Body Size, Habitat, and Diet of Freshwater Crabs *Isolapotamon mindanaoense* and *Sundathelphusa miguelito* (Crustacea: Brachyura) in the Municipality of Lake Sebu, South Cotabato, Philippines

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ABSTRACT

Isolapotamon mindanaoense (Rathbun 1904) and *Sundathelphusa miguelito* Mendoza and Sy 2017 have narrow biogeographical distribution and are both regarded as endemic to Mindanao island. They are common and publicly consumed freshwater or semi-terrestrial crabs inhabiting vicinities near the waterfalls of Lake Sebu Municipality, South Cotabato in Mindanao, but both species are scarcely investigated. This study aimed to examine the body size, microhabitat and the feeding ecology of these freshwater crab species. Sex and carapace width and length of individuals were determined from specimens collected by hand at three waterfall sampling sites. Feeding and feeding niche overlap were respectively analyzed using the index of relative importance (IRI) of prey items from individual crab stomachs and the Schoener's R_o index. Food items ingested include fish fragments, insect body parts, fragments of aquatic vascular plants, freshwater algae, sand grains and amorphous materials, and these items were similar between species. However, the larger *I. mindanaoense* appeared to ingest more fish fragments and other animal prey items compared to *S. miguelito* which ingested more amorphous materials that are derived from benthic plants. However, the R_o value of 93% was high, suggesting very similar diet. The two species further partition niches, with *S. miguelito* being smaller in size and inhabiting sand and gravel substrate, while the larger *I. mindanaoense* inhabit areas with big boulders. Hence, the crabs can be categorized as omnivorous and detrivorous, and exhibit feeding and habitat niche partitioning that alleviate possible resource competition between the two species.

Keywords: Mindanao, feeding ecology, IRI, omnivory, niche partitioning, diet

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INTRODUCTION

Primary freshwater crabs are found in the tropics and subtropics and occur in a wide variety of aquatic and terrestrial habitats (Cumberlidge 2016). These decapod crustaceans are present in tree holes and leaf axils and in almost all freshwater bodies (Ng and Ng 2018). A fair number of species are also adapted to live in caves and rice fields (Yeo et al. 2008). Freshwater crabs are primarily nocturnal, preferring to remain hidden during the day in sheltered places and foraging mostly at night (Grinang et al. 2016). They are largely omnivorous scavengers, mainly feeding on plant matter, but some are opportunistic carnivores feeding either on live prey such as fish and prawns or on dead animals that they encounter, and cannibalism is not uncommon (Ng and Tan 1998; Magalhães 2003; Cumberlidge 2016).

Freshwater crabs are one of the most ecologically important macro-invertebrate groups in tropical inland waters worldwide (Rodriguez and Magalhães, 2005; Yeo et al. 2008). Like most freshwater decapod crustaceans, these crabs have very high level of endemicity, require good forest cover (Yeo et al. 2008) and pristine water conditions to survive and are excellent indicators of good water quality (Reynolds et al. 2013). Crabs are never considered to be an important group in trophic webs, and this might be due to lack of knowledge about their trophic roles in aquatic ecosystems (Grinang et al. 2016).

Previous studies have suggested that crabs show selectiveness in food preferences depending on the food's nutritional values, varieties and accessibility (Meziane et al. 2002; Dahdouh-Guebas et al. 2011). Moreover, studies of the feeding ecology of animals contribute to the knowledge of the nutritional requirements of species, interactions with other organisms, and community organization patterns over evolutionary time (Carvalho et al. 2016; Cumberlidge 2016). According to Giddins et al. (1986), crabs prefer decaying leaves to senescent or fresh leaves when given the choice. They also suggested that crabs allow leaves to decompose inside their burrows for many weeks before eating them. During this time, tannins are lost from the leaves through leaching, while nitrogen concentration increases through bacterial action, resulting in higher nutritional content. Another advantage of taking leaves into their burrows is having a safe environment for crabs to eat without fear of predators, tidal inundation, high temperatures and low humidity (Wolcott and O'Connor 1992). As is characteristic of brachyurans, most of the food items were found to be highly crushed into small fragments and hence only those structures that could be identified were relied upon for determining food composition and evaluation (Carvalho et al. 2017).

Futuyma (2005) reported that physical conditions of freshwater crabs (substratum type, salinity, temperature) as well as ecological traits (competitive interactions, predation pressure and feeding behavior) may differ among various environments. All these factors have led to a high degree of endemism in freshwater crabs. One of the key processes driving freshwater crab diversification is allopatric speciation resulting from geographic isolation, relatively low fecundity and poor dispersal abilities (Cumberlidge et al. 2009). These ecological conditions and resources that influence the survival and persistence of species in an ecosystem are within the purview of the ecological niche concept (Holt 2009). An ecological niche of a species is an abstract mapping of population parameters onto multidimensional environmental space, the axes of which are abiotic and biotic factors that influence birth and death rates (Holt 2009). Speciation of freshwater crabs can be linked with niche segregation and diversification (Marijnissen et al. 2008), but the present changing environments and habitat loss can also contribute to niche shifts (Cumberlidge et al. 2009).

