Research Article

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Seaweed ethnobotany of eastern Sorsogon, Philippines

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Knowledge on the seaweeds of eastern Sorsogon in the Philippines is uneven. Not only is eastern Sorsogon among the areas of high seaweed diversity but locals there have interacted with seaweeds for ages. Despite seaweeds' assumed importance to Sorsoganon, ethnobotanical records are missing. In this study, we documented the traditional knowledge on seaweed use and determined the rate of knowledge transmission among the locals of eastern Sorsogon. Vernacular names and modes of preparation were given of the 12 identified species bearing culinary and medicinal importance. Ten species were eaten while three were used therapeutically. Based on ethnobotanical indices, *Caulerpa chemnitzia* ecad *turbinata* and *Gelidiella acerosa* were the most important seaweeds. The least cited was *Caulerpa racemosa*. Our study demonstrated that most of the seaweed resources in eastern Sorsogon remain largely untapped, as the identified ethnotaxa were only about 5% of the total seaweed species diversity reported for the area. The seaweed knowledge in eastern Sorsogon appeared to be homogenous across age groups with primary sources of knowledge biased towards female relatives (mothers and grandmothers) and to children as inheritors. Cessation of seaweed knowledge may come at a potential cost, as a significant fraction of the population did not transmit their knowledge to others. Our study furthered the interest in providing sophisticated resource management recommendations that consider the relationships of traditional and scientific knowledge of seaweed selection and use in eastern Sorsogon and beyond.

Keywords: Bulusan; *Caulerpa chemnitzia* ecad *turbinata*; edible seaweed; *Gelidiella acerosa*; medicinal seaweed; Sta. Magdalena

INTRODUCTION

Ethnobotany is the study of traditional knowledge on plant use. Seaweeds have had long and strong associations with humans. Indigenous people have inherited rich traditional knowledge, which contains a valuable history of culture and practices (Balick and Cox 1997). Human gathering of seaweeds has been practiced by

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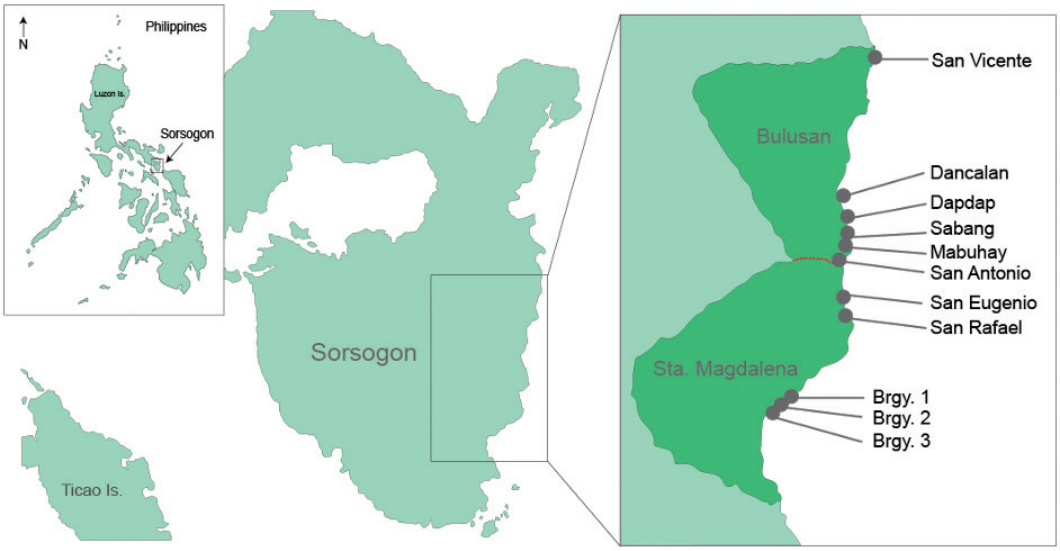

Fig. 1. Map of eastern Sorsogon showing the study sites in Bulusan and Sta. Magdalena.

many coastal communities worldwide. Testaments reflect on the broad-spectrum role of seaweeds on key human histories (Khalilieh and Boulos 2006, Erlandson et al. 2007, Dillehay et al. 2008, Pérez-Lloréns et al. 2020, Mouritsen et al. 2021). Concern, however, has repeatedly been expressed about the rapid loss of seaweed traditional knowledge due to neglect or lack of transmission (Turner 2016, Thurstan et al. 2018). Ethnobotanical studies, therefore, serve to record folk seaweed knowledge before its oblivion from the local communities and the scientific purview.

