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Brown Algal Diversity Along Selected Coastlines of the Jaffna Peninsula and Delft Island, Sri Lanka

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ABSTRACT

Marine algae are important biological resources with considerable ecological and economic significance. Understanding their diversity and distribution is essential for biodiversity conservation and the sustainable utilization of marine resources. However, comprehensive information on the diversity and distribution of marine algae along the northern coastal regions of Sri Lanka has remained limited for more than five decades. Therefore, this study investigated the diversity and distribution of brown algae along selected coastal areas of the Jaffna Peninsula and Delft Island, Sri Lanka. The study was conducted at four sites within the Jaffna Peninsula and three sites on Delft Island. Brown algal communities were surveyed using the transect method, in which 0.5 m x 0.5 m quadrats were placed at uniform intervals along each transect. Three replicate transects were established at each study site. Brown algal species were identified based on their morphological characteristics, and species diversity was assessed using the Shannon-Wiener and Simpson's diversity indices. A total of thirteen brown algal species were identified across the study sites, with significant variations in species diversity observed among locations. The highest diversity was recorded at Site-1 on Delft Island (09°31'19.9" N, 79°43'32.6" E) (Shannon-Wiener index, H=1.90; Simpson's diversity index, 1-D=0.85). Members of the family Sargassaceae were the most dominant brown algae across the majority of the selected sites, *Padina boryana* exhibited the highest relative abundance across three sites. The findings of this study demonstrate the occurrence of diverse brown algal community along the coastal areas of the Jaffna Peninsula and Delft Island. These baseline data provide valuable information for future ecological studies, conservation initiatives, and the sustainable management of marine algal resources in northern Sri Lanka.

Keywords: Algal diversity, Brown algae, Delft Island and Jaffna Peninsula.

1. INTRODUCTION

Seaweeds are marine macroalgae that inhabit coastal and shallow marine environments where sufficient light is available for photosynthesis. They commonly occur in habitats such as mudflats, estuaries, coral reefs, lagoons, and rocky shores, which provide favourable conditions for their sustainable growth [1]. Based on their morphology, biochemical, and pigment characteristics, seaweeds are broadly classified into three major groups: green algae (Chlorophyta), brown algae (Phaeophyta), and red algae (Rhodophyta). From a nutritional perspective, seaweeds are valuable sources of proteins and lipids, dietary fiber and essential minerals [2]. In several Asian countries, various seaweed species have been used as staple ingredients in traditional cuisines for centuries [3]. More recently, numerous bioactive compounds have been isolated and characterized from seaweeds, resulting in their increasing application in the food, cosmetic, and pharmaceutical industries. The chemical

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composition of seaweeds varies considerably depending on species, environmental conditions, seasonal changes, and the time of harvest.

Brown algae are particularly abundant in shallow coastal waters and are often exposed during low tide. This group range from small filamentous form to large and structurally complex seaweeds. Brown algae contain the accessory pigment fucoxanthin, together with various phaeophycean tannins, which contribute to their characteristic brownish coloration [4]. They are recognized as an excellent source of biologically active secondary metabolites. Numerous compounds with diverse bioactivities have been reported from brown algae[5]. Among these, phlorotannins, phytosterols, and polyphenolic compounds have attracted considerable attention.

Sri Lanka, an island nation situated in the northern Indian Ocean, has a coastline extending approximately 1,700 km and supports a rich diversity of marine flora. Numerous seaweed species have been documented from the Northern, Western, and Southern coastal regions of the country [6-8]. Approximately 440 marine algal taxa representing 148 genera have been reported from Sri Lanka [9]. Despite this considerable diversity, detailed investigations of marine algal community along the Northern coastline and its surrounding islands remain limited. Prolonged geopolitical instability in the region over the past several decades has restricted systematic surveys and biodiversity assessments. The most comprehensive studies on marine algae from northern Sri Lanka were conducted by Durairatnam during the 1960s. Consequently, updated information on the diversity and distribution of marine algae in this region is lacking.

Therefore, the present study was undertaken to investigate the diversity and distribution of brown algae along selected coastal areas of the Jaffna Peninsula and Delft Island, Sri Lanka. The findings of this study are expected to provide baseline information for future ecological studies, biodiversity conservation initiatives, and the sustainable utilization of marine algal resources in northern Sri Lanka.

2. MATERIALS AND METHODOLOGY

2.1 Study area

The study was conducted in selected coastal regions of the Jaffna Peninsula and Delft Island, Sri Lanka (Figure 1), The sampling sites were selected based on their accessibility to the seashore to facilitate regular field sampling and monitoring throughout the study period. The sampling sites in the Jaffna Peninsula included Point Pedro (09°49'22.9" N, 80°15'14.4" E), Thondamanaru (09°49'16.3" N, 80°07'47.3" E), Pannai (09°39'16.5" N, 79°59'57.4" E), and Mandaitivu (09°36'40.7" N, 80°00'15.3" E). In Delft Island, three sampling sites were selected: Site 1 (09°31'19.9" N, 79°43'32.6" E), Site 2 (09°29'43.2" N, 79°43'49.9" E), and Site 3 (09°29'50.4" N, 79°39'57.6" E).

