terete throughout with abruptly constricted branch bases and multicavities, *Polycavernosa*-type (Tseng and Xia, 1999) spermatangial conceptacles. It resembles *G. blodgettii* Harvey in gross morphology, but differs from the latter which has shallow, *Textorii*-type spermatangial conceptacles (Yamamoto, 1978). Lewmanomont (1994) noted that it is rather common along the east coast of the Gulf of Thailand.**12. *Hydropuntia edulis* (Gmelin) Gurgel et Fredericq, 2004: 155****(Fig. 19)**Abbott *et al.*, 1991; Abbott, 1994; Lewmanomont, 1994 (as *Gracilaria edulis*).**Basionym:** *Fucus edulis* Gmelin, 1768, 113.**Synonyms:** *Fucus lichenoides* Gmelin, 1768, 120.*Gracilaria lichenoides* (Gmelin) Greville, 1830, LIV.*Gracilaria edulis* (Gmelin) Silva, 1952, 253.*Polycavernosa fastigiata* Chang et Xia, 1963, 125.*Hydropuntia fastigiata* (Chang et Xia) Wynne, 1989, 477.**Specimens examined: Thailand:** Trat: Apr. 10, 1989 (KL6506), Apr. 11, 1989 (KL6521).**Malaysia:** Penang: Feb. 23, 1983 (BISH577516).**Remarks:** This species (as *F. edulis*) was originally described by Gmelin (1768) from Indonesia. Silva (1952) transferred it to *Gracilaria* on a nomenclatural basis. Chang and Xia (1963) described *Polycavernosa fastigiata* from Hainan Island, Guangdong Province, China. Wynne (1989) merged *Polycavernosa* with the earlier name *Hydropuntia* Montagne and transferred *P. fastigiata* to the latter genus. Abbott *et al.* (1991) again merged *Hydropuntia* with *Gracilaria* and treated *H. fastigiata* (= *P. fastigiata*) as a synonym of *G. edulis*. Gurgel and Fredericq (2004) supported the independence of the genus *Hydropuntia* in Gracilariaceae, and transferred *G. edulis* to *Hydropuntia*. This species is terete throughout with dense and fastigiated branching in its upper part and multicavities, *Polycavernosa*-type spermatangial conceptacles (Tseng and Xia, 1999). This species was first reported in Thailand as *P. fastigiata* by Abbott (1988) from Laem Hin, north of Ko Loi, Trat (the Gulf of Thailand), and from Phuket (the Andaman Sea). This species is common in Southeast Asian waters.

**13. *Hydropuntia eucheumatoides* (Harvey) Gurgel et Fredericq, 2004: 155 (Fig. 20)**

Chang and Xia, 1976; Yamamoto, 1978; Lewmanomont, 1994 (as *Gracilaria eucheumoides*), Terada and Yamamoto, 2002 (as *G. eucheumatoides*).

**Basionym:** *Gracilaria eucheumatoides* Harvey, 1860, 331.

**Specimens examined: Thailand:** Ko Samui: ([Terada1595](#)).

**Remarks:** This species was originally described by Harvey (as *G. eucheumoides* Harvey (as “*eucheumioides*”) 1860) from the Ryukyu Islands (Okinawa, Japan), and has been reported from various regions of SE Asia. The name of ‘*eucheumoides*’ was emended to the current spelling name by Silva *et al.* (1996). Gurgel and Fredericq (2004) supported the independence of the genus *Hydropuntia* in Gracilariaceae, and transferred *G. eucheumatoides* to *Hydropuntia*. The succulent and prostrate habit with compressed thallus of this alga is very distinctive, resembling no other species of *Gracilaria*. Yamamoto and Noro (1993) confirmed that spermatangial conceptacles were *Polycavernosa*-type (on the basis of the *in vitro* cultured materials from the Philippines). This species was first reported in Thailand by Lewmanomont (1994) from Phuket Island (the Andaman Sea). It also grows in Samui Island (the Gulf of Thailand).