The recent discovery of *Sundathelphusa miguelito* adds to the four species of the same genus endemic to Mindanao Island (Mendoza and Sy 2017). Holotypes of the species were collected from Barangay Lake Seloton, Municipality of Lake Sebu, South Cotabato Province. On the other hand, *Isolapotamon mindanaoense* was first described in 1998, adding to the three Mindanao Island endemic species of the same genus (Ng and Tan 1998). The type locality of *I. mindanaoense* was along Tibuan River that empties into Davao Gulf. The ecology and/or biology of both freshwater and/or semi-terrestrial species are poorly studied (Ng and Tan 1998; Esser and Cumberlidge 2008; Cai et al. 2016; Mendoza and Sy 2017).

The ecological role of many tropical freshwater crabs is least understood despite their importance in trophic structures including food chains that can be traced up to human consumption (Yeo et al. 2008; Williner et al. 2014; Cumberlidge et al. 2015). The body of knowledge on the biology and trophic roles of freshwater crabs in aquatic ecosystems is inadequate (Grinang et al. 2016). Information on body size and the feeding ecology of freshwater crabs is crucial for the conservation (Yeo et al. 2016) and aquaculture utilization of species (Pan et al. 2020). Examining the food and feeding habits or diet composition is considered very important in crustacean ecology, biology and evolution (Felgenhauer et al. 1989) and in developing conservation strategies (Yeo et al. 2016; Cumberlidge 2016). This study aimed to quantify the natural diet of the two freshwater crab species through stomach content analyses of freshwater crabs inhabiting Lake Sebu Municipality in the Province of South Cotabato, Mindanao, Philippines.

MATERIALS AND METHODS

Description of Study Area

Specimens were collected in the Municipality of Lake Sebu, South Cotabato, which is located south-central of Mindanao Island, Southern Philippines and lies geographically between 6° 10.45’N and 124° 43.95’E (Figure 1), surrounded by rolling hills and mountains covered with thick rain forest. The municipality has three lakes with Lake Sebu as the biggest. The lake’s shores and the surrounding rainforest are home to the indigenous T’bolis, Tirurays, Ubos and Manobos. The vegetation of Lake Sebu, South Cotabato can be classified into two categories, forest land and cultivated land. The major crops are corn and rice, and the type of soil is sandy loam. There are few extensive wetlands within the province of South Cotabato, the most significant being Lake Sebu. Most of the landscape in the area has been modified for eco-tourism or is utilized for irrigated rice cultivation.

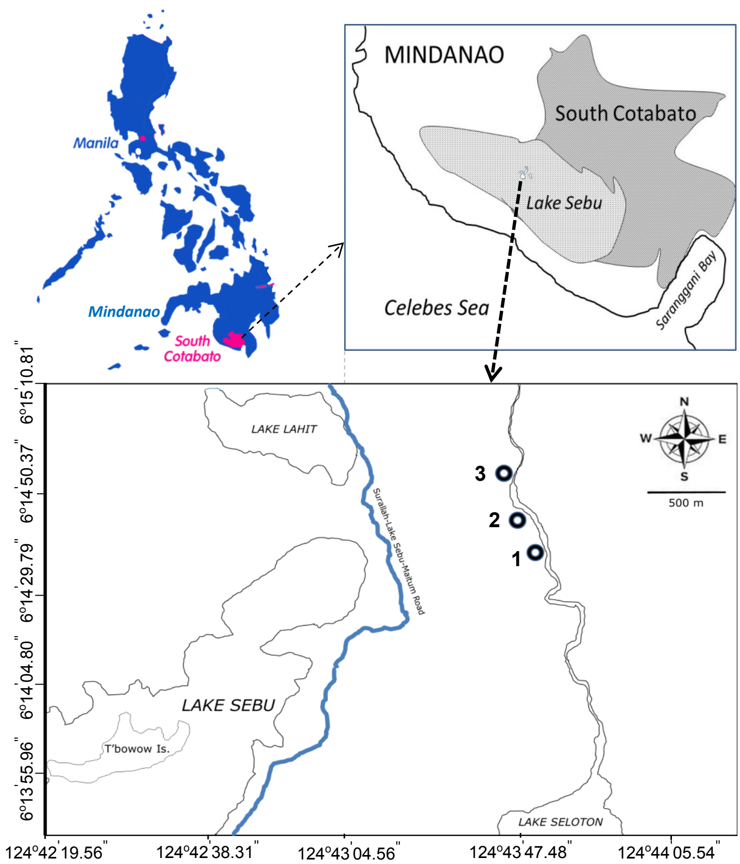

Figure 1. Map of the Philippines showing Lake Sebu and sampling sites (1, 2, and 3) for freshwater crabs.