2.2 Sampling method

Sampling was conducted following the methodology described by English *et al.* [10]. At each study site, three replicate transects, each measuring 30 m in length, were positioned perpendicular to the shoreline. The transects were positioned parallel to one another and separated by a distance of 50 m. Sampling points were located at 3 m intervals along both sides of each transect. At each sampling point, a 0.5 m x 0.5 m quadrat was placed, and the percentage cover of brown algal species within the quadrat was estimated. Sampling continued at 3 m intervals along the entire 30 m length of each transect. All surveys were conducted within the shallow intertidal zone.

Brown algal species were initially identified in the field using standard identification guides [7,8]. Specimens that could not be confidently identified *in situ* were collected and transported to the laboratory in plastic containers filled with seawater for further examination. Voucher specimens were preserved and deposited in the herbarium of the Department of Botany, Faculty of Science, University of Jaffna, Sri Lanka. The abundance of each brown algal species was determined as the number of individuals per square meter and expressed as a percentage of the total number of brown algal abundance recorded at each site.

2.3 Data analysis

The mean percentage cover of each brown algal species was calculated for each study site. Species diversity was evaluated using the Shannon-Weiner diversity index and Simpson's diversity index. Difference in diversity indices among the study sites were assessed using one-way analysis of variance (ANOVA).

The Shannon–Wiener diversity index was calculated as:

$$H' = \sum_{i=1}^{S} p_i In(p_i)$$

where S is the total number of species and p_i is the proportion of individuals (or percentage cover) belonging to the ith species.

Simpson's diversity index was calculated as:

$$D = 1 - \sum_{i=1}^{S} p_i^2$$

where p_i is the proportional abundance (or percentage cover) of the ith species.

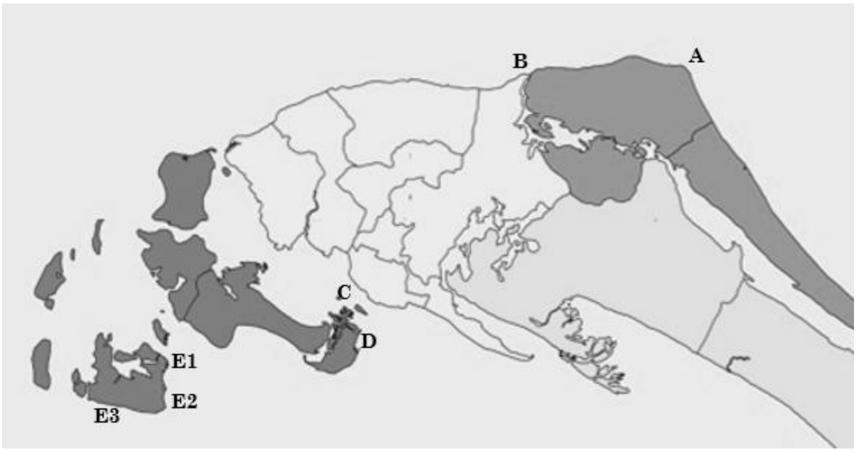

Figure 1. Coastal sites surveyed for brown algal diversity in the Jaffna Peninsula and Delft Island, Sri Lanka. (A) Point Pedro, (B) Thondamanaru, (C) Pannai, (D) Mandaitivu, (E1) Site 1, Delft Island, (E2) Site 2, Delft Island, and (E3) Site 3, Delft Island.

3. RESULTS AND DISCUSSION

A total of thirteen brown algal species belonging to the families Dictyotaceae and Sargassaceae were recorded from the selected coastal sites in the Jaffna Peninsula and Delft Island (Table 1). Members of the family Sargassaceae were the dominant brown algae at all study sites except in Delft Island site-2, where species belonging to Dictyotaceae were comparatively more abundant (Figure 2). The Sargassaceae species identified during the survey were *Sargassum polycystum*, *Sargassum ilicifolium*, *Sargassum swartzii*, *Turbinaria ornata*, *Turbinaria conoides*, *Hormophysa cuneiformis* (Figure 3). In *Sargassum polycystum* C. Agardh (Figure 3a), is characterized by a proliferous thallus with terete primary branches bearing branched spines. The phylloids vary from ovate to oblong and possess an asymmetrical or cuneate base, a distinct midrib that either disappears below the apex or extends to the top, and margins with coarse teeth. Secondary branches bear linear-lanceolate phylloids with asymmetrical bases, whereas the branchlets possess narrowly lanceolate phylloids with dentate margins and an indistinct midrib. Vesicles are stalked and occur singly or in clusters; they are small, spherical to ovate, and may be entire or provided with ear-like wings on both sides, often terminating in a leaflet or mucro. Receptacles are cylindrical or compressed, with toothed margins, and are either simple or forked. They occur in clusters at the bases of the phylloids and vesicles. The alga is attached to the substrate by a discoid holdfast.