**14. *Hydropuntia fisheri* (Xia et Abbott) Wynne, 1989: 477 (Fig. 21)**

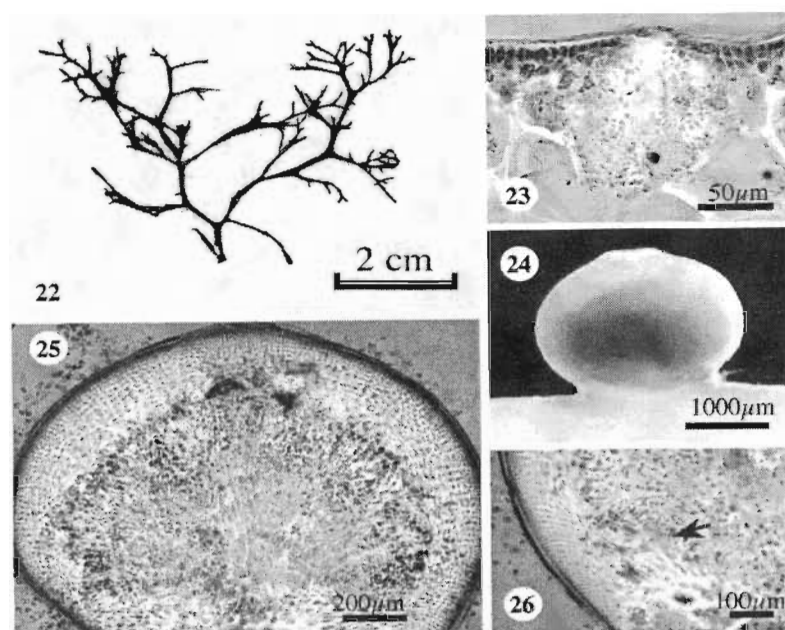
Lewmanomont, 1994 (as *Gracilaria fisheri*).

**Basionym:** *Polycavernosa fisheri* Xia et Abbott, 1987, 411.

**Synonym:** *Gracilaria fisheri* (Xia et Abbott) Abbott, Zhang et Xia, 1991, 23.

**Specimens examined: Thailand:** Pattani: June 28, 1983 ([BISH504365](#) (JRF#1087), Holotype); Songkhla: Sept. 28, 2003 ([Terada1591-1594](#)).

**Remarks:** This species (as *P. fisheri*) was originally described by Xia and Abbott (1987) from Pattani (the Gulf of Thailand) and is endemic to Thailand (especially abundant in the Gulf of Thailand). After Wynne (1989) transferred it to *Hydropuntia*, Abbott *et al.* (1991) again transferred it to *Gracilaria*. In this study, we treated it as *Hydropuntia fisheri* because Gurgel and Fredericq (2004) supported the independence of the genus *Hydropuntia*. It is terete throughout with many branches constricted at the bases, and multicavities, *Polycavernosa*-type spermatangial conceptacles. It resembles *G. manilaensis* Yamamoto et Trono in gross morphology, but differs from the latter which has deep pot-shaped, *Verrucosa*-type spermatangial conceptacles.



**Figures 22-26** *Hydropuntia multifurcata* (Børgesen) Wynne from Ko Libong on Sept. 23, 2003 (Terada 1574).

**Figure 23** Vertical section of the spermatangial conceptacle, showing multicavities *Polycavernosa*-type.

**Figure 24** Cystocarp, showing slightly rostrate ostiole and abruptly constricted base.

**Figure 25** Vertical section of the cystocarp, showing large gonimoblast cells.

**Figure 26** Close up of the basal traversing filament (arrow) present between gonimoblast and the cystocarpic floor.

### 15. *Hydropuntia multifurcata* (Børgesen) Wynne, 1989: 477

(Figs. 22-26)

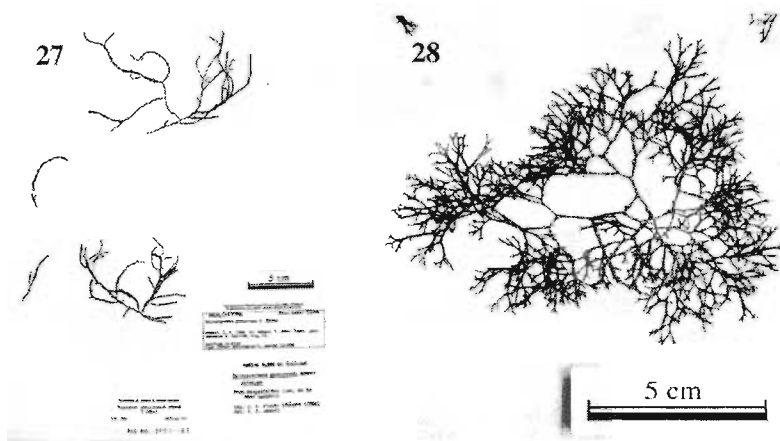
Millar, 1997; Terada *et al.*, 2000; Lewmanomont and Chirapart, 2004 (as *Gracilaria multifurcata*).