Sampling Sites

All three sampling sites are located in Barangay Lahit, Lake Sebu (Figure 1). The barangay is located 684 meters above sea level (masl). The vegetation cover in the sampling area includes many fruit trees, overshadow trees, grasses and vegetables. The fruit trees available are palm, citrus and mango. This area has several scenic waterfalls located along the main stream of a river originating from nearby Lake Seloton in the east. Lake Sebu is the source of these waterfalls and their water outflow pass through the nearby agricultural lands, municipalities and barangays. Crabs were collected by hand at the vicinities of Hikong Alo falls (site 1), Hikong Bente falls (site 2), and Hikong B'Lebel falls (site 3). Neither residential nor commercial establishments are found along the river of the falls.

Figure 2. Sampling localities for the two freshwater crab species in Lake Sebu, South Cotabato: (a) Hikong Alo falls, (b) Hikong Bente falls and (c) Hikong B'Lebel falls.

The first waterfall, dubbed Hikong Alo, which literally means passage falls in T'boli is an ecotourism site (part of Lake Sebu's Seven Waterfalls and Zipline Adventure). This site is located 684 meters above sea level (masl) at 6°14' 36.3" and 124°43' 45.4"E (Figure 2A). Located approximately 1.3 kilometers from the main road, this is the widest and most accessible among the seven falls in the area. The river in the waterfalls is relatively shallow and fast flowing with a muddy to rocky substrate.

During the sampling period, the water was muddy and dark because it rained the night before. About 1 m downstream of the area, the river deepens and substrate at this site is silt.

Hikong Bente waterfalls (Figure 2B) is located 659 masl at 6°24' 42.3"N and 124°43' 44.8"E. It is a 70-foot tall waterfall with sheer rock wall standing on its left while a menagerie of shrubs clings on the right wall.

The third waterfall, Hikong B'Lebel (Figure 2C), is situated 714 masl at 6°14' 51.7"N and 124°43' 41.6"E. It was not accessible and required passing through slippery rocks and steep cliffs while clinging to the roots of whatever plants or trees growing in its cliffs. The water was shallow and fast flowing through a rocky to sandy substrate.

The water temperature in sites 1, 2 and 3 were 25°C, 26°C and 26°C, respectively; pH levels in sites 1, 2 and 3 were 4.19, 3.35 and 3.59, respectively; and the respective dissolved oxygen measured in mg per liter were 5.73, 5.6 and 5.69. Moreover, the current velocity were 1.2, 1.42 and 1.28 m/s, respectively. These values are within quality standards according to the Department of Environment and Natural Resources [DENR] (2016) and can support aquatic life.

Collection and Processing of Samples

Information about the freshwater crabs was assessed via face to face interviews across the sampling sites. Calling them "kagang", local communities harvest the crabs for household consumption during the fallow season of farming. The two freshwater crab species, *Isolapotamon mindanaoense* and *Sundathelphusa miguelito,* were found to co-occur under rocks and in burrows along river banks.

The entire sampling period was for three days (10-12 March 2017) with one day spent per site. Samples were collected during the day (0500H-1200H and 1300H-1700H), involving purposive walks of six persons near the plunge area and along the stream bank of the waterfall sampling site. Freshwater crabs were caught by hand in soil burrows, after lifting large stones and checking boulders submerged in shallow, slow-moving sections of the stream. The freshwater crabs were then narcotized and subsequently killed by immersing them in icy water. Fresh coloration of the collected crabs was recorded by photography before preserving them in 95% ethanol. Preserved samples were then immediately (< 2 days) transported to the laboratory as prolonged (10 weeks) storage in alcohol would have influence on carapace width (Rufino et al. 2004) and body weight (Qureshi et al. 2008) of the crab.

In the laboratory, the sex of individual crab was determined. Also measured were the carapace width (CW, the distance across the carapace at its widest point) and carapace length (CL, the distance along the midline, from the frontal to the posterior margin of the carapace) using a Vernier caliper with accuracy of 0.01 mm. Crabs were counted and segregated based on their sex and size. The sex of the crabs was characterized based on the morphology of the abdomen. The pleon (abdomen) in most male crabs is narrow and triangular in form, while females have a broader and rounded abdomen (Lopretto 1976). Collected samples were identified based on the taxonomic key provided by Ng (2004).