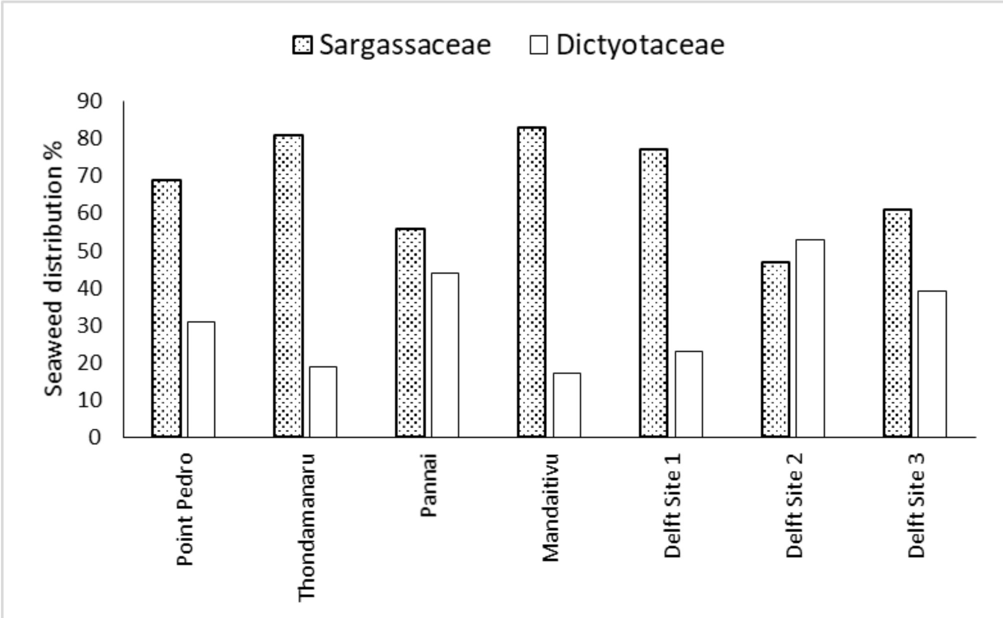

Figure 2. Bar chart showing the distribution of brown algae from the Dictyotaceae and Sargassaceae families across selected sites in the Jaffna Peninsula and Delft Island.

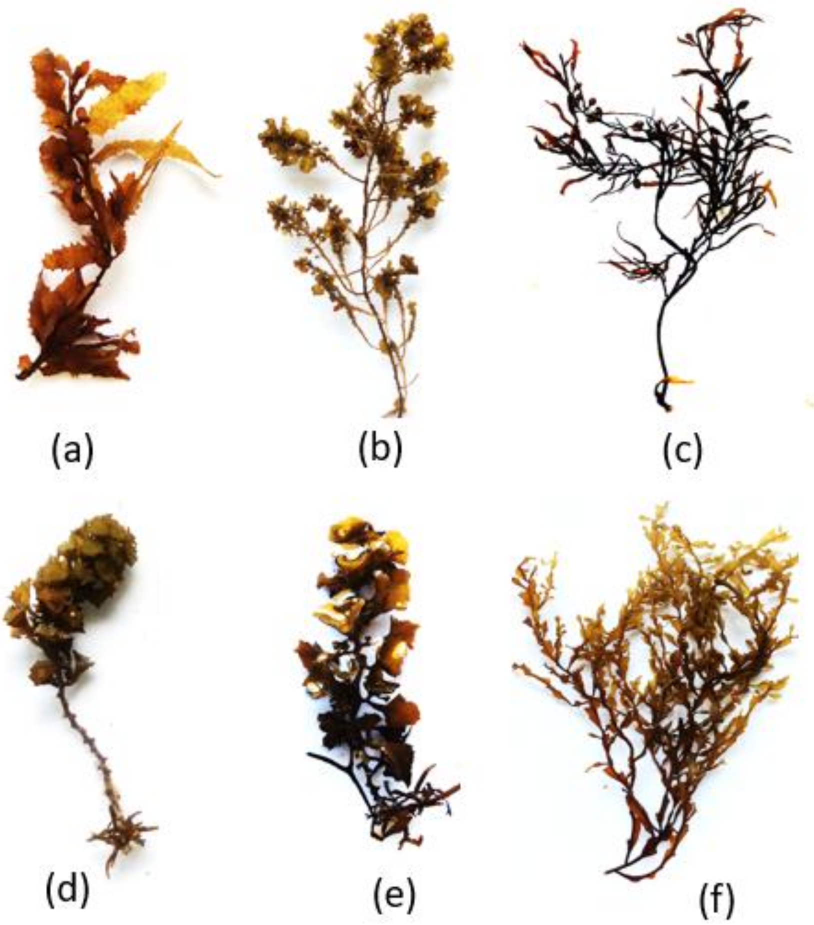

Figure 3. Brown algal species identified in this study from the Sargassaceae family. (a) *Sargassum polycystum*, (b) *Sargassum ilicifolium*, (c) *Sargassum swartzii*, (d) *Turbinaria ornata*, (e) *Turbinaria conoides*, (f) *Hormophysa cuneiformis*.

