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Density and diet of invasive alien anuran species in a disturbed landscape: A case in the University of the Philippines Mindanao, Davao City, Philippines

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Abstract. *Jabon KJD, Gamalo LED, Responte MA, Abad RG, Gementiza GDC, Achondo MJMM. 2019. Density and diet of invasive alien anuran species in a disturbed landscape: A case in the University of the Philippines Mindanao, Davao City, Philippines. Biodiversitas 20: 2554-2560.* The population density and diet composition of three invasive alien anuran species (IAS) (*Kaloula pulchra, Hoplobatrachus rugulosus*, and *Rhinella marina*), recorded from a disturbed landscape in the University of the Philippines Mindanao campus, were determined in this study. With the total area of 18 km^2 covered, *R. marina* (3.89 ind/km^2) showed to have the highest density followed by *K. pulchra* (0.83 ind/km^2) then *H. rugulosus* (0.056 ind/km^2). Furthermore, 20 samples of *R. marina* and 10 samples *of K. pulchra* were used for gut analysis in which all have stomach contents. Thirteen prey orders were identified in both species with different degrees of prey digestion. The Frequency of Occurrence (FOO) showed orders Spirobolida, Coleoptera, and Hymenoptera were constantly occurring in *R. marina* while only Hymenoptera for *K. pulchra*. On the other hand, Degree of Food Preference showed similarities with Hymenoptera as the most preferred prey in both species, especially for *K. pulchra* (2.8) as compared to *R. marina* (1.8). Accidental occurrence and occasionally preferred food items such as organic and inorganic matter were also present in both species. A notable record of a skink (Reptilia, Scincidae) as prey item was found in *R. marina*, indicative of its generalist and carnivorous diet and its potential impact on the native vertebrate fauna in the area. This study proposes that the occurrence of IAS with regards to their high density and variable prey preferences can be a factor disturbing biological diversity in an altered landscape.

Keywords: Disturbed landscapes, frequency of occurrence, food preference, invasive alien anuran species, population density

INTRODUCTION

Amphibian diversity and endemism in the Philippines are especially high (Diesmos et al. 2002). A total of 110 native taxa of frog species are now recognized in the country, with 85% of the native fauna being the highest estimate of endemism in the Indo-Malayan realm (Brown et al. 2012). In the island of Mindanao alone, there are 40 endemic species of frogs identified in Northeastern Mindanao and adjacent islands (Sanguila et al. 2016). More endemic species are yet to be discovered within the rocky mountain ranges of Mindanao which may offer opportunities for diversification of amphibian species (Alcala and Brown 1998).

During the past decades, the ecology of amphibians started to get attention (Sparling et al. 2000) because of global amphibian population declines (Houlahan et al. 2000). In 2017, International Union for Conservation of Nature Red List of Threatened Species (IUCN) showed that 41% of global amphibians are now threatened with extinction primarily due to habitat loss, pollution, fires, climate change, disease, and overexploitation. In addition, the introduction of non-native species into an ecosystem also poses threat to native species. According to IUCN (2017), invasive alien species (IAS) are the second most common threat associated with extinction of amphibians, reptiles, and mammals.

IAS are non-native small scale and large scale species introduced, accidentally or intentionally, outside of their natural past or present distribution, and can threaten biological diversity with adverse ecological and economic impacts on native fauna (Bruton and Merron 1985). According to Diesmos et al. (2006), there are currently six invasive alien amphibians in the Philippines that have originated from different parts of Asia, America and Caribbean which include *Lithobates catesbeianus* (Shaw 1802) (American Bullfrog), *Kaloula pulchra* (Gray, 1831) (Brown Bullfrog), *Rhinella marina* (Linnaues, 1758) (Cane Toad), *Hylarana erythraea* (Schlegel, 1837) (Green Paddy Frog), *Hoplobatrachus rugulosus* (Wiegmann, 1834) (Chinese Tiger Frog), and *Eleutherodactylus planirostris* (Cope, 1862) (Greenhouse Frog). One common example is the introduction of *R. marina* supposedly to control sugar cane pest in Negros, which became widespread and competes with native frog species such as *Fejervarya raja, Polypedates leucomystax,* and *Kaloula conjuncta negrosis* (Joshi 2011).