Stomach Content Analysis

The diet composition of the freshwater crabs was evaluated through the examination of their stomach contents. The carapace of a crab was removed, and the entire stomach was carefully extracted. The stomach was dorsally cut and spread apart. Stomach content was flushed onto a Petri dish with filtered water, and viewed under a binocular microscope. As suggested by Sukumaran and Neelakantan (1977) each prey item was identified to the lowest possible taxonomic level. Algae were identified based on intact filaments. For vascular plants, presence of fragments of leaves was useful in detecting macrophytic remains. Insects were identified based on fragments of legs and wings. Fish was identified based on undigested fragments of scales, teeth and gills. Amorphous and sand grains were identified as decayed organic matter and fine inorganic particles, respectively.

The feeding ecology of freshwater crabs was analyzed using the index of relative importance (IRI). The IRI is a composite measure that reduces bias in descriptions of animal dietary data (Hart et al. 2002). The percentage number (N%), volume (V%) and frequency occurrence (F%) of different types of food materials were recorded. The percentages of F, V, N and IRI were calculated using the following formulae of Hyslop (1980):

$$\text{Percentage occurrence, F\%} = \frac{\text{The number of stomachs in which a given food item is found}}{\text{Number of stomachs examined}} \times 100$$

$$\text{Percentage numbers, N\%} = \frac{\text{The number of food items found in each stomach}}{\text{Number of total food items in all specimens}} \times 100$$

$$\text{Percentage volume, V \%} = \frac{\text{Volume of one food item found in all specimens}}{\text{The volume of all food items in all specimens}} \times 100$$

$$\text{Index of Relative Importance (IRI)} = \text{F \%} \times (\text{N \%} + \text{V \%})$$

Diet overlap between species among sampling sites was computed using the formula of Schoener (1970): $R_o = 100\ (1 - \Sigma|px_i - py_i|/2)$, where R_o is the overlap index expressed as percentage, and px_i and py_i are the relative importance (ratio of the points) of each food item *i* in the stomachs of predator *x* (*Isolapotamon mindanaoense*) and *y* (*Sundathelphusa miguelito*).

RESULTS AND DISCUSSION

The Two Crab Species

Crab individuals collected from sites 1, 2, and 3, respectively, were 45, 40, and 30 individuals for *Sundathelphusa miguelito* (n = 115; 56 females and 59 males), and 32, 32, and 45 individuals for *Isolapotamon mindanaoense* (n = 109; 48 females and 61 males) (Table 1). *I. mindanaoense* individuals were most common at the highest elevation (Site 3) while *S. miguelito* dominated the two lower elevation sites 1 and 2 (Table 1). The two species are regarded as endemic to Mindanao Island (Ng and Tan 1998; Mendoza and Sy 2017). This is the first account on the demography and ecology of both species in a specific location in the Southern part of Mindanao Island. As in the study of Cai et al. (2016), more males were collected for the freshwater crabs *Parathelphusa reticulata* and *P. maculata*. The disparity in numbers could be related to females having slower growth than males, which is probably a consequence of the different reproductive effort between the sexes (Hartnoll and Gould 1988). But sampling bias and behaviour (Colpo and Negreiros-Fransozo 2016) and the impact of predation and/or harvesting (Cumberlidge 2011; Yeo et al. 2008) may also explain the deviation from the 1:1 female to male sex ratio.

Table 1. Number of individuals of freshwater crabs *Isolapotamon mindanaoense* and *Sundathelphusa miguelito* examined for their diet from the three sampling sites in Lake Sebu, Mindanao, Philippines

Species	Number of Individuals			
	Sampling Sites			
	Site1	Site 2	Site 3	TOTAL
Gecarcinucidae				
Sundathelphusa miguelito	45	40	30	115
Potamidae				
Isolapotamon mindanaoense	32	32	45	109
Total number of individuals	77	72	75	224

Morphological Description

Following Bott (1970) and Ng and Tan (1998), the male abdomen of *I. mindanaoense* is proportionately broader (Figure 3). The larger female specimen possesses a distinctly higher and more convex carapace, and the dactylus of the last ambulatory leg is also proportionately longer. Carapace ovoid, dorsal surface distinctly convex, smooth; anterolateral regions without granules.

According to Mendoza and Sy (2017), the live coloration of the carapace of *Sundathelphusa miguelito* ranges from pale yellow to pale brown (Figure 4). Legs and ventral surface of the body are lighter in color on all specimens. Male pleon (Figure 4D) inverted T-shaped, relatively broad for the genus; dorsal surface gently convex longitudinally.