In the present study, *S. polycystum* was reported from Point Pedro, Pannai, Mandaitivu, and all three sampling sites on Delft Island. This species has previously been reported from several locations in Sri Lanka, including Mandativu, Keerimalai, and Matara [7]. *S. polycystum* has been reported to possess potential prebiotic properties when incorporated into the diets of Asian seabass (*Lates calcarifer*) fingerlings [11]. In addition, extracts of this species have demonstrated *in vitro* inhibitory effects against tyrosinase activity and melanin production, suggesting its potential application as skin-whitening agent in the cosmetics industry [12]. Furthermore, hot-water extracts of *S. polycystum* have been shown to regulate gastric acidity and improve gastric mucosal injury in experimental rats [13].

Table 1. Species list of brown algae in selected regions of Jaffna and Delft Island.

Family	Species	Point Pedro	Thondamanaru	Pannai	Mandaitivu	Delft Site 1	Delft Site 2	Delft Site 3
Dictyotaceae	*Canistrocarpus cervicornis*	+	-	-	-	-	-	-
	Dictyota dichotoma	+	+	-	+	+	+	-
	Lobophora variegata	-	-	-	-	-	+	-
	Padina tetrastromatica	-	+	-	-	-	-	-
	Padina minor	+	-	-	-	-	-	-
	Padina boryana	-	+	+	-	-	+	+
	Stoechospermum marginatum	+	-	-	-	+	-	-
Sargassaceae	*Sargassum polycystum*	+	-	+	+	+	+	+
	Sargassum ilicifolium	+	-	-	-	+	-	-
	Sargassum swartzii	-	-	-	+	-	-	-
	Turbinaria ornata	+	-	-	-	+	+	+
	Turbinaria conoides	-	-	-	-	+	-	-
	Hormophysa cuneiformis	-	+	+	+	+	+	-

In *Sargassum ilicifolium* (Turner) C. Agardh (Figure 3b), is characterized by a tough thallus with a cylindrical, warty main axis bearing several primary branches. Both primary and secondary branches are slightly compressed and exhibit irregular or alternate branching pattern. The branchlets are short and cylindrical. Phylloids on the primary and secondary branches are shortly stalked, oblong-ellipsoidal to lanceolate, with irregularly dentate-serrate margins and a distinct midrib that gradually fades towards the apex. In contrast, the phylloids on the branchlets are small, obovate, and possess an indistinct midrib. Numerous vesicles, which are shortly stalked and range from spherical to obovate in shape, are often provided with ear-like wings. Receptacles occur in racemose clusters within the axils of the phylloids. The alga is attached to the substrate by a discoid holdfast.

In the present study, *S. ilicifolium* was recorded from Point Pedro and Site-1 on Delft Island. This species was previously reported by Durairatnam [7] from Bambalapitiya and the Pearl Banks in the Gulf of Mannar. *S. ilicifolium* has been reported to possess several biological activities of potential therapeutic importance, including anticancer, antimicrobial, anti-inflammatory, and antidiabetic properties. Methanolic extracts of this species have demonstrated significant analgesic and anti-inflammatory activities [14]. Furthermore, *S.*

ilicifolium has shown promising wound-healing potential [15].

In *Sargassum swartzii* C. Agardh (Figure 3c) is characterized by a coarse, bushy thallus. The main axis is cylindrical and smooth, bearing several radially arranged primary branches. These primary branches possess thick, elongate-lanceolate phylloids with an asymmetrical base, a percurrent midrib, margins that are either entire or shallowly dentate, and acute apices. Vesicles are stalked and occur singly or in clusters, with rounded or mucronate apices and a flattened, cuneate stalks. The receptacles are compressed, slightly spinulose at the apices, and forked two to three times. The alga is attached to the substrate by a discoid holdfast. In the present study, *S. swartzii* was recorded from Mandaitivu. This species was previously reported by Durairatnam [7] from Mandativu, Karativu and Jaffna lagoon. Recently, it has been documented from Hikkaduwa [16]. Sulfated polysaccharides isolated from *S. swartzii* have shown anti-inflammatory properties and therapeutic potential against lung inflammation induced by airborne particulate matter [16].

Turbinaria ornata (Turner) J. Agardh (Figure 3d) is characterized by an erect thallus with a coarse, rigid, and leathery texture. The main axes are terete, with sparse and irregular branching. The phylloids are large and stalked, displaying an obpyramidal or turbinate shape when viewed laterally. In apical view, the distal marginal blade appears rounded-triangular, bearing coarse, sharp teeth along the outer margins and often with a concave center partially surrounded by an inner crown of teeth. In lateral view, the phylloids are narrowly triangular, with obtuse, smooth ridges that taper sharply towards the stalk. Large vesicles are embedded within the central portion of the phylloids. The receptacles are racemose and irregularly forked, develop at the base of the phylloid stalk. The alga attached to the substrate by a coarse, discoid holdfast and branched rhizoidal stolons. In the present study, *T. ornata* was recorded from Point Pedro and all three sampling sites on Delft Island. This species has also previously been reported from Galle and Mandativu [7]. *T. ornata* has attracted considerable interest because of its diverse biological activities, including antibacterial [17], anti-coagulant [18] anti-inflammatory[19] antioxidant [20], and anti-proliferative properties [21].