These IAS are able to survive on various food types and in a wide range of environmental conditions as they thrive in foreign environments. The feeding behavior of frog species in the wild includes insects and arthropods, having specialized diet on selection of prey with species restricted in forests and man-altered environments (Braga et al. 2012). Comparison of diet in invasive and native populations is necessary to understand dietary requirements, dietary flexibility, and the associated impacts of invasive species (Courant et al. 2017; Bissattini and Vignoli 2017; Bissattini et al. 2018, 2019).

The distribution and feeding ecology of the IAS has been thoroughly linked to changes in the population of local species (Braga et al. 2012). Thus, an assessment on the presence and density of IAS in an altered habitat such as the University of the Philippines (UP) Mindanao campus is important in determining the status of the ecosystem. Knowledge on their feeding preference is also essential in understanding the ecology of these non-native species and for linking their effects to the native fauna. Moreover, the information gathered in this study could be used in managing IAS to further protect and conserve local species. This study was conducted to determine the presence and assess the feeding ecology of invasive alien anuran species in UP Mindanao campus.

MATERIALS AND METHODS

Time and place of study

The samples of this study were collected within the vicinity of the University of Philippines Mindanao (UP Mindanao) Campus, Mintal, Tugbok District, Davao City, Philippines (Figure 1). Sampling sites include (i) grassland and open areas with high anthropogenic activity; (ii) within patches of woodland and bushlands; and (iii) within human settlements. Three transects were established in Site 1, four transects for Site 2, and two transects for Site 3. Sampling was conducted from 6:00 PM to 11:00 PM or when anuran activity is high on February 9-11 and December 18-20, 2018 for Site 1, February 16-18, 2018 for Site 2, and March 24-25, 2018 for Site 3. A total of at least 140 man-hours were spent throughout the entire sampling period. Samples were separated according to areas of collection and processed for further identification.

Sampling collection

Prior Informed Consents (PICs) were requested from the Local Government Units of Mintal and a Gratuitous Permit from the Department of Environment and Natural Resources (DENR) Region XI were secured prior to sampling.

A modified belt transect survey by Heyer et al. (1994) was employed for the collection of samples. Two-hundred meter transect of ten meters wide was established per identified sampling site on the campus. Within the established transects, cruising method was employed for the collection of anurans. This method involved one or more people foraging along a linear route (Ibanez et al. 2004). General information such as date, place and time of capture was taken to label the samples. All collected anurans were placed in plastic bags with sufficient amount of air to avoid suffocation. Samples were separated according to areas being collected and were brought to the campsite for further processing and identification.

Figure 1. Map of University of the Philippines-Mindanao Campus showing Sites 1, 2, and 3 (red, black, and white respectively) consisting of transects wherein the specimens were taken (Lifted from Google Maps, 2017)

Data processing and identification

All collected samples were processed immediately to minimize stress. Necessary morphometric measurements were measured using a caliper and/or a ruler. Identification of specimens was done by measuring snout-vent length (SVL), taken from the tip of the nose to the opening of cloaca at tail base, and conducting ocular observation on the morphological features of the anurans, which include the body top pattern, body top color, toe disc, and presence of warts. These data were recorded and compared to the published field guide of amphibians and reptiles by Alcala (1986). The identified non-invasive alien species were released back to their habitat. Meanwhile, a maximum number of twenty (20) samples per invasive alien species were sacrificed for gut analysis. This was done to completely assess their diet including the intestinal content of the analyzed species (Schoener 1989; Macale et al. 2008).

Gut analysis

Identified invasive alien frog species were sacrificed first through double pithing. Scalpels and forceps were used as each sample were laid down on a dissecting tray with pins held down on its sides. The gastrointestinal tract from the stomach to the intestine was removed and stored with 70% ethanol for preservation in separate plastic containers that were properly sealed.

To obtain the gut contents from the collected samples, the stomach was sliced open using sharp blades and scalpel until all contents were easily collected. Microscopy, using a dissecting microscope, was conducted to analyze the gut composition. Food items were classified as animal prey (insects, vertebrates, arachnids, etc.), plant matter or other (inorganic matter, carrion, and other discarded items). For animal prey, identification was at least up to order level.