Sorsogon is the southeasternmost province on Luzon Island in the Philippines (Fig. 1). As the province is surrounded by marine waters, locals in Sorsogon largely depend on the sea for their source of food and income. A wide range of marine resources are abundant in the province (Trono 1992, Guanio 1993, Olaño et al. 2009, Nieves et al. 2013, Amano and Mojados 2018). Seaweeds, collectively referred to locally as 'gulaman', are one of the highly sought-after autochthonous marine resources in eastern Sorsogon (Llana 1992, 1994, Nyan 1993, Kraft et al. 1999). While this area is long recognized as home to rich seaweed diversities (Trono 1975, 1976, Kraft et al. 1999, Dumilag et al. 2020), seaweed ethnobotanical knowledge among the locals of eastern Sorsogon has received disproportionate attention. Despite the economic shift in Sorsogon from gleaning to farming seaweeds beginning in the early 1990s (Salayao et al. 1991) until the present (Andriesse and Lee 2021), seaweeds are still gathered today for a variety of purposes such as food and medicinal resources. No study has yet to compile information on seaweeds that have been exploited, and the diversity of applications to which the locals in eastern Sorsogon have put them. Here, we examine the selection and use of seaweeds, and the status of knowledge transmission among the local communities in eastern Sorsogon.

MATERIALS AND METHODS

Knowledge was amassed concerning the seaweed selection and use among local inhabitants collectively referred to as the Bulusanon and Busaiganon from Bulusan (12°45'08" N, 124°08'08" E) and Sta. Magdalena (12°38'56" N, 124°06'30" E), respectively (see map in Fig. 1). Six sites were surveyed in Bulusan namely Dancalan, Dap-Dap, Mabuhay, Sabang, San Antonio and San Vicente (Buhang) while five sites for Sta. Magdalena, including Brgy 1 (San Francisco), Brgy 2 (Mother of Perpetual), Brgy 3 (Del Rosario), San Eugenio (Alig-igan), and San Rafael (Bil-og). Permits to conduct the study were given by various personnel from the local government units of Bulusan and Sta. Magdalena. A separate consent was given by each participant conveying their acceptance verbally after an interviewer clearly explained the goal of the study. Responses were obtained from participants using a combination of questionnaire survey (Supplementary Fig. S1) and semi-structured interviews. The survey form was originally written in English and later translated in Sorsoganon language comprising questions that collect information about demographic profile (age, sex, years of residency, educational attainment, and current

or most recent occupation), local names of seaweeds, mode of food or therapeutic preparation, and history of knowledge transfer. Seaweed species cited during interviews were collected and verified by the interviewees. Voucher specimens were prepared and deposited at the Herbarium Sorsogonense (HS). The overall methodology including seaweed collection and species identification have been explained in Dumilag and Javier (2022). Ethnobotanical indices were measured. The frequency of citation per species was expressed as the sum of informants that cite the use for the species while proportion weight value of each species relative to all other taxa represented by the relative frequency citation or the RFC (Phillips et al. 1994). Calculation of use value (UV) and fidelity level (FL) followed that of Dumilag and Javier (2022). Each response was initially written in printed forms and later transcribed via Google Form. Responses were populated in Microsoft Excel ver. 10.60 and were analysed using Wizard Pro data analysis version 1.9.49 (Evan Miller, Chicago, IL, USA) for descriptive statistics in the form of frequencies and percentages. Knowledge transmissions (KT) were inferred based on the origin and to whom the knowledge was passed onto. To see the association of the number of seaweed selection and age, Pearson Correlation Coefficient analysis was computed. The flow of KT was presented in Sankey plots using SankeyMATIC (http://sankeymatic.com/build/) and were expressed in terms of weighted connections of knowledge transfer among the origin of knowledge, the respondents, and to whom the respondents passed the knowledge onto.

RESULTS

Demographic profile

One hundred forty-five locals participated in this study. The majority of the respondents were female (73.1%) and were native to eastern Sorsogon (86.2%). The mean age was 53 years old with an average year of local residency of 49 years. Most of the participants were married (68.3%), educated at a high school level (52.4%), and had no formal professional occupation (88.6%). Positive answers about the use of seaweed with perceived culinary and medicinal values were 97.9 and 84.8%, respectively. Although only 28.4% of the population constituted seaweed gatherers or vendors as their major livelihood source, an additional 18.2% of the respondents claimed that they also sold seaweeds.