**Basionym:** *Gracilaria multifurcata* Børgesen, 1953, 42.

**Synonym:** *Polycavernosa multifurcata* (Børgesen) Chang et Xia, 1963, 123.

**Specimens examined: Thailand:** Ao Khao Kwai, Ranong: Feb. 2002 (Kasetsart); Ko Libong: Sept. 23, 2003 (Terada 1574-1576); Satun: Sept. 24, 2003 (Terada 1577-1579)

**Remarks:** This species (as *G. multifurcata*) was originally described by Børgesen (1953) from Mauritius, as having compressed thalli that are repeatedly irregularly furcated and multicavities, *Polycavernosa*-type spermatangial conceptacles. It was transferred to *Polycavernosa* by Chang and Xia (1963), and later to *Hydropuntia* by Wynne (1989). Abbott *et al.* (1991) again restored it to the original name *Gracilaria multifurcata*. However, we treated it as *Hydropuntia multifurcata* because Gurgel and Fredericq (2004) supported the independence of the genus *Hydropuntia*. This alga was reported from Australia by Millar (1997), and from Malaysia by Terada *et al.* (2000). Chirapart and Lewmanomont (2002) and Lewmanomont and Chirapart (2004) reported this taxon from Ao Khao Kwai, Ranong (the Andaman Sea), as a first record from Thailand. In this study, we confirmed its characteristically compressed appearance (Fig. 22), *Polycavernosa*-type spermatangial conceptacles (Fig. 23), and the presence of basal traversing filaments between the gonimoblast and cystocarpic floor (Figs. 25, 26) on the materials from Ko Libong and Satun (the Andaman Sea).



**Figure 27** *Hydropuntia percurrens* (Abbott) Wynne from Songkhla on Oct. 13, 1986 (BISH510496, Holotype).

**Figure 28** *Hydropuntia ramulosa* (Chang et Xia) Wynne from Chonburi on March 2, 1989 (KL6404).

**16. *Hydropuntia percurrens* (Abbott) Wynne, 1989: 477 (Fig. 27)**

Lewmanomont, 1994 (as *Gracilaria percurrens*).

**Basionym:** *Polycavernosa percurrens* Abbott, 1988, 146.

**Synonym:** *Gracilaria percurrens* (Abbott) Abbott *et al.* 1991, 23.

**Specimens examined: Thailand:** Songkhla: Oct. 13, 1986 (BISH510496 Holotype, BISH510745, Isotype (all Abbott17986)); Chonburi: Mar. 2, 1989 (Kasetsart).

**Remarks:** This species was originally described as *Polycavernosa percurrens* by Abbott (1988) from Ko Yo, Songkhla (the Gulf of Thailand). Wynne (1989) transferred it to *Hydropuntia*, but Abbott *et al.* (1991) again transferred it to *Gracilaria*. In this study, we treated it as *Hydropuntia percurrens* because Gurgel and Fredericq (2004) supported the independence of the genus *Hydropuntia*. It is related to *G. edulis* in gross morphology, but is different from the latter in having percurrent axes. This species is endemic to Thailand (especially abundant in the Gulf of Thailand).

**17. *Hydropuntia ramulosa* (Chang et Xia) Wynne, 1989: 477 (Fig. 28)**

Lewmanomont, 1994 (as *Gracilaria bangmeiana*).