Data analysis

Population density was calculated for each site wherein the total area of the study site amounted from the sum of all transect area per site. Population density of species was calculated using:

$$Density = \frac{N_i}{A}$$

Where,
N_i : total number of individuals per species
A : total area (km^2) of the study site covered

The Frequency of Occurrence (FOO) was used to classify the rate of different food groups that appeared per stomach and was used to evaluate how frequent the food group in each stomach with content analyzed. FOO is formulated as:

$$FOO = \frac{Number\ of\ stomach\ an\ item\ appeared}{Total\ number\ of\ stomach\ with\ content} X100$$

A food group was classified as constant (> 50% total stomachs per species), secondary (25-50% total stomachs per species), or accidental (< 25% total stomachs per species).

To infer about the consumption of particular food item from the counted gut components, the degree of food preference (DFP) index developed by Braga (1999) was implemented. Food was ranked by the categories from 1 to 4 in the following way: the maximum value (4) was assigned only when one food group was present in the stomach. If more than one group was obtained, the value “3” was given to the most abundant, “2” to secondary and “1” to occasional occurrence of the groups. Abundance was estimated by the number of prey items of each category in each stomach. Food groups were then categorized as highly preferential (3< DFP < 4), preferential (2 < DFP < 3), secondary (1 < DFP < 2) or occasional (0 < DFP < 1).

DFP was calculated as:

$$DFP = \frac{S_i}{N}$$

Where,
S_i : sum of values given to a food group i in the guts
N : total number of guts of each species analyzed

RESULTS AND DISCUSSION

Species composition of anurans in the study area

During the entire sampling of areas in the University of the Philippines-Mindanao, we collected and observed 111 individuals belonging to seven species of amphibians. The anuran species consisted of *Kaloula pulchra* (Gray, 1831) (16), *Fejervarya raja* (Smith, 1930) (9), *Limnonectes leytensis* (Boettger, 1893) (1) *Polypedates leucomystax* (Gravenhorst, 1829) (9), *Rhinella marina* (Linnaeus, 1758) (70), *Kalophrynus pleurostigma* (Tschudi, 1838) (5), and *Hoplobatrachus rugulosus* (Wiegmann, 1834) (1). Four of the species recorded were endemic to several Southeast Asian countries including the Philippines namely *Fejervarya raja, Limnonectes leytensis, Polypedates leucomystax* and *Kalophrynus pleurostigma*. Among the seven species of anurans collected, only three (43%) species were classified as IAS according to their natural distribution from other countries as recorded by the International Union for Conservation of Nature (IUCN) Red List (Table 1).

The kind of ecosystem the study area might explain the low species richness of anurans dominated by IAS in terms of number of individuals. The campus is within a heavily disturbed area surrounded by agricultural areas, human communities, and built-up structures, which limits the existence of other species. Many studies have reported that urbanization decreases anuran diversity favoring non-native species (Knutson et al. 1999; McNeeley 2001; Gagné and Fahrig 2007; McKinney 2008).

Table 1. Invasive alien anuran species collected in the study area and their natural distribution (IUCN 2017)

Species	Family	Common name	Native range
Hoplobatrachus rugulosus	Dicroglossidae	Chinese tiger frog; East Asian bullfrog; Taiwanese frog	Cambodia; China; Hong Kong; Lao People's Democratic Republic; Macao; Myanmar; Taiwan, Province of China; Thailand; Vietnam.
Kaloula pulchra	Microhylidae	Brown bullfrog; banded bullfrog; Asian painted frog	Bangladesh; Cambodia; China; Hong Kong; India; Indonesia; Lao People's Democratic Republic; Macao; Malaysia; Myanmar; Singapore; Thailand; Vietnam.
Rhinella marina	Bufonidae	Cane toad; marine toad	South America ;Argentina; Bolivia; Brazil; Ecuador; Colombia; Paraguay; Venezuela; the Guianas; Peru; Trinidad and Tobago; Central America; Mexico

Currently, there are six invasive alien amphibian species in the Philippines (Diesmos et al. 2006; Joshi 2011). Local records in Mindanao stated the occurrence of these IAS with their introduction in different areas of the country. Confirmed sightings of *R. marina* in Mindanao (Alcala and Brown 1998), *K. pulchra* in Panabo City, Davao del Norte (Sy 2013), and *H. rugulosus* in Tacurong, Sultan Kudarat Province, Calinan, Davao City, Bukidnon, and Agusan del Sur (Diesmos et al. 2006; Peralta et al. 2015; Sularte et al. 2015) could explain the manifestation of the present species in the study area and how these species thrived throughout Mindanao.