Seaweed selection and use

A total of 12 seaweed species belonging to two phyla (Rhodophyta and Chlorophyta) and 10 genera were reported to be used ethnobotanically (Table 1, Figs 2 & 3). Seaweed used by the locals were valued either for their culinary or medicinal importance, save for *Caulerpa chemnitzia* which had both uses. Ten species were identified as edibles while only three species have perceived medicinal value. The modes of preparation are presented in Table 2. The rhodophytes, *Chondria armata* and *Digenea simplex* (both belong to the family Rhodomelaceae), claimed to have anti-helminthic property, while the chlorophyte *C. chemnitzia* was used to treat goiter. All recorded species were shared by the Bulusanon and Busaignon respondents. While locals that use *Codium* cf. *edule* ('Abalang') were represented by all sites in Sta. Magdalena, only one site (San Vicente) used this species in Bulusan. Eastern Sorsogon seaweed species constituted a unitary (single word), binary (two words) or trinary (three words) term. Each species had one to three vernacular names with etymologies either from a unique (e.g., 'Abalang', 'Binagong', and 'Lato') or derived name (all other vernacular names, see Table 1). Repeating names were recorded for four entities (i.e., 'Lukad-Lukad, 'Pancit-pancitan', 'Rakom-Rakom', and 'Tikog-Tikog'). Several of the derived names had explicit attributions describing the species' morphological appearance (e.g., 'Gulaman na matarom' means spiny seaweeds and 'Burubalete' means *Ficus*-like). Vernacular names may also denote the species' direct use (e.g., 'Gulaman indudulsi' means a seaweed dessert, 'Gulaman inpupurga' means a vermifuge seaweed). The most vended seaweeds were *Gelidiella acerosa* (64.2%) and *C. chemnitzia* (29.9%), which valued at Philippine Peso (PhP) 100–150 per kilo and PhP 10 per heap (US$1 = PhP 53, as of June 2022), respectively. Seaweeds were sold only within the local community. Representative vended seaweeds and products are presented in Fig. 4.

Ethnobotanical indices

Computed values for ethnobotanical indices are summarized in Table 1. Maximum FL (FL = 100%) was expressed by all species except *C. chemnitza*. The highest RFC (88.97%) and UV (1.61) were however obtained for *C. chemnitza*, consistently followed by *Gracilaria gigas* (RFC = 83.45, UV = 0.99) and *Gracilaria* cf. *arcuata* (RFC = 73.79, UV = 0.94), respectively. The least used species is *Caulerpa racemosa* (RFC = 3.45, UV = 0. 04).

Table 1. A list of seaweed ethnotaxa in eastern Sorsogon, Philippines, including local name, taxonomic group, mode of preparation, relative frequency citation (RFC), use value (UV) and percent fidelity index (% FL)

Species	Local name (meaning)	Taxonomic group (phylum, order)	Mode	RFC	UV	% FL
Food seaweed						
Acanthophora spicifera (M. Vahl) Børgesen	Gulaman na matarom (spiny seaweed), Tikog-Tikog (spinous)	Rhodophyta, Ceramiales	2, 3	47.59	0.63	100
Betaphycus gelatinus (Esper) Doty ex P. C. Silva	Kinalingking (camote dipped fries-like), Lukad-Lukad (the dried kernel of coconut used to extract the oil [copra])	Rhodophyta, Gigartinales	1, 2, 3	29.66	0.37	100
Caulerpa chemnitzia ecad. *turbinata* (J. Agardh) Fernández-García & Riosmena-Rodríguez[a]	Lato	Chlorophyta, Bryopsidales	2, 3	88.97	1.61	64.70
Caulerpa racemosa (Forsskål) J. Agardh	Bulagsong (fake)	Chlorophyta, Bryopsidales	2, 3	3.45	0.04	100
Codium cf. *edule* P. C. Silva	Abalang	Chlorophyta, Bryopsidales	1, 2, 3	17.93	0.19	100
Gelidiella acerosa (Forsskål) Feldmann & Hamel	Gulaman indudulsi (a dessert seaweed)	Rhodophyta, Gelidiales	4	72.41	0.82	100
Gracilaria cf. *arcuata* Zanardini	Durudancalan (dancalan tree-like, as in *Calophyllum inophyllum*), Gulaman insusuli [brown] (a seaweed vegetable)	Rhodophyta, Gracilariales	1, 2, 3	73.79	0.94	100
Gracilaria gigas Harvey	Pancit-pancitan (pancit-like, as in the popular noodle dish in the Philippines), Gulaman insusuli [green] (a seaweed vegetable)	Rhodophyta, Gracilariales	1, 2, 3	83.45	0.99	100
Kappaphycopsis cottonii (Weber Bosse) Dumilag & Zuccarello	Binagong, Lukad-Lukad (the dried kernel of coconut used to extract the oil [copra])	Rhodophyta, Gigartinales	1, 2, 3	32.41	0.48	100
Ohelopapa flexilis (Setchell) F. Rousseau, Martin-Lescanne, Payri & L. Le Gall	Barangay (as in the smallest political unit in the Philippines), Burubalete (balete tree-like as in *Ficus* sp.), Rakom-Rakom (packed)	Rhodophyta, Ceramiales	2, 3	13.10	0.15	100
Medicinal seaweed						
Chondria armata (Kützing) Okamura	Gulaman inpupurga (a vermifuge seaweed)	Rhodophyta, Ceramiales	1, 5	84.14	0.84	100
Digenea simplex (Wulfen) C. Agardh	Gulaman inpupurga (a vermifuge seaweed)	Rhodophyta, Ceramiales	1, 5	4.14	0.04	100