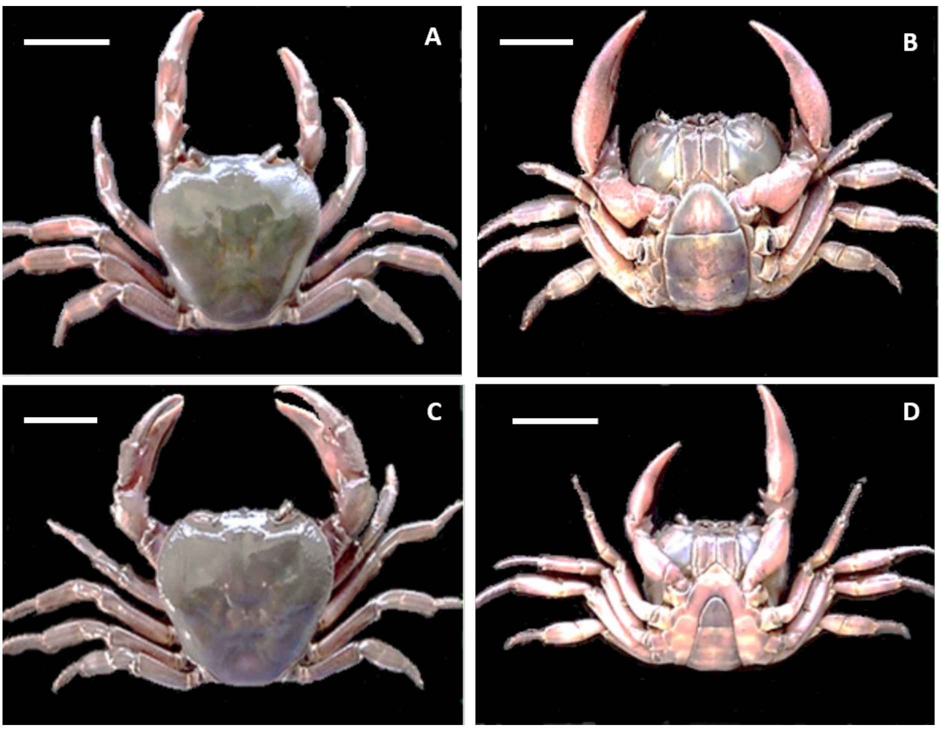

Figure 3. *Isolapotamon mindanaoense* female dorsal and ventral view (A & B) and male dorsal and ventral view (C & D). Scale bar =20 mm.

Figure 4. *Sundathelphusa miguelito* dorsal and frontal view of female crab (A & B) and male dorsal and ventral view (C & D). Scale bar = 20 mm.

Body Size and Distribution

Both species were found in all sampling sites with individuals normally associated with burrows. A total of 224 individual specimens were collected with sizes ranging between 21-13 mm CL and 26.5-16 mm CW for *S. miguelito*, and 41-12 mm CL and 46-20 mm CW for *I. mindanaoense*. Carapace width values regressed ($r2$ = 0.95, $p< 0.05$) with carapace length values of males and females of both species clearly show smaller *S. miguelito* individuals as against those of *I. mindanaoense* with an overlap of large size *S. miguelito* female crabs and the smaller *I. mindanaoense* individuals (Figure 5).