Hoplobatrachus rugulosus

In encountering this species, its large size, prominent dark spots and green coloration were observed. However, failure to capture this species was attributed to its alert behavior, which tends to flee against human presence. The Chinese tiger frog, *H. rugulosus*, belongs to the Dicroglossidae family. Natural habitats of these species include freshwater marshes, intermittent freshwater marshes, arable land, pastureland, rural gardens, urban areas, ponds, aquaculture ponds, open excavations, irrigated land, seasonally flooded agricultural land, and canals and ditches (Diesmos et al. 2006). Lin and Ji (2005) collected tiger frogs from Eastern China and determined its insectivorous diet with the presence of some invertebrates as prey.

Kaloula pulchra

During the sampling period, this species was moderately difficult to record because of i their small size and its dark coloration blended well in their cryptic microhabitats. These microhabitats include grassland cover, crevices, and other places with minimal amount of light. SVL of all 15 recorded individuals were recorded bearing a mean value of 55.3 ± 9.60 mm. The banded bullfrog, *K. pulchr*a, is a frog from the Microhylidae family. This species thrives in disturbed habitats including flooded grasslands, roadside puddles and hidden areas like burrows, holes, or crevices in trees and buildings (Diesmos et al. 2006). These species voraciously prey on flies, crickets, moths, grasshoppers, earthworms and more (Kuangyang et al. 2004).

Rhinella marina

This species has dark green coloration, warty skin, and frequently in immobile state, when observed in the sampling sites. This species usually blended well in the presence of leaf litter and other vegetation areas even in times of disturbance. However, most individuals were also found in anthropogenic areas like buildings and roads, living in groups, increasing their likability to be detected throughout the sampling period. SVL of each individual was measured which was calculated to have a mean of 97.33 ± 23.07 mm. Cane toads, *R. marina,* are members of the family Bufonidae. These toads are widespread in humid and dry environments in many places including man-made establishments with any vegetation cover and shallow bodies of water for breeding (Lever 2001). Opportunistic feeding habits are commonly observed in this species in which there is active consumption of any terrestrial animal at ground level during nighttime (Hinkley 1962). The prey preference includes terrestrial arthropods, snails, crabs, small vertebrates, and other materials gorged as food (Lever 2001).

Density of anurans in the study area

Looking at the density shown in Table 2, the least value of population density among the three invasive species in Site 1 was that of *H. rugulosus* (0.17 ind./km^2). Such low density might be attributed to its alert behavior in the presence of human activities in which an observed individual was quick to escape during the entire sampling. Another possibility in the minimal sighting recorded was its accidental observation upon encountering the individual in which the species might thrive on a different microhabitat unlike the microhabitat in which it was encountered.

The species *K. pulchra* ranks second in terms of density in the study area. Some of these factors include the significant increase of observed *K. pulchra* in nighttime (Berry 1964) and high activity in periods of heavy rainfall (Diesmos et al. 2006). Another factor was the specific habitat type for *K. pulchra* wherein the species thrive in hardly detected areas such as holes and crevices (Diesmos et al. 2006) affecting the observed number of individuals in the study. This was confirmed upon encountering these species in different microhabitats like in rock crevices and flooded grasslands within grounds of the built-up areas.