Turbinaria conoides (J. Agardh) Kützing (Figure 3e) is characterized by an erect, coarse, leathery, and bushy thallus that often forms dense colonies. The main axes are terete and muricate in the lower portions, with branches arising in all directions. The phylloids are long-stalked and turbinate, while the distal marginal phylloids are irregularly triangular, rounded, or lobed, and may occasionally be deeply incised on one side. The margins bear sharp teeth with tips that are either flat or concave. The stalk is subterete to slightly triangular, and vesicles are embedded within the central region of the phylloids. The receptacles are forked and occur in clusters at the bases of the phylloid stalks. The alga is attached to the substrate by a discoid holdfast.

In the present study, *T. conoides* was recorded only from Site-1 on Delft Island. Durairatnam (1961) [7] previously reported the occurance of this species from Delft and Pungudutivu. The ethyl acetate fraction of *T. conoides* has demonstrated antibacterial, antioxidant, and anticancer activities, exhibiting synergistic effects when compared with standard compounds [22]. Traditionally, this species has also been used as a fertilizer, insect repellent, and pesticide [23].

Hormophysa cuneiformis (J.F. Gmelin) P.C. Silva (Figure 3f), is characterized by a bushy, caespitose thallus with a terete main axis bearing irregularly arranged branches that extend in all directions. These branches are foliaceous and consist of cylindrical axes with leaf-like wings arranged in two to three planes. The wings exhibit intermittent interruptions, from which new wings or branches may emerge. The upper portions of the wings are truncated and cuneate at the base, with margins bearing large teeth. Oblong or ellipsoidal vesicles develop in the middle of the swollen wings. The alga is attached to the substrate by a discoid holdfast. In the present study, *H. cuneiformis* was recorded from Thondamanaru, Pannai, Mandaitivu and Site-1 and -2 on Delft Island. This species has been reported to contain appreciable levels of phenolic compounds and to exhibit antioxidant and antibacterial activities [24].

The members of family dictyotaceae identified in this study were *Canistrocarpus cervicornis*, *Dictyota dichotoma*, *Lobophora variegata*, *Padina tetrastromatica*, *Padina minor*, *Padina boryana* and *Stoechospermum marginatum* (Figure 4).

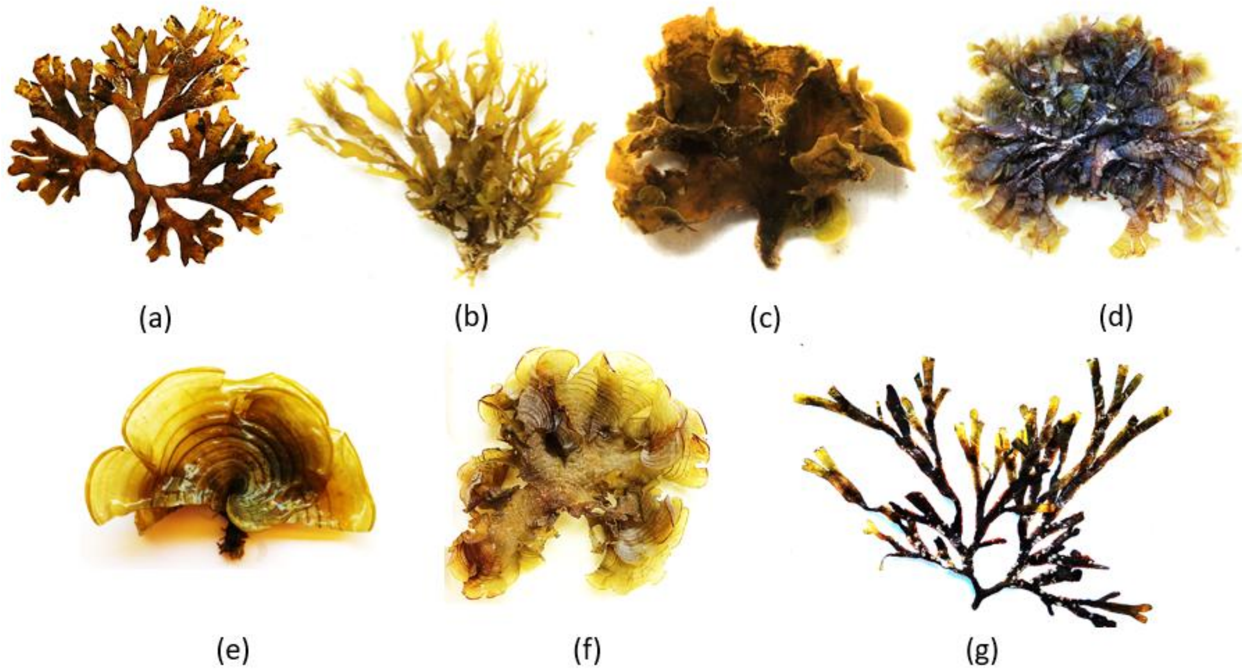

Figure 4. Brown algal species identified in this study, all belonging to the family Dictyotaceae. (a) *Canistrocarpus cervicornis*, (b) *Dictyota dichotoma*, (c) *Lobophora variegata*, (d) *Padina tetrastromatica*, (e) *Padina minor*, (f) *Padina boryana*, (g) *Stoechospermum marginatum*.