1, raw; 2, salad; 3, viand; 4, jellies; 5, decoction (see Table 2).
[a]Also used to treat goiter.

Table 2. Mode and preparation of seaweed ethnotaxa known to Sorsoganon

Mode (local term)	Preparation
Culinary	
Raw (lab-as)	Eaten directly
Salad (kilaw)	Wash and rinse seaweed, squeeze in calamodin or vinegar as desired; may be blanched
Viand (insusuli / ingugulay)	Wash and rinse seaweed, add garlic, onion and salt, coconut milk maybe added; boil, stir and simmer
Jellies (gulaman)	Wash to remove dirt, boil, cool, re-wash with fresh water, drain and sun-dry (or exposed to nighttime air); repeat procedures to achieve dried bone white seaweeds; soak to water, let the seaweed expand, drain; add calamondin extracts to seaweeds soaked in water or with tamarind or *Spondias* leaves (lubas), boil, strain with a cheesecloth while still hot, add sugar and milk, mold as desired, allow to cool, best to refrigerate before serving
Medicinal	
Raw (lab-as)	Remove secondary branches, save the main axis for direct oral ingestion
Decoction (linab'unan)	Wash, blanch with hot water, drink when cooled; calamondin or tamarind or sugar can be added

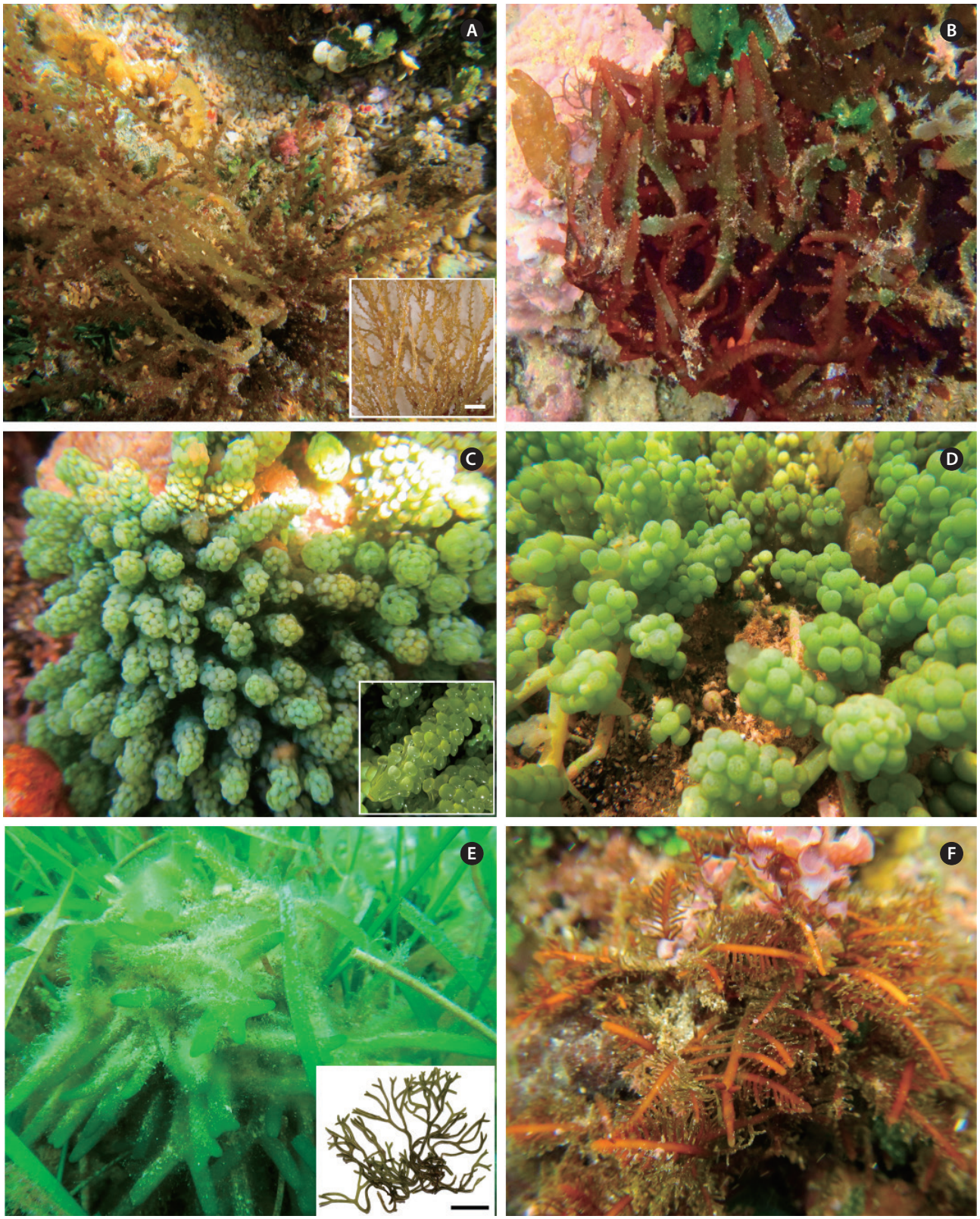

Fig. 2. Underwater habit of seaweed ethnotaxa of eastern Sorsogon. (A) *Acanthophora spicifera* including inset details of its branch. (B) *Betaphycus gelatinus*, (C) *Caulerpa chemnitzia* ecad. *turbinata* including inset details of its ramuli, (D) *Caulerpa racemosa*, (E) *Codium* cf. *edule* including inset detail of its habit. (F) *Gelidiella acerosa*. Scale bars represent: Inset in A, 1 cm; inset in E, 5 cm.

