

Caulerpa falcifolia Harvey and Bailey (Chlorophyta) from Sibutu Island, Tawi-Tawi, a new record for the marine algal flora of the Philippines

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ABSTRACT.– The marine flora of the Philippines is among the most diverse in the Indo-West Pacific region. Among the most prominent and speciose genera is *Caulerpa*, currently represented by about 50 species, varieties and forms in the country. A beautiful, distinctive species, *Caulerpa falcifolia* Harvey and Bailey, originally described from Tonga, is herein reported as a new additional member to the growing number of *Caulerpa* species recorded from the Philippines. Samples were collected from the littoral zone off Sibutu Island in the province of Tawi-Tawi and are herein described, illustrated and compared with morphologically similar species.

KEY WORDS: green algae, morphology, seaweed, taxonomy

INTRODUCTION

Species of the green algal genus *Caulerpa* are mainly valued as human food in the Philippines. Several varieties of *Caulerpa racemosa* (Forsskål) J. Agardh, *C. lentillifera* J. Agardh and *C. macrodisca* Decaisne are gathered from the wild as food while a limited amount is farmed for the local market (Cordero, 1980; Horstmann, 1978, 1983). The diversity of *Caulerpa* in the Philippines is high. Fourteen species were monographed by Meñez and Calumpong (1982) from the central Philippines while 24 species and numerous subspecific taxa were reported by Silva et al. (1987) from the entire country. The latest national enumeration listed 50 taxa of *Caulerpa* including many varieties and forms (Ang et al., 2013), perhaps among the highest of any country in the world. But

these records certainly need critical re-examination and further study.

The Sulu archipelago on the extreme southwestern corner of the Philippines consists of hundreds of small islands strewn between the main southern Philippine island of Mindanao and the large Malaysian state of Sabah, forming a roughly 400 km island chain running in a southwest to northeast orientation. It is very topographically distinct and situated outside the typhoon belt conferring a distinct advantage for the widespread seaweed farming activities there. Tawi-Tawi is the province at the southwesternmost section of the island chain. Nineteen species of *Caulerpa* have been reported from Tawi-Tawi (Trono 1997; 2004). During one of the collecting trips done recently in Tawi-Tawi, an additional member of *Caulerpa* was found and added to the growing number of species in the region, and which also constituted a new

record for the marine flora of the Philippines. This report describes the morphology of this new element and compares it with closely related species already documented in the Philippines and elsewhere.

MATERIAL AND METHODS

Specimens were collected in the sandy bottom of the shallow subtidal area off the village of Tandubanak, east side of Sibutu Island in Tawi-Tawi ($4^{\circ}47'59.99''\text{N}$, 119°

$28'59.99''\text{E}$, see Fig. 1) on 12 July 2018. Samples were collected by snorkeling or skin diving from waters ca. 4 m deep. Freshly collected samples were photographed to show three dimensionality, then pressed for herbarium specimens (Coppejans et al., 2009). Some portions were preserved in 10% formalin-seawater solution and stored in the dark to retain natural colors. Gross external morphology and morphometric descriptions were provided, and compared with those of similar species. Voucher specimens have been deposited in various herbaria including

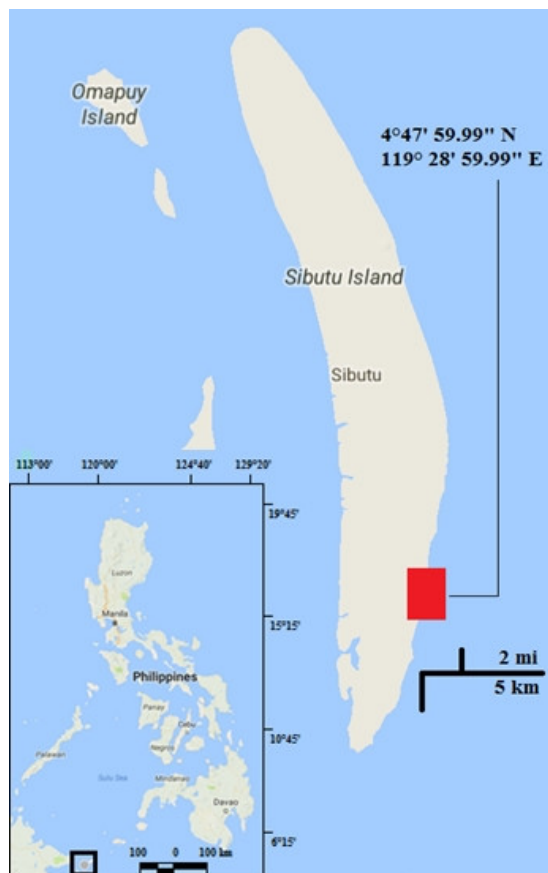


FIGURE 1. Map of Sibutu Island, with exact collecting site (Tandubanak) indicated with square and coordinates.

PNH, CEBU (Thiers, continuously updated) and the Marine Science Museum of the Mindanao State University – Tawi-Tawi College of Technology and Oceanography.