Canistrocarpus cervicornis (Kützing) De Paula & De Clerck (Figure 4a) is characterized by bushy, erect thalli with irregular dichotomous branching. The branch apices are rounded to acute, and the angles between branches are broader in the lower portions of the thallus than in the upper regions. The thallus exhibits surface proliferations and marginal growth, and bears multichambered antheridial sori and scattered sporangia. The alga is attached to the substrate in shallow waters by means of a holdfast. In the present study, *C. cervicornis* was recorded from the coastal region of Point Pedro. This species was not reported by Durairatnam (1961) [7] or Coppejans *et al*. (2009) [8] in their surveys of Sri Lankan marine algae. However, Coppejans *et al*. (2009) [8] documented two other species of genus *Canistrocarpus*, namely *C. crispatus* and *C. magneanus*, in Hikkaduwa. The occurrence of *C. cervicornis* in Point Pedro may therefore represent an extension of its known distribution within Sri Lanka. *C. cervicornis* has attracted attention because of its potential pharmaceutical applications. Extracts of this species have antiviral activity against herpes simplex virus type 11[25], antileishmanial activity, and larvicidal action against *Aedes aegypti* [26].

Dictyota dichotoma (Hudson) J.V. Lamouroux (Figure 4b) is characterized by an upright, bushy thallus with strap-shaped branches that exhibit dichotomous branching at angles ranging from 15 to 45 degrees. The branches maintain a nearly uniform width towards their apices and possess proliferous margins along the thallus. Tetrahedrally divided sporangia occur on both surfaces of the thalli, while oval sori bear antheridia and oogonia, with the oogonia being obovate and the antheridia cylindrical in shape. The alga is attached to hard substrates by means of holdfasts. In the present study, *D. dichotoma* was recorded from Point Pedro, Thondamanaru, Mandaitivu and Site-1 and Site-2 on Delft Island. Durairatnam (1961) [7] previously reported this species from Galle, Sri Lanka. Other members of the genus *Dictyota*, including *D. ceylanica*, *D. ciliolate,* and *D. friabilis*, have also been documented from different parts of Sri Lanka [8]. Species of *Dictyota* are known to be rich sources of bioactive phytoconstituents, particularly terpenes, and have been reported to possess antioxidant, antimicrobial, and hypoglycemic properties [27]. Fucoxanthin isolated from *D. dichotoma* has shown anticancer activity against breast cancer cell lines without exhibiting cytotoxic effects on normal cells [28]. Additionally, extracts of *D. dichotoma* have been shown to enhance rice seed germination under salinity stress [29].

In *Lobophora variegata* (J.V. Lamouroux) Womersley ex Oliveira (Figure 4c) features a fan-shaped, reniform thallus that is typically prostrate and found either singly or in clusters. Its arrangement is often irregular, with overlapping, semi-circular marginal lobes that may have entire or occasionally divided margins. Surface hairs are organized in concentric bands. Sporangial sori, which are dispersed over both surfaces, contain club-shaped sporangia, while oogonial sori, also scattered, containing oval oogonia. Numerous rhizoids extend from the lower surface of the thallus, attaching to the substrate via short, moniliform rhizoidal filaments. In the present study, *L. variegata* was recorded from Site-2 on Delft Island. This species was previously reported by Coppejans *et al*. (2009) [8] from Beruwala, Sri Lanka. *L. variegata* has been recognized as a valuable bioindicator species for assessing metal contamination in marine environments [30]. Extracts and fractions of this species have demonstrated potential against protozoal infections caused by *Giardia intestinalis*, *Entamoeba histolytica* and *Trichomonas vaginalis* [31]. Furthermore, extracts of *L. variegata* have been shown to inhibit HIV-1 entry, suggesting that this alga may serve as a promising source of novel HIV-1 inhibitory compounds [32].

Padina tetrastromatica Hauck (Figure 4d) is characterized by a flabellate thallus divided into numerous narrow, overlapping blades that extend almost to the base. The upper portion of the thallus bear smaller blades with inwardly rolled margins, giving the thallus a broad and lightly calcified appearance. Distinct zonation is evident due to the presence of reproductive structures arranged on both sides of narrow rows of hairs, which occur in concentric bands on the lower surface of the blades. The alga is attached to the substrate by a stipose holdfast. In the present study, *P. tetrastromatica* was recorded in Thondamanaru. This species was also reported by Durairatnam [7] from Galle and Jaffna, Sri Lanka. *P. tetrastromatica* has demonstrated anti-herpes simplex virus activity [33], as well as anti-inflammatory and antioxidant properties [34]. In addition, this species has shown anti-hepatitis B virus activity [35].