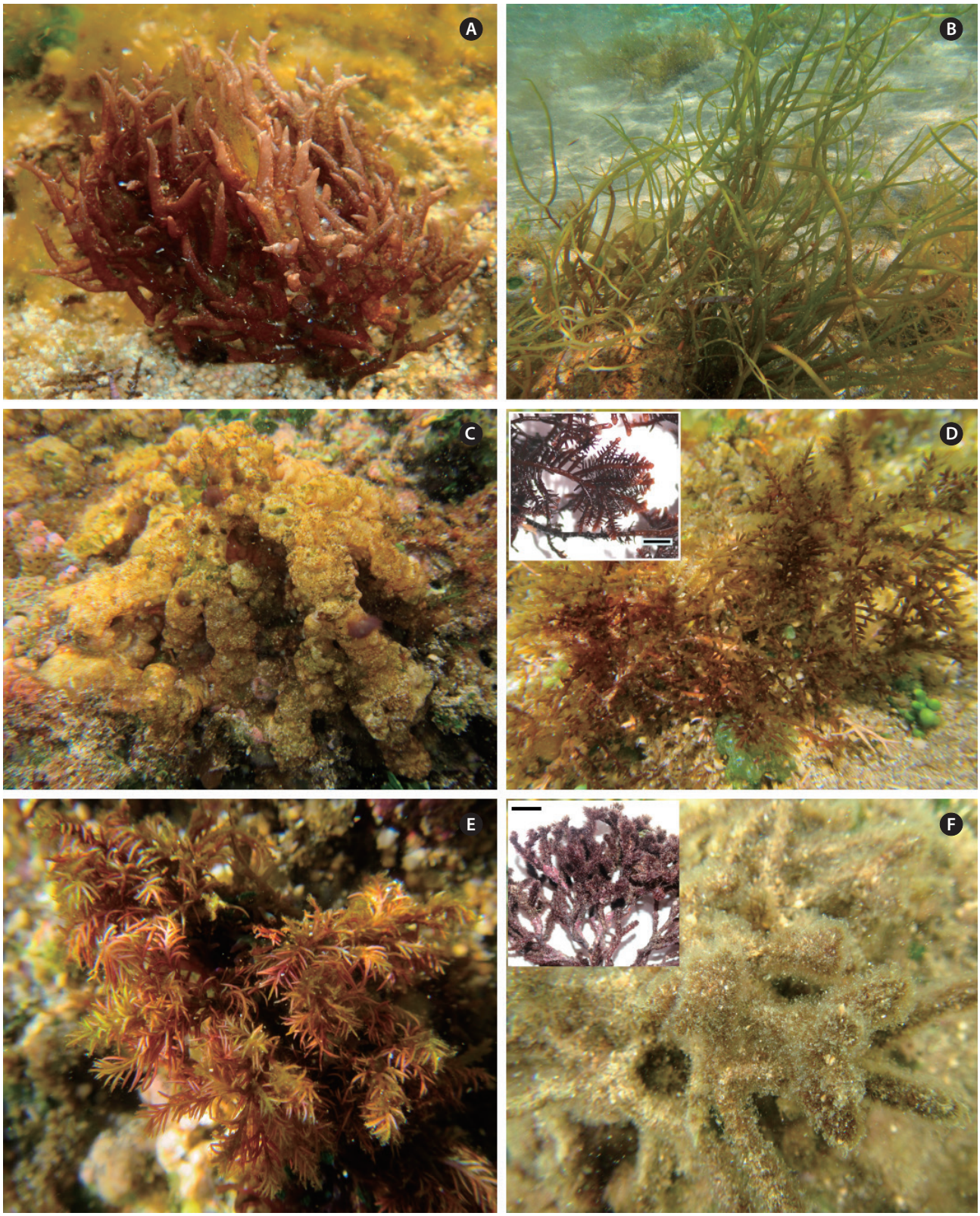

Fig. 3. Underwater habit of seaweed ethnotaxa of eastern Sorsogon. (A) *Gracilaria* cf. *arcuata*, (B) *Gracilaria gigas*, (C) *Kappaphycopsis cottonii*, (D) *Ohelopapa flexilis* including inset details of its branches. (E) *Chondria armata*, (F) *Digenea simplex*, including inset details of its branches. Scale bars represent: Inset in D & F, 1 cm.

Fig. 4. Products of seaweed ethnotaxa of eastern Sorsogon. (A) A gatherer of *Caulerpa chemnitzia* showing his produce. *Sargassum* spp. are used to cover sacks of seaweeds during boat transport. (B) Dried *Gelidiella acerosa*. (C) A locally made jelly iced-candy made from *G. acerosa*.