**Basionym:** *Polycavernosa ramulosa* Chang et Xia, 1963, 125.

**Synonym:** *Gracilaria bangmeiana* Zhang et Abbott, in Abbott, Zhang et Xia, 1991, 23.

**Specimens examined: Thailand:** Chonburi: March 2, 1989 (KL6404). Rayong: Apr. 19, 1986 (BISH648957 (KL5216)).

**Remarks:** This species (as *Polycavernosa ramulosa*) was originally described from Hainan Island, Guangdong Province, by Chang and Xia (1963). It was also reported from Vietnam (Nguyen, 1992). It was transferred to *Hydropuntia* which has nomenclatural priority over *Polycavernosa* (Wynne, 1989). Later, this genus was reduced to the synonymy of *Gracilaria* (Abbott *et al.*, 1991). However, *Gracilaria ramulosa* is a later homonym of *Gracilaria ramulosa* J. Agardh (1876), and they proposed the new name *Gracilaria bangmeiana* Zhang et Abbott (Abbott *et al.*, 1991). In this study, we treated it as *Hydropuntia ramulosa* because Gurgel and Fredericq (2004) supported the independence of the genus *Hydropuntia*. This species is similar to *Hydropuntia edulis* (Gmelin) Gurgel et Fredericq (= *G. edulis* (Gmelin) Silva) in its terete habit, but differs from the latter in having dense branching with short intervals in the upper part. Lewmanomont (1994) reported this alga from Ban Phe, Rayong (the Gulf of Thailand), and Palian, Trang (the Andaman Sea).

**18. *Hydropuntia urvillei* Montagne, 1842: 7**

Lewmanomont, 1995 (as *Gracilaria urvillei*).

**Synonyms:** *Corallopsis urvillei* (Montagne) J. Agardh, 1876, 583.

*Polycavernosa urvillei* (Montagne) Xia et Abbott, 1987, 414.

*Gracilaria urvillei* (Xia et Abbott) Abbott, Zhang et Xia, 1991, 23.

**Specimens examined: Thailand:** Satun: Aug. 1972 (Kasetsart).

**Remarks:** This species was originally described as *Hydropuntia urvillei* from Australia (Torres Strait) by Montagne (1842). Agardh (1876) transferred it to *Corallopsis*, and later Xia and Abbott (1987) transferred it to *Polycavernosa*. Wynne (1989) transferred it to *Hydropuntia* as the species has nomenclatural priority over *Polycavernosa*. This genus was once again reduced to the synonymy of *Gracilaria* (Abbott *et al.*, 1991). However, Gurgel and Fredericq (2004) supported the independence of the genus *Hydropuntia* in Gracilariaceae. In this study, we treated it as *Hydropuntia urvillei*. It was also reported from Malaysia and Indonesia (Xia and Abbott, 1987). The multi-segmented thalli with stipitate branches and surface projections of this alga are very distinctive. Lewmanomont (1995) reported this alga from Satun (the Andaman Sea) as a first record for Thailand.

According to Tseng and Xia (1999), 58 species and 4 varieties of *Gracilaria* (*sensu lato*) are reported in Western Pacific and SE Asia. However, it includes temperate species that are distributed only in Japan, Korea, and China; we estimate that tropical species in their list are less than 45. Currently, 18 species are known in Thailand. This means that nearly half of tropical Southeast Asian species distribute in Thai waters. Furthermore, among 18 Thai species, 4 species (*Gracilaria irregularis*, *Gracilaria minuta*, *Hydropuntia fisheri* and *Hydropuntia percurrans*) have been reported only from Thailand. The Thai collection represent a diversity of marine habitats from open oceanic Andaman coasts to brackish mangrove pools.

**ACKNOWLEDGEMENTS**

We wish to express our gratitude to Dr. H. Ogawa, Kitasato University, for his valuable suggestions on our work in the Biodiversity group in the JSPS-ORI (Japan Society for the Promotion of Science-Ocean Research Institute, the University of Tokyo) program. Cordial thanks are due to Dr. A. Prathep, Prince of Songkhla University, for her valuable suggestions of the fieldwork in Ko Libong and for the donation of the specimen of *G. euclideanoides* for us. We acknowledge Dr. I. A. Abbott, University of Hawaii at Manoa for critically reviewing the manuscript and for valuable suggestions. We thank Dr. C. Puttock, for the privilege to observe the specimen housed in the Bishop Museum, USA. This study was supported in part by the JSPS.

**REFERENCES**

- Abbott, I.A. 1984. *Gracilaria* from California: Key, list and distribution of the species. p. 97-99. *In*: I.A. Abbott, and J. Norris (eds.). Taxonomy of Economic Seaweeds, with reference to some Pacific and Caribbean species volume I, California Sea Grant College Program, University of California, La Jolla.
- Abbott, I.A. 1988. Some species of *Gracilaria* and *Polycavernosa* from Thailand. p. 137-150. *In*: I.A. Abbott (ed.). Taxonomy of Economic Seaweeds, with reference to some Pacific and Caribbean species volume II, California Sea Grant College Program, University of California, La Jolla.
- Abbott, I.A. 1994. New records and a reassessment of *Gracilaria* (Rhodophyta) from the Philippines. p. 111-118. *In*: I.A. Abbott (ed.). Taxonomy of Economic Seaweeds, with reference to some Pacific species volume IV, California Sea Grant College Program, University of California, La Jolla.