Padina minor Yamada (Figure 4e) is characterized by a small, flabellate, and infundibular thallus with broadly rounded lobes that are shortly stipitate. The thallus is often divided into fan-shaped blades with inwardly curved margins and exhibits moderate calcification. Tetrasporangial sori are produced without an indusium and are arranged in alternating fertile and sterile zones of equal width. The alga is attached to the substrate by a discoid holdfast. In the present study, *P. minor* was recorded from the coastal regions of Point Pedro. This species has also been reported from other parts of Sri Lanka [8]. *P. minor* has been shown to possess gastroprotective activity in experimental rats [36] and larvicidal activity against *Aedes aegypti* larvae [37]. Additionally, extracts of this species have been reported to enhance the growth and production of soybean plants [38].

Padina boryana Thivy (Figure 4f) is characterized by a fan-shaped thallus with segments that are flattened and elongated on one side. The upper portion of the thallus divides into lobes with smooth margins, while light calcification is restricted to the upper surface. Hairs are arranged in concentric bands on the upper surface, and tetrasporangial sori occur in alternating bands adjacent to the hair bands. Antheridia develop in patches on the ventral surface of the thallus. The alga is attached to the substrate by a discoid holdfast.

In the present study, *P. boryana* was recorded from Thondamanaru, Pannai and Site-2 and -3 on Delft Island. *P. boryana* has demonstrated the ability to inhibit melanin synthesis in melanoma cells and is therefore being explored for potential medicinal and cosmeceutical applications [39]. Sulphated fucoidans isolated from *P. boryana* have been shown to inhibit colony formation in colorectal carcinoma cells without exhibiting cytotoxic effects [40]. Furthermore, extracts of this species have demonstrated broad-spectrum antimicrobial activity [41].

Stoechospermum marginatum (C. Agardh) Kützing (Figure 4g) is characterized by erect, tufted thalli that are linear and ligulate in form. The fronds are flattened and exhibit repeated dichotomous branching. The angles between the branches are broader in the lower portions of the thallus and become progressively narrower towards the upper regions. Sporangial sori are arranged in longitudinal rows along the margins of the fronds. The alga is attached to the substrate by rhizoids arising from the holdfast. In the present study, *S. marginatum* was recorded from Point Pedro and Site-1 on Delft Island. This species was also reported by Durairatnam (1961) [7] from Colpetty and Mandativu, Sri Lanka. *S. marginatum* has attracted attention as a potential natural alternative to synthetic antioxidants and antimicrobial agents used in the pharmaceutical industry [42]. Furthermore, methanolic extracts of this species have demonstrated strong angiosuppressive and antiproliferative activities [43].

Based on the Shannon-Wiener index, Delft Site-1 exhibited the highest species diversity (H=1.90), followed by Point Pedro (H=1.82) and Delft Site-2 (H=1.70) (Table 2). No significant difference in species diversity was observed between Thondamanaru (H=1.33) and Mandaitivu (H=1.36). In contrast, lower diversity values were recorded at Delft Site-3 (1.09) and Pannai (H=1.06). A similar pattern was observed for Simpson's diversity index analysis.

Seven brown algal species were recorded from both Delft Site-1 and Point Pedro, whereas six species were documented from Delft Site-2. Thondamanaru and Mandaitivu each supported four brown algal species, while only three species were recorded from Delft Site-3 and Pannai. At Delft Site-1, *Hormophysa cuneiformis* exhibited the highest relative abundance (20%) (Figure 5), whereas *Padina minor* the dominant species at Point Pedro, accounting for 27% of the total abundance. *Padina boryana* showed the highest relative abundance at Delft Site-3 (39%), Delft Site-2 (25%), and Pannai (44%). In contrast, *Dictyota dichotoma* (38%) and *Sargassum swartzii* (34%) were the most abundant species at Thondamanaru and Mandaitivu, respectively. Although the present study focused exclusively on brown algae, future investigations should aim incorporate green and red algae to provide more comprehensive understanding of marine algal diversity in northern Sri Lanka. Long-term monitoring studies encompassing different seasons were also recommended, as algal diversity and distribution may vary in response to seasonal environmental fluctuations. Furthermore, the documented brown algal species represent potential sources of valuable bioactive compounds. Therefore, future research should explore their chemical composition and evaluate their pharmacological and industrial applications.