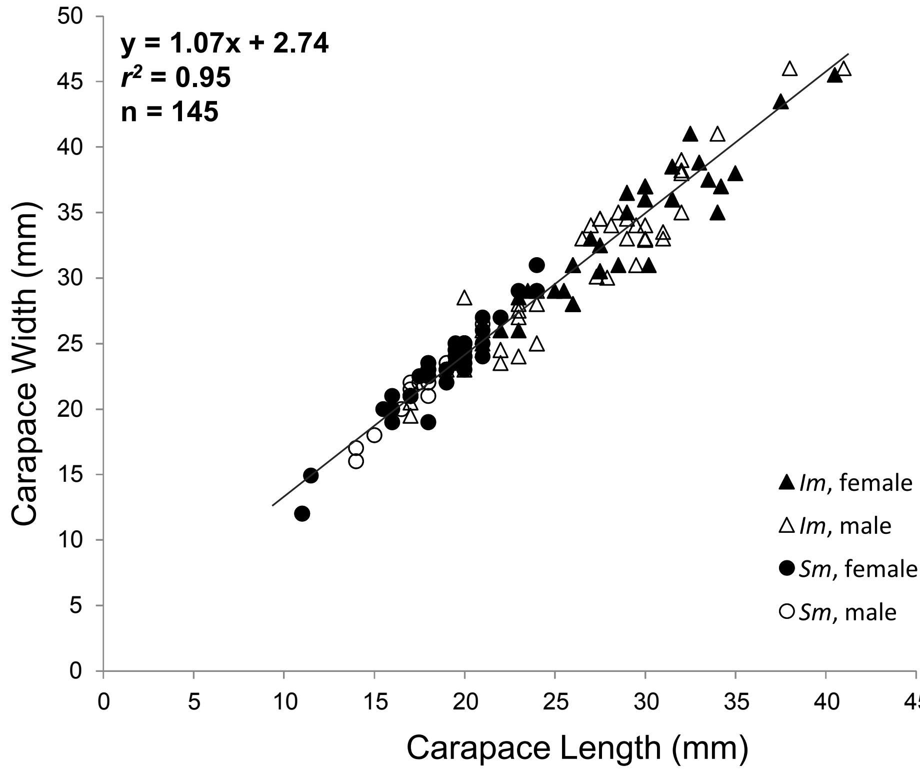

Figure 5. Carapace width and carapace length scatterplot for females and males of both *Isolapotamon mindanaoense* (Im) and *Sundathelphusa miguelito* (Sm) crabs from South Cotabato, Mindanao.

The distribution of different sizes of male and female individuals of both species showed some degree of overlap (Figure 6). The largest male and female individuals of *I. mindanaoense* were collected at the highest elevation site (site 3), but the distribution of these individuals does not seem to overlap with individuals of *S. miguelito* of both sexes at the same site. Males of *I. mindanaoense* had an overlapping distribution with both sexes of *S. miguelito* at the lowest elevation (site 2). Similarly, at the intermediate elevation (site 1), males of *I. mindanaoense* overlapped with the distribution of *S. miguelito* females, and some small-sized female *I. mindanaoense* overlapped with both sexes of *S. miguelito*. Habitat partitioning was shown with most *S. miguelito* individuals inhabiting sand and gravel substrate, while the larger *I. mindanaoense* inhabit areas with big boulders.

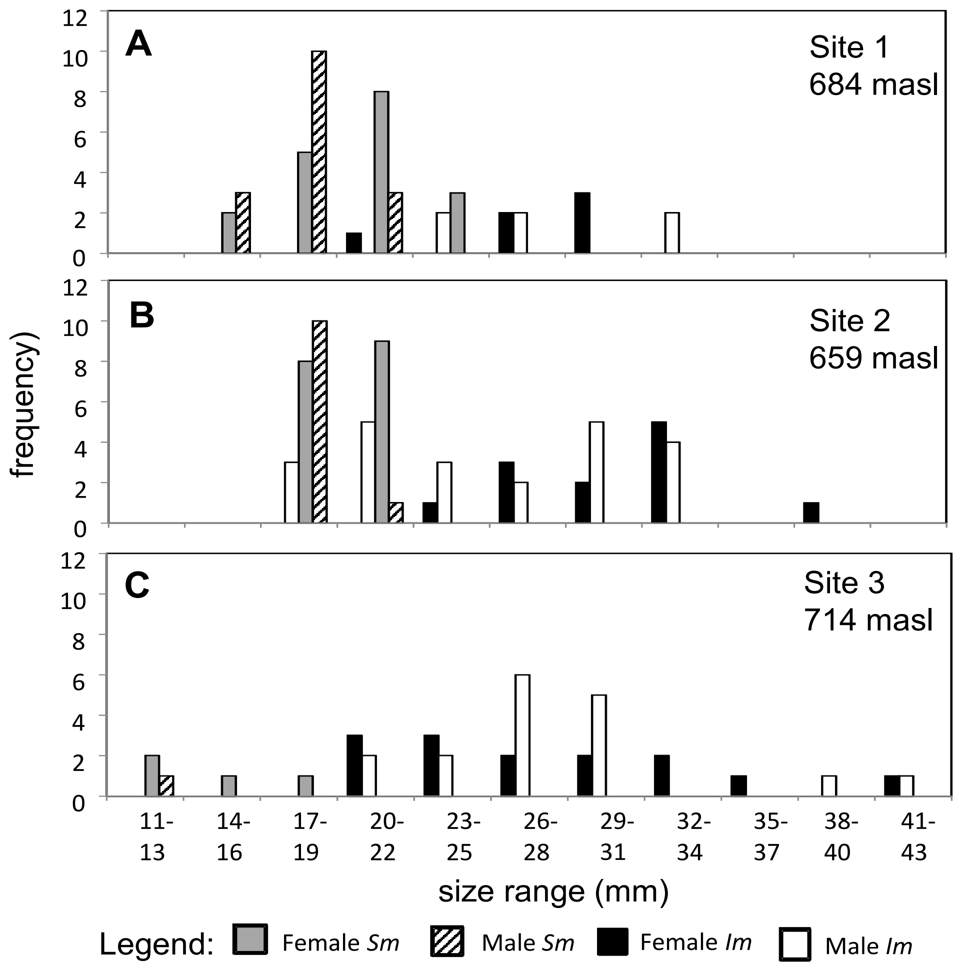

Figure 6. Size-frequency distribution histograms for males and females of both *Isolapotamon mindanaoense* (Im) and *Sundathelphusa miguelito* (Sm) in the three waterfall sampling sites. masl = elevation as meters above sea level.