- Abbott, I.A., Zhang, J., and Xia, B. 1991. *Gracilaria mixta*, sp. nov. and other western Pacific species of the genus (Rhodophyta: Gracilariaceae). Pacific Science 45: 12-27.
- Agradh, C.A. 1820. Species algarum..... vol. I. Berling, Lund.
- Agradh, J.G. 1876. Species genera et ordines algarum, seu descriptiones succinctae specierum, generum et ordinum, quibus algarum regnum constituitur III (1). Weigel, Lipsiae.
- Bird, C.J. 1995. A review of recent taxonomic concepts and developments in the Gracilariaceae (Rhodophyta). J. Appl. Phycol. 7: 255-67.
- Børgesen, F. 1953. Some marine algae from Mauritius. Additions to the parts previously published. V. Det Kongelige Danske Videnskabernes Selskab, Biologiske Meddelelser 21: 1-62.
- Bory de Saint-Vincent, J.B.G.M. 1828. Criptogamine. p. 96-136. In: Voyage Autour du Monde, .....La Coquille..... A. Duperry, L. I. (ed.). Bertrand, Paris.
- Chang, C.F., and Xia, B.M. 1963. *Polycavernosa*, a new genus of the Gracilariaceae. Studia Marina Sinica 3: 119-126.
- Chang, C., and Xia, B. 1976. Studies on Chinese species of *Gracilaria*. Studia Marina Sinica 11: 91-163.
- Chiang, Y. M. 1981. Cultivation of *Gracilaria* (Rhodophyta, Gigartinales) in Taiwan. Proc. Int. Seaweed Symp. 10: 569-573.
- Chirapart, A., and Ruangchaui, R. 1999. A new record of *Gracilaria*, *G. rubra* C.F. Chang et B.M. Xia from Thailand. p. 137-143. In: Abbott, I.A. (ed.). Taxonomy of Economic Seaweeds, with reference to some Pacific species volume VII, California Sea Grant College Program, University of California, La Jolla.
- Chirapart, A., and Lewmanomont, K. 2002. A different flattened species of *Gracilaria* from Thailand. p. 237-243. In: I.A. Abbott, and K. McDermid (eds.). Taxonomy of Economic Seaweeds, with reference to some Pacific species volume VIII, California Sea Grant College Program, University of California, La Jolla.
- Critchley, A.T., and Ohno, M. 1998. The seaweed resources of the world. JICA, Yokosuka.
- Dawson, E.Y. 1949. Studies on northeast Pacific Gracilariaceae. Allan Hancock Fund. Publ. Occas. Pap. 7: 1-54.
- Dawson, E.Y. 1954. Notes on tropical Pacific marine algae. Bull. South. Calif. Acad. Sci. 53: 1-7.
- Dawson, E.Y., Acleto, C., and Foldvik, N. 1964. The seaweeds of Peru. Beih. Nova Hedwigia 13: 1-111.
- De Toni, J.B. 1895. Phyceae japonicae novae addita enumeratione algarum in ditone maritima Japoniae hucusque collectarum. Mmoire del Reale Instituto Veneto di. Scienze, Lettere ed Arti 25(5):1-78, 2 pls.
- Doty, M., and Fisher, J. 1987. Experimental culture of seaweeds (*Gracilaria*) in Penang, Malaysia. Bay of Bengal Program, Food and Agriculture Organization. Working paper 52. Madras, India.
- Fredericq, S., and Hommersand, M.H. 1989. Comparative morphology and taxonomic status of Gracilariopsis (Gracilariales, Rhodophyta). J. Phycol. 25: 228-241.
- Fredericq, S., and Norris, J.N. 1992. Morphological studies on some tropical species of *Gracilaria* Grev. (Gracilariaceae, Rhodophyta): Taxonomic concepts based on reproductive morphology. p. 137-155. In: I.A. Abbott, and J.N. Norris (eds.). Taxonomy of Economic Seaweeds, with reference to some Pacific and Western Atlantic species volume III, California Sea Grant College Program, University of California, La Jolla.
- Gmelin, S.G. 1768. Historia fucorum. Academica Scientiarum, Peteropoli. St. Petersburg.
- Greville, R.K. 1830. Algae Britannicae, or descriptions of the marine and other inarticulated plants of the British Island, belonging to the order Algae, with plates illustrative of the genera. Edinburgh.