RESULTS AND DISCUSSION

A survey of the species of *Caulerpa* around Tawi-Tawi has added a new element and is described as follows.

Caulerpa falcifolia Harvey and Bailey (Figs. 2A-D)

Plants forming extensive mats on the sandy bottom (Fig. 2A), growing along with seagrasses and other *Caulerpa* species at ca. 4 m deep. Plants anchored to substrate by stoloniferous structures (Fig. 2B) which are

buried under ca. 1 cm of sandy substrate, branched a few times, terete, smooth, to 1.5 mm in diameter, issuing slender rhizoids downwards, to 0.8 mm in diameter, gradually tapering into fibrous tips. Branches are upright, about 5-8 cm high, often spaced apart in irregular intervals, usually unbranched, main axis beset with ramuli throughout, the basal section (1-2 mm from stolon) often bare (Fig. 2D). Ramuli flattened, upcurved, to 4.0 mm long, 0.7-0.9 mm in diameter at the distal 2/3, becoming acuminate distally, bases with faint constriction at point of connection with main axis, radially arranged, commonly forming 3-4 rows along the main axis, sometimes 6-8 rows in more mature samples (Fig. 2C), at times bilaterally arranged, rarely overlapping.

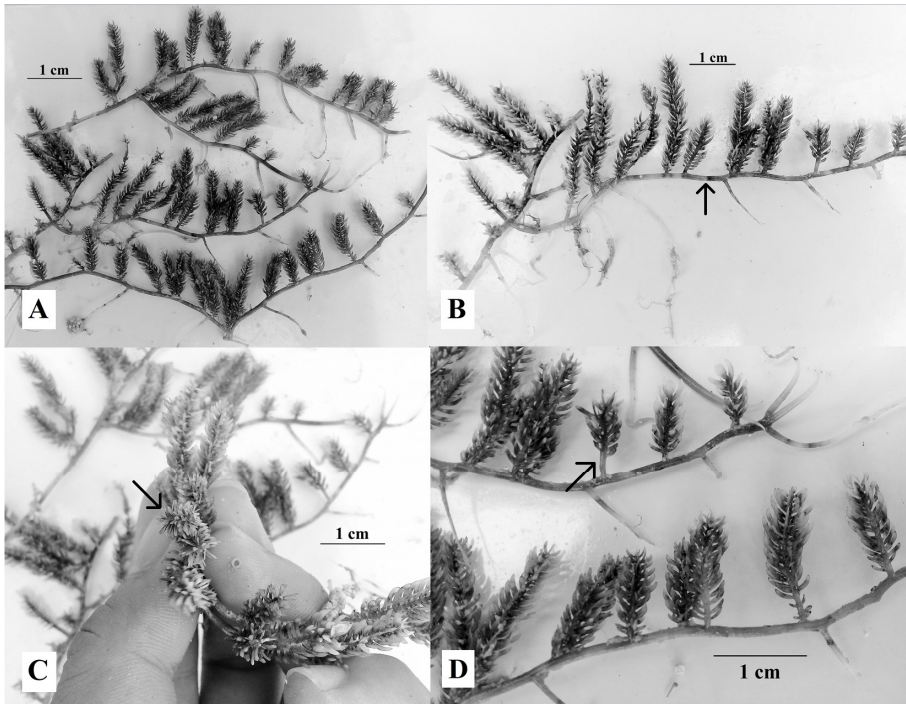


FIGURE 2. *Caulerpa falcifolia*, (A) Habit of several plants showing distinct horizontal stolon issuing upright branches and downward growing rhizoids (B) Close-up of one plant showing the creeping stolon (arrow) (C) Close-up and top view of several ramuli showing their multi-ranked arrangement (arrow) (D) Close-up detail of naked base of upright branch (arrow)

Specimens examined: AAT0287(1-3), intertidal area off Tandubanak village, Sibutu municipality, Sibutu island, Tawi-Tawi province, Philippines, 12 July 2018 [three herbarium sheets deposited in PNH, CEBU and the Marine Science Museum of the Mindanao State University – Tawi-Tawi College of Technology and Oceanography, Sanga-Sanga]

At first glance, the specimens brought to mind a closely similar species *Caulerpa reyesii* Meñez & Calumpong (1982) which was first described from Siquijor island in central Philippines which also forms loose and sprawling colonies on the sandy substratum. Ramuli in *C. reyesii* are somehow similar with those of *C. falcifolia* but have obovate, overlapping, clavate and less upcurved branchlets, features absent in our samples. Our samples also resembled *Caulerpa mexicana* var. *pluriseriata* W.R. Taylor (1975) in having flat and radially arranged ramuli but *C. falcifolia* has shorter branchlets and has almost no constrictions at the base of the branchlets being arranged in several rows. Furthermore, the ramuli in the former are stouter, up to 2.0 mm in diameter (Taylor, 1975). The close similarity of *C. reyesii* and *C. mexicana* var. *pluriseriata* was also suggested by Belleza and Liao (2007). It is notable that the latter was documented from three sites in the Philippines, namely Bohol island (Belleza and Liao, 2007), Pangasinan in northern Luzon and in Siquijor, the type locality of the former (Taylor, 1975). In describing *C. reyesii*, however, Meñez and Calumpong (1982) have not compared their samples with those of Taylor's.