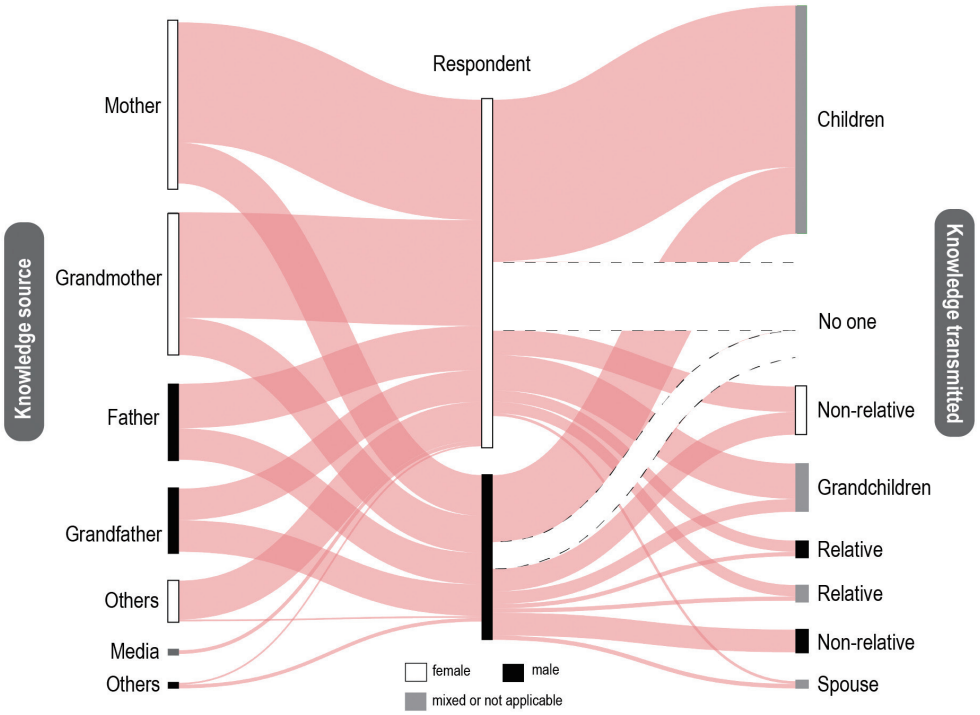

Fig. 5. Rate of transmission of the seaweed traditional knowledge among locals in eastern Sorsogon. The thickness of the lines indicates the relative frequency of knowledge transmission among the source, respondents and to whom the respondents transmitted the knowledge. Sources of knowledge favor female relatives (mothers and grandmothers) and to children as inheritors.

Knowledge transmission

The flow of seaweed knowledge transmission among the locals of eastern Sorsogon is presented in Fig. 5. Although age of the participants and the number of seaweed species (and use) were positively correlated, the relationship between these variables was weak ($r^2 = 0.0003$). True to both gender respondents, knowledge on seaweed use was transmitted primarily from female relatives (mother = 32.5% and grandmother = 28.7%) and passed dominantly onto their children (46%), grandchildren (9.7%) and female non-relatives (9.7%). A total of 19.1% of the respondents did not transmit the seaweed knowledge to anyone.

DISCUSSION

Mounting evidence has shown those seaweeds in eastern Sorsogon are abundant and diverse, yet those that are regarded as ethnotaxa are not documented. Currently, there are about 250 seaweed species recorded for the area (Trono 1975, 1976, Kraft et al. 1999, Dumilag et al. 2020). In this study, only 12 species were identified to have ethnobotanical values. Many seaweeds with various known uses (see Pereira 2016) are also found in eastern Sorsogon however not used by the locals there. Comparative counts indicated that seaweed ethnotaxa represented only about 5% as compared with that of the current estimate of the entire roster of seaweed species reported for the area. This finding indicated that only a few seaweed species are currently tapped by the locals from among the otherwise greater number of available species. The low seaweed ethnotaxa reported in this study cannot be ascertained, although factors on taste preference and degree of perceived usefulness among the locals cannot be ruled out. We found that local seaweed selection in eastern Sorsogon was limited