- Gurgel, C.F.D., Liao, L.M., Fredericq, S., and Hommersand, M.H. 2003a. Systematics of *Gracilariopsis* Dawson (Gracilariales, Rhodophyta) based on *rbcL* sequence analysis and morphological evidence. *J. Phycol.* 39:154-171.
- Gurgel, C.F.D., and Fredericq, S. 2004. Systematics of the Gracilariaceae (Gracilariales, Rhodophyta): a critical assessment based on *rbcL* sequence analyses. *J. Phycol.* (in press.)
- Hariot. 1891. Liste des algues marines rapportées de Yokosuka (Japon) par M. le Dr. Savatier. *Mém. Soc. Nat. Sc. Nat. Mathém. Cherbourg*, ser. 3. 27: 211-230.
- Harvey, W.H. 1860. Characters of new algae, chiefly from Japan and adjacent regions, collected by Charles Wright in the north Pacific exploring expedition under Captain John Rodgers. *Proc. Amer. Arts and Sci.* 4: 327-335.
- Lewmanomont, K. 1994. The species of *Gracilaria* from Thailand. p. 135-148. *In*: I. A. Abbott (ed.). *Taxonomy of Economic Seaweeds, with reference to some Pacific species volume IV*, California Sea Grant College Program, University of California, La Jolla.
- Lewmanomont, K. 1995. *Gracilaria urvillei* (Montagne) Abbott: A new record for Thailand. p. 223-226. *In*: I. A. Abbott (ed.). *Taxonomy of Economic Seaweeds, with reference to some Pacific species volume V*, California Sea Grant College Program, University of California, La Jolla.
- Lewmanomont, K., and Chirapart, A. 2004. Additional records of *Gracilaria* from Thailand. *In*: I.A. Abbott, and K. McDermid (eds.). *Taxonomy of Economic Seaweeds, with reference to some Pacific species volume IX*, Hawaii Sea Grant College Program, University of Hawaii, Honolulu.
- Millar, J.K. 1997. Some flattened species of *Gracilaria* from Australia. p. 111-123. *In*: I.A. Abbott (ed.). *Taxonomy of Economic Seaweeds, with reference to some Pacific species volume VI*, California Sea Grant College Program, University of California, La Jolla.
- Millar, J.K., and Xia, B. 1999. The genera *Gracilaria* and *Gracilariopsis* from Norfolk island, Southwestern Pacific. p. 113-119. *In*: I.A. Abbott (ed.). *Taxonomy of Economic Seaweeds, with reference to some Pacific species volume VII*, California Sea Grant College Program, University of California, La Jolla.
- Montagne, J.P.F.C. 1842. *Prodromus generum specierumque phycearum novarum, in itinere ad polu Antarcticum Regis Ludovici Philippi Jussu ab illustri Dumont d'Urville peracto collectarum, notis diagnosticis tantum huc evulgatarum, descriptionibus vero fusioribus nec non iconibus analyticis jam jamque illustrandarum auctore C. montagne. D. M. Parisiis (apud Gide, editorem), Paris.*
- Nguyen, H.D. 1992. Vietnamese species of *Gracilaria* and *Gracilariopsis*. p. 207-210 *In*: I.A. Abbott (ed.). *Taxonomy of Economic Seaweeds, with reference to some Pacific and Atlantic species volume III*, California Sea Grant College Program, University of California, La Jolla.
- Norris, J. 1984. *Gracilaria* from the Gulf of California: Key, list and distribution of the common species. p. 93-96. *In*: I.A. Abbott, and J. Norris (eds.). *Taxonomy of Economic Seaweeds, with reference to some Pacific and Caribbean species volume I*, California Sea Grant College Program, University of California, La Jolla.
- Ohno, M., Terada, R., and Yamamoto, H. 1999. The species of *Gracilaria* from Vietnam. p. 99-111. *In*: I.A. Abbott (ed.). *Taxonomy of Economic Seaweeds, with reference to some Pacific species volume VII*, California Sea Grant College Program, University of California, La Jolla.
- Pang, S.M. 1994. Some species of *Gracilaria* from Peninsular Malaysia and Singapore. p.125-133. *In*: I.A. Abbott (ed.). *Taxonomy of Economic Seaweeds, with reference to some Pacific species volume IV*, California Sea Grant College Program, University of California, La Jolla.