Table 2. Distribution and density of invasive alien anuran species collected from the three sites in UP Mindanao, Davao City, Philippines

Species	S1		S2		S3	
	N_i	Density	N_i	Density	N_i	Density
Kaloula pulchra	15	2.5	0	0	0	0
Rhinella marina	31	5.17	26	3.25	13	3.25
Hoplobatrachus rugulosus	1	0.17	0	0	0	0
Site area	6 km^2		8 km^2		4 km^2	

Out of the three species, *R. marina* (5.17 ind./km^2) was calculated to have the highest density among the three species in all sites. The widespread distribution of the species and highly significant amount of individuals observed includes many factors affecting its density in the studied area. The docile nature of the species during the entire sampling and the variety of habitats it can thrive within disturbed or vegetation areas (Lever 2001) reserved the species accessible for observation. The vast feeding habit (Hinkley 1962) and competition within breeding sites likely increased the survival for the species even in introduced areas. A specialized defense mechanism of *R. marina* is evident in its parotid glands wherein the toxic secretions are known to cause illness and death in both domestic and wild animals (Lever 2001). Due to this, capability of *R. marina* to be preyed by other animals such as snakes was greatly reduced that resulted in a higher density of the species in its area. Furthermore, the species *R. marina* were present in all three sites, recognizing it as the most distributed invasive alien anuran species in the sampling area. Lever (2001) states how this species can thrive in any dry and humid environment within urban areas and shallow areas of water as breeding sites. With the variety of habitat types in the three sites, this species is still capable to thrive and distribute in these areas. Toft (1981) reported that *R. marina* differed from other species of bufonids mainly in the habitat type, with its diet being different from other forest species.

Gut content analysis

Amphibians including anurans belong to a very diverse group of vertebrates in which their feeding mechanism is generally opportunistic (Vignoli and Luiselli 2012; Vignoli et al. 2017). Frogs and toads, being generalist predators, target prey with food up to gape width being ingested (Browne 2009). In this study, 30 samples of stomachs from the two invasive alien anuran species (*R. marina and K. pulchra*) were obtained with the contents greatly composed of arthropod diet (Table 3).

Among all food groups, frequently occurring items were invertebrates. *R. marina* showed to have the most diverse food groups, which varies from the most commonly occurring ants (FOO=80%), spirolobids (FOO=80%), and beetles (FOO=75%) to less common diet such as spiders (FOO=15%), lepidopterans (FOO=5%) and orthopterans (FOO=5%). *K. pulchra*, on the other hand, had only four food groups documented in this study, which include mostly smaller diets such as ants (FOO=90%), millipedes (FOO= 20%), mites (FOO=10%) and beetles (FOO=10%) (Table 4).

Table 4. Frequency of Occurrence (FOO; expressed as %) and Degree of Food Preference (DFP) of gut contents in samples of IAS collected in UP Mindanao, Davao City, Philippines

Diet category	*Rhinella marina*		*Kaloula pulchra*	
	FOO	DFP	FOO	DFP
Invertebrates				
Class Insecta				
Order Blattodea				
Family Blattidae	15^a	0.15^o		
(termites)	55^s	1.25^s		
Order Coleoptera (beetles)	75^c	1.35^s	10^a	0.2^o
Order Hemiptera				
Family Nabidae	10^a	0.1^o		
Order Hymenoptera				
Family Formicidae	80^c	1.8^s	90^c	2.8^p
Order Lepidoptera				
(larvae)	5^a	0.05^o		
Order Orthoptera				
Family Gryllidae	5^a	0.05^o		
Class Diplopoda				
Order Spirobolidae				
Family Trigoniulidae	80^c	1.55^s		
Order Julida				
Family Julidae	10^a	0.1^o		
Order Polydesmida				
Family Paradoxosomatidae	20^a	0.2^o	20^a	0.3^o
Class Arachnida				
Order Araneae (spiders)	15^a	0.3^o		
Order Acarina (mite)			10^a	0.1^o
Class Gastropoda				
Order Pulmonata (slug)	5^a	0.05^o		
Vertebrates				
Class Reptilia				
Order Squamata				
Family Scincidae	5^a	0.1^o		
Plant material				
Leaves	5^a	0.1^o	10^a	0.1^o
Twigs	25^a	0.4^o		
Fruits	20^a	0.1^o	20^a	0.2^o
Wood	20^a	0.2^o	20^a	0.2^o
Others				
Pebbles	5^a	0.05^o	10^a	0.1^o
Plastic	5^a	0.05^o		

Note: FOO: Constant (c): >50%; Secondary (s): 25-50%; Accidental (a): <25%; DFP: hp-highly preferential (3<DFP<4); p-preferential (2<DFP<3); s-secondary (1<DFP<2); o-occasional (0<DFP<1)

Both species consume preys according to their range of body sizes (Anderson et al. 1