to rhodophytes yielding either carrageenans (*Betaphycus gelatinus, Kappaphycopsis cottonii*) or agars (*Acanthophora spicifera*, *Gelidiella acerosa*, *Gracilaria* spp., *Ohelopapa flexilis*) and to edible siphonous algae (*Caulerpa* spp., *Codium* cf. *edule*). A clear congruity in traditional and scientific knowledge classification of seaweeds was generally not found. It is surprising that despite a long list of edible or medicinal seaweeds known in the Philippines (Pereira 2016, Dumilag and Javier 2022), no phaeophytes were utilized by the locals in eastern Sorsogon. The local term '*Kulapu*' is a collective term for the Sorsoganon Fucales. These include several species of *Sargassum*, *Turbinaria*, and *Hormophysa* that are used as fodder. In one instance, '*Kulapu*' were seen utilized as a cover protecting seaweed harvest during boat transport (Fig. 3A). Future studies on ethnobotany emphasizing the use of fucoids as fodder in eastern Sorsogon is desired. Knowledge on seaweed selection intersected among sites in eastern Sorsogon. *C. chemnitzia* ('Lato') and *Gelidiella acerosa* ('Gulaman indudulsi') appeared to be the most commonly used seaweeds in the area (with high RFC and UV). The popularity of *C. chemnitzia* and *G. acerosa* is driven by a number of factors including, but not limited to, a strong drive towards maintaining local food systems, and sourcing resources for a livelihood. *Gelidiella acerosa* has been historically a valuable seaweed export (Kraft et al. 1999) and its use in jellies (*dulsi*) is found today in Sorsoganon kitchens. The use of *C. chemnitzia* in restaurant settings outside the collecting area was also observed. It is said that if the origin of *C. chemnitzia* is from eastern Sorsogon, its taste quality is better as compared from those collected elsewhere in Sorsogon. This so called "regional image" creates unique identity of the seaweeds collected from eastern Sorsogon. Kraft et al. (1999) also alluded similar notion for eastern Sorsogon's *Betaphycus gelatinus* (as *Betaphycus philippinensis*) as the only source of 'highly prized' beta-carrageenan in the Philippines.

Caulerpa racemosa was the least cited seaweed species among the locals. The local name of *C. racemosa* is '*Bulagsong*', which means fake. This etymological cue points to seaweed preference to the morphologically similar-looking but "real edible" *C. chemnitza*. Many of our respondents knew that *C. racemosa* can be eaten but they prefer to collect and eat *C. chemnitza*. *C. chemnitzia* was said to be less briny and comes in bite-sized pieces, and so easier to chew. One of our respondents also claimed that *C. racemosa* can be poisonous (*nakahudong*). First isolated from a Philippine *Caulerpa* by Aguilar-Santos and Doty (1968), the toxin caulerpin has shown no acute significant toxicity in mice (Vidal et al. 1984). Only in rare cases *C. racemosa* may contain pathogenic bacteria that may cause foodborne disease (Kartika et al. 2021). However consumption of *C. racemosa* has proven safe and can provide multiple benefits to health (Nagappan and Vairappan 2014).

The use of one species, *Codium* cf. *edule* ('*Abalang*'), was limited to San Vicente in Bulusan yet its use is reported from all sites in Sta. Magdalena. As San Vicente is the nearest town of Bulusan to Sta. Magdalena (see Fig. 1). It appeared that knowledge on the local use of *Codium* cf. *edule* was more widespread among Busaiganon than to those of Bulusanon. *Codium edule* is regarded as an ed-

ible seaweed in Japan, Hawaii, and the Philippines (Abbott 1978, 1984, Arasaki and Arasaki 1983, Agngarayngay et al. 2005). Besides being edible, the Philippine *C. edule* has anti-cancer properties (Bayro et al. 2019, Vasquez et al. 2019). Including *C. edule*, six other *Codium* species were reported from eastern Sorsogon (Dumilag et al. 2020). *Codium* materials from eastern Sorsogon may also be tested to diversify seaweed species selection for drug discoveries.

Only three species were identified as having perceived medical value. *Chondria armata* and *Digenea simplex* were used as vermifuge while *C. chemnitzia* as a treatment for goiter. These species consistently had folk claims from elsewhere (Tseng 1935, Tungpalan 1983, Phang 1987, Anggadiredja 2009, Dumilag and Javier 2022) and were also tested scientifically (Kreitmair 1925, Mori et al. 2018, Tapotubun et al. 2020). *Chondria armata* contains domoic acid while kainic acid can be found in *D. simplex*. These compounds are classified as neurotoxin responsible for their anti-helminthic property (Higa and Kuniyoshi 2000). Care should be considered when taking these substances as these are known to be lethal in certain dosages (Wright et al. 1989, Perl et al. 1990). Most of the respondents indicated that the decoction of the alga was still a choice drug, especially when caught short of finances or if commercial medicine is unavailable. Information dissemination would particularly benefit the public on the proper use of these seaweed resources to avoid uncalled-for incidents.

We initially hypothesized that age was a factor in knowledge accumulation, however we found that seaweed knowledge in eastern Sorsogon appeared to be homogenous across all ages. Female relatives (mothers and grandmothers) were the predominant providers of seaweed knowledge while children were favored as the largest beneficiaries. Our finding are consistent with previous studies (Voeks 2007, Teixidor-Toneu et al. 2021). Although seaweed knowledge was conserved and transmitted vertically through family dissemination within families, still, a significant portion of the population withheld what they knew. The adaptive function of culture is said to be dependent on strong knowledge transmission (Berkes et al. 2000). Dissolution of knowledge transmission therefore thwarts the capacity of the locals to entrench preservation of culture at large. What is now needed is a broader promotion of traditional knowledge, to study the information it offers, and to incorporate science-driven data to traditional knowledge. All these efforts aid in collectively crafting appropriate resource management recommendation.

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CONFLICTS OF INTEREST

The authors declare that they have no potential conflicts of interest.

SUPPLEMENTARY MATERIALS

Supplementary Fig. S1. Sample survey form used in this study (https://www.e-algae.org).

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