- Papenfuss, G.F. 1966. Notes on algal nomenclature-V. Various Chlorophyceae and Rhodophyceae. *Phykos* 5: 95-105.
- Silva, P. 1952. A review of nomenclatural conservation in the algae from the point of view of the type method. *Univ. Calif. Publ. Bot.* 25: 241-324.
- Silva, P.C., Basson, P.W., and Moe, R.L. 1996. Catalogue of the benthic marine algae of the Indian Ocean. University of California Press, Berkeley.
- Steentoft, M., Irvine, L.M., and Farnham, W.F. 1995. Two terete species of *Gracilaria* and *Gracilariopsis* (Gracilariales, Rhodophyta) in Britain. *Phycologia* 34: 113-127.
- Suringar, W.F.R. 1867. *Algarum Japonicarum Musei Botanici Lugduno Batavi index praecursorius*. *Annales Bot. Musei Bot. Lugd. Bat.* 3: 256-259.
- Terada, R., Kawaguchi, S., Masuda, M., and Phang, S. M. 2000. Taxonomic notes on Marine algae from Malaysia III. Seven species of Rhodophyceae. *Botanica Marina* 43: 347-357.
- Terada, R., and Yamamoto, H. 2002. Additional notes on *Gracilaria eucheumatoides* Harvey from Vietnam. p. 225-230. *In*: I.A. Abbott, and K. McDermid (eds.). *Taxonomy of Economic Seaweeds, with reference to some Pacific species volume VIII*, California Sea Grant College Program, University of California, La Jolla.
- Tokuda, H., Ohno, M., and Ogawa, H. 1988. The resources and cultivation of seaweeds, monographs on aquaculture science 10, Midorisyobo, 354 p, Tokyo.
- Trono, G.C. Jr. 1997. Field guide and atlas of the seaweed resources of the Philippines. Bookmark, Makati.
- Tseng, C., and Xia, B. 1999. On the *Gracilaria* in the Western Pacific and the Southeastern Asia region. *Botanica Marina* 42: 209-217.
- Wynne, M.J. 1989. The re-instatement of *Hydropuntia* Montagne (Gracilariaceae, Rhodophyta). *Taxon* 38: 476-479.
- Xia, B. 1985. *Gracilaria* from China: Key, list and distribution of the species. p. 71-76. *In*: I.A. Abbott, and J.N. Norris (eds.). *Taxonomy of Economic Seaweeds, with reference to some Pacific and Caribbean species volume I*, California Sea Grant College Program, University of California, La Jolla.
- Xia, B. 1986. On *Gracilaria salicornia* (C. Agardh) Dawson. *Oceanologica et Limnologica Sinica* 4: 100-106.
- Xia, B., and Abbott, I.A. 1987. New species of *Polycavernosa* Chang and Xia (Gracilariaceae, Rhodophyta) from the western Pacific. *Phycologia* 26: 405-418.
- Yamamoto, H. 1978. Systematic and anatomical study on the genus *Gracilaria* in Japan. *Mem. Fac. Fish. Hokkaido Univ.* 25: 97-152.
- Yamamoto, H., and Noro, T. 1993. *In vitro* life history and spermatangial types of *Gracilaria eucheumoides* (Gracilariaceae, Rhodophyta). *Jpn. J. Phycol.* 41: 131-135.
- Yamamoto, H., Ohno, M., and Nguyen, H.D. 1994. *In vitro* life histories and spermatangial types of two *Gracilaria* species of from Vietnam, *G. heteroclada* and *G. firma*. *Jpn. J. Phycol.* 42: 331-333.
- Yoshida, T. 1998. Marine algae of Japan. Uchidaroukakuho, Tokyo.
- Zhang, J., and Xia, B. 1988. On two new *Gracilaria* (Gigartinales, Rhodophyta) from south China. p. 131-136. *In*: I.A. Abbott (ed.). *Taxonomy of Economic Seaweeds, with reference to some Pacific and Caribbean species volume II*, California Sea Grant College Program, University of California, La Jolla.
- Zhang, J., Xia, B., Wang, Y., and Pan, G. 1995. Additions to the species of *Gracilaria* of China. p. 197-205. *In*: I.A. Abbott (ed.). *Taxonomy of Economic Seaweeds, with reference to some Pacific species volume V*, California Sea Grant College Program, University of California, La Jolla.