Table 2. Shannon-Wiener and Simpson's diversity index values for brown algae recorded at different sites in the Jaffna and Delft coastal regions

Sites	Shannon Wiener index (H)	Simpson's diversity index (1-D)
Point Pedro	1.82	0.83
Thondamanaru	1.33	0.73
Pannai	1.06	0.66
Mandaitivu	1.36	0.75
Delft Site 1	1.90	0.85
Delft Site 2	1.70	0.82
Delft Site 3	1.09	0.68

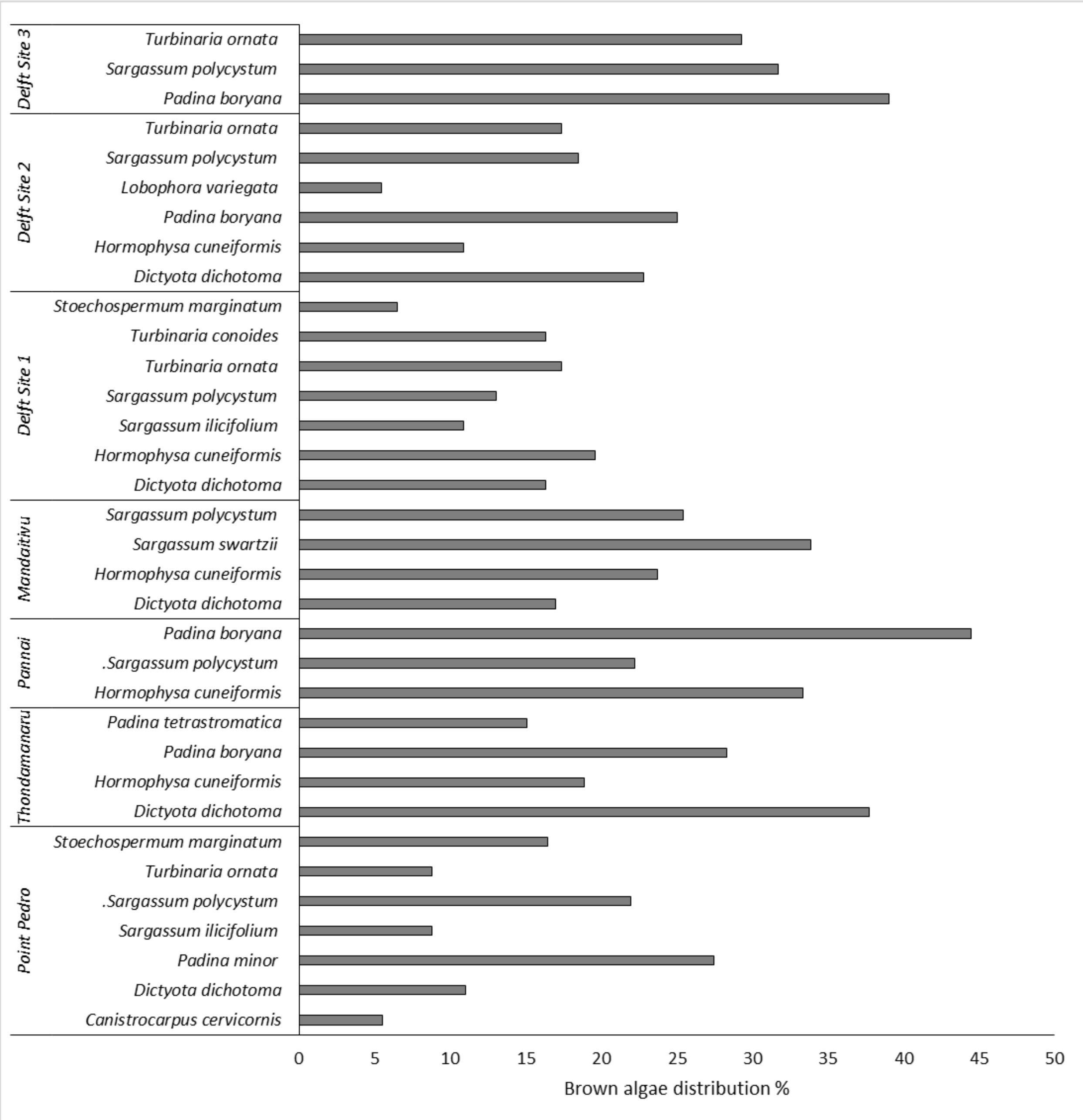

Figure 5. Bar chart showing the distribution of brown algal species across selected sites.

4. CONCLUSION

The present study documented thirteen species of brown algae from selected coastal sites of the Jaffna peninsula and Delft Island, Sri Lanka, including six species belonging to the family Sargassaceae and seven species belonging to the family Dictyotaceae. Among the surveyed loctions, Delft Site-1 and Point Pedro exhibited the highest species diversity, while *P. boryana* was the most abundant species across three of the selected sites. These findings provide an updated baseline on the diversity and distribution of brown algae in northern Sri Lanka and highlight the ecological importance of these coastal habitats. The information generated through this study can support long-term biodiversity monitoring, guide conservation and coastal resource management strategies, and assist in the sustainable utilization of economically valuable brown algal resources. Continued monitoring is recommended to detect changes in species composition associated with environmental change and increasing anthropogenic pressures.

Author's contribution

TCJ- Conception, Data collection, Experimentation, Analysis, Writing and Editing; ECJ- Conception, Design, Data collection, Experimentation, Analysis, Writing and Editing; KM- Analysis, Writing and Editing.

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