The materials on hand have also been associated with *C. taxifolia* (M. Vahl) C. Agardh based on their gross habit and ramuli shape and dimensions, except that in the latter the ramuli are typically bilateral.

Taylor (1975) has, in fact, recognized this unique pluriseriate form as a variety under *C. taxifolia* instead of associating it with *C. mexicana* (Sonder) J. Agardh. Another similarly pluriseriate form from Sri Lanka and India was described as *C. taxifolia* f. *tristichophylla* Svedelius (1906), subsequently recorded again in the Pearl Banks of Sri Lanka by Durairatnam (1961), but which was not recorded in the comprehensive survey of Sri Lankan seaweeds by Coppejans et al. (2009). This form has now been recognized as similar with the materials on hand (Belton et al., 2015). There have been suggestions that *C. mexicana* may be an ecophene of *C. taxifolia* due to some indistinguishable or overlapping morphological characters (Coppejans and Prud'homme van Reine, 1992). Chisholm et al. (1995) observed the transformation of *C. taxifolia* into "mexicana" morphology under culture conditions. Later, a comparative morphological and molecular analysis of representative populations of the two species from the Mediterranean and elsewhere in the North Atlantic has shown that the two are distinct (Olsen et al., 1998). Kazi et al. (2013) also provided additional evidence for the distinct nature of the two species through a multi-gene analysis. Notwithstanding the clear genetic distinction of the two species, morphological overlaps were often observed (Benzie et al., 2000).

Recognizing and according taxonomic ranks to entities displaying multiple variations in ramuli orientation within species of *Caulerpa* is not uncommon. Within the definition of *C. sertularioides* (Gmelin) Howe, for example, there are a number of forms showing ramuli arrangement ranging from the truly bilateral to verticillate (radial) with each one given formal taxonomic distinctions at the subspecific level (Taylor, 1960). There is

evidence that these variations might be environmentally-induced when shifts between bilateral to radial symmetry (and vice versa?) of ramuli were observed under different regimes of light attenuation (Calvert, 1976). In a study involving samples of *C. taxifolia* collected from several sites near Townsville, Australia, Benzie et al. (1997) found comparable allozyme profiles between typical, bilateral forms of *C. taxifolia* from the mainland and a pluriseriate (“multifarious”) form collected from an offshore reef ca. 100 km from the mainland, suggesting the latter to be an ecological variant of *C. taxifolia* without according any formal taxonomic designation.

The question then arises whether or not to recognize the materials at hand at the species level, i.e., *Caulerpa falcifolia* Harvey and Bailey. Guiry et al. (2018) listed this entity as a currently accepted species. Since its first description based on samples from its type locality in Tonga (Friendly Islands) by Harvey and Bailey (1851), it has been recorded in a number of locations such as Indonesia (Atmadja and Prud’homme van Reine, 2014), Vietnam (Hau et al., 2015), northern Australia (Lewis, 1987; Belton et al., 2015), including an obscure record of a sample collected from a home aquarium in New Caledonia (Niel, 1983 as cited by Garrigue and Tsuda, 1988). This particular record was later picked up by Payri (2007). In all of these cited records, only the New Caledonian aquarium record and that from northwestern Australia (Belton, et al., 2015) used the name at the varietal level. The first record from New Caledonia was subsequently recognized at the species level by Garrigue and Tsuda (1988) and by Payri (2007). On one hand, Hau et al. (2015) chose to recognize it at the species level by citing the seminal work of Draisma et al.

(2014) whom they misquoted as advocating the rejection of the varietal status in favor of reinstating the name to the species rank. A quick perusal of the supplemental Table S2 of Draisma et al. (2014) revealed that while *C. falcifolia* is marked as current in Algaebase (accessed by them on September 2013, and by the authors on July 2018), the species was excluded from their list due to its being a synonym of *C. taxifolia* f. *tristichophylla* or being recognized by them at the varietal level. This proposal to recognize the entity as a variety of *C. taxifolia* is not followed in this report for reasons of better taxonomic stability. In many revisionary studies published lately (Belton et al., 2014, 2015; Draisma et al., 2014; Price, 2011) there have been many redefinitions and lumping of species based on thorough morphological and molecular analyses often resulting in the reinstatement of older, available names for these entities.

Plants were found growing sparsely on the sandy substratum about 4 m deep along with the seagrass *Enhalus acoroides* (L.f.) Royle and other *Caulerpa* species like *C. brachypus* Harvey, *C. cupressoides* (Vahl) C. Agardh, *C. sertularioides* and *C. lentillifera*.

Type locality.— Tongataboo, Friendly Islands [*vide* Harvey and Bailey, 1851; present day Tongatapu Island in the Kingdom of Tonga]

Distribution.— Vietnam (Quang Ngai), Indonesia, New Caledonia, Tonga, Australia (Queensland, northern Western Australia), and the Philippines (Tawi-Tawi)

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