Body size (Schoener 1970) and spatial distribution (Uzunmehmetoğlu et al. 2019) are good indicators of potential competition among species that belong to the same clade. Similar body size of sympatric crab species may suggest stronger competition as the range of food items would overlap for individuals of these species (Giri and Loy 2008). Smallest individuals of *I. mindanaoense* and the largest individuals of *S. miguelito* would be expected to compete on similar food items as their body sizes strongly overlap, and the overlap seems to be strong at the two lower elevation sites. However, possible competition would be minimized as both species inhabit different microhabitats as mentioned above.

Stomach Content and Feeding Niche Overlap

All 224 collected crab individuals of the two species were dissected for gut content analysis. The food items eaten by the two freshwater crab species showed that their trophic roles in the community are as omnivores and opportunistic predators that link several trophic levels from both aquatic and terrestrial communities. In total, six food categories (Table 2) were identified from foregut contents in *I. mindanaoense* and *S. miguelito*. Different food items were found in the stomach of the freshwater crabs, including fish, insects, plant, algae, sand grains and amorphous. The overall food composition in their gut was similar in both male and female species. However, differences in the trophic activity between juvenile and adult crabs were not observed.

Studies of the feeding ecology of animals contribute to the knowledge of the nutritional requirements of species, interactions with other organisms, and community organization patterns over evolutionary time (Lampert et al. 1992). Freshwater crabs generally emerge from their hideout burrows at night (nocturnal) and forage for food (Yeo et al. 2008). They are primarily omnivorous; generally scavengers but some are primarily vegetarians while other species are able to capture live prey (Grinang et al. 2016).

Table 2. Frequency of occurrence (FO), number (N), volume (V), and the Index of Relative Importance (IRI) of the different stomach food items of freshwater crabs *Isolapotamon mindanaoense* and *Sundathelphusa miguelito*

Food Item	%FO	%N	%V	IRI	% IRI
Isolapotamon mindanaoense					
Fish	37.60	27.60	18.25	1723.96	30.49
Insects	17.60	7.23	9.51	294.62	5.21
Vascular plants	29.50	20.50	20.34	1204.78	21.31
Freshwater algae	21.60	11.56	15.40	498.62	8.82
Sand grains	20.70	11.17	14.64	534.27	9.45
Amorphous	31.92	21.94	21.86	1398.10	24.73
Sundathelphusa miguelito					
Fish	37.50	22.11	32.96	2065.13	24.47
Insects	15.60	9.76	19.26	452.71	5.36

Table 2. Frequency of occurrence (FO), number (N), volume (V), and the Index of Relative Importance (IRI) of the different stomach food items of freshwater crabs *Isolapotamon mindanaoense* and *Sundathelphusa miguelito* (Cont'n.)

Food Item	%FO	%N	%V	IRI	% IRI
Vascular plants	32.50	20.00	39.26	1925.95	22.82
Freshwater algae	20.60	10.73	21.11	655.90	7.77
Sand grains	22.70	11.54	22.96	783.15	9.28
Amorphous	39.70	25.85	38.52	2555.49	30.28

The stomach contents of both crab species appeared to contain highly digested matter and hence identification of food organisms was found difficult. Further, unlike in large-sized crabs, no crustacean or mollusc was found in the stomachs of small-sized crabs possibly due to their less developed chelae, which were not strong enough to crush the exoskeleton of arthropoda as well as molluscs (Sukumaran and Neelakantan 1997; Carvalho et al. 2017). In the stomach of *I. mindanaoense* (Table 2), amorphous materials comprised the bulk of the diet (21.86% volume, 24.73% IRI). Fish fragments (37.6% frequency occurrence, 27.36% number, 30.49% IRI) formed its most important prey and the most abundant ingested prey of the crab species. Insects (5.21% IRI) were the least important prey of the crab. It was observed that there was no variation in food items consumed among crabs with different body sizes and also no variation in ingested food items between male and female crabs.

In percentage frequency of occurrence of prey items, fish was the principal food item in the stomachs of *I. mindanaoense* (37.6%). The percentages of amorphous, plants, algae, and sand grains were the second highest (31.92%, 29.5%, 21.6% and 20.7%, respectively) while insects (17.6%) were found in smaller quantities (Table 2). As for the percentage volume, major prey items in the stomach contents of *I. mindanaoense* were amorphous (21.86%), plants (20.34%), fish (18.25%), algae (15.4%), sand grains (14.64%) and insects (9.51%) (Figure 5). The fish and insects in the stomachs could not be identified to species level due to the crushed and ground food items that occurred during the feeding behavior of the crabs. Ranging from 5.21% to 30.49%, the IRI of the food items in *I. mindanaoense* confirmed the predominance of principal prey items. The highest percentage IRI was for fish fragments (30.49%), whereas the lowest value (5.21%) was for insects (Table 2).

A similar diet has been observed in the freshwater crab *Sundanonautes africanus*. Sodamola et al. (2016) reported that different food items were found in the guts of

S. africanus, irrespective of size, sex and season. They include insects, plant materials, detritus, algae and sand grains. Sand grains in all the guts containing food of both *S. miguelito* and *I. mindanaoense* as the sand grains were probably ingested along with food items during feeding. Sand grains or gastroliths are believed to help macerate food materials in the cardiac stomach of crustaceans (Felgenhauer et al. 1989).

In the stomachs of *S. miguelito* (Table 2), plants composed the bulk of the diet (39.26% volume, 22.82% IRI). Amorphous (39.7% frequency occurrence, 25.85% number, 30.28% IRI) formed its most important prey and the most abundant ingested prey of the crab. Insects (5.36% IRI) were the least important prey of the crab. The percentage volume showed that the major prey items in the stomach contents of *Sundathelphusa* were plants (39.26%), amorphous materials (38.52%), fish (32.96%), sand grains (22.96%), algae (21.11%) and insects (19.26%), respectively. In percentage of frequency of occurrence, amorphous material was the principal food item in the stomachs (39.7%) of *S. miguelito*. The percentages of fish fragments, plant fragments, sand grains, and algae were the next highest (37.5%, 32.5%, 22.7% and 20.6%, respectively). Insects (15.6%) were found in smaller quantities in the stomach of the crabs (Table 2).

Freshwater crabs exhibited various feeding habits with many kinds of food items such as amorphous, fish, insects, plant materials, algae and sand grains. The IRI values of the food items of *S. miguelito* ranged from 5.36% to 30.28%. The highest percentage IRI was observed for amorphous materials (30.28%) whereas the lowest (5.36%) was for insects (Table 2).

A large amount of fish fragments was found in the stomach of the larger *I. mindanaoense* indicating that the animal is capable of ingesting both plant and animal matter along with dead and decaying matter, which points to its omnivorous nature. The large amount of animal matter ingested by the crabs suggest a way to enhance the energy supply derived from less nutritional food (Williner et al. 2014). Presently both small and large crabs were observed to consume algae, insects, fish, plant matter, sand grain and amorphous material.

The large amount of amorphous materials in the stomach of *S. miguelito* may be attributed to the degree of digestion in the macerating cardiac stomach of the crab. The study showed that the animal is capable of ingesting both plant and animal matter along with dead and decaying matter that indicated the omnivorous nature of the animal. This is in agreement with the freshwater crabs *V. litterata* or herring bow crab (Devi et al. 2013), *Maydelliathelphusa masoniana* (Sharma et al.

2016), and *Trichodactylus borellianus* (Carvalho et al. 2017), which were all reported to be omnivores capable of ingesting both animal and plant tissues. This study also revealed that *S. miguelito* is a bottom feeder because examination of its stomach contents showed that the deposit feeding method was more usual. Future studies should attempt to confirm the findings here by investigating the feeding activity of male and female and different-sized (adults and juveniles) *I. mindanaoense* and *S. miguelito*, both daily and seasonally, as well as looking at the feeding morphology of both species.

CONCLUSION

This study provides some baseline information on body size, distribution and feeding habits of endemic freshwater crab species *Isolapotamon mindanaoense* and *Sundathelphusa miguelito*. Body sizes of the specimens collected overlapped among males and females within each species, but habitat partitioning was evident with the large-sized *I. mindanaoense* that were more common in big boulder habitats than the smaller *S. miguelito* which were found in sand and gravel substrates. In this study, the stomach contents of the two freshwater crab species had similar types of food items like insects, sand grains, fishes, algae, plants and amorphous material. However, some differences were observed based on the higher frequency of fish and animal fragments in the stomachs of the larger *I. mindanaoense* than those in *S. miguelito*, which appeared to consume more plant-based amorphous materials and decayed matter. Thus, the crabs under study are omnivorous and detritivorous, considering that they consume plant and decomposed matter as well as animal matter. All kinds of food consumed were readily available, showing that the crabs were not selective in the consumption of available food in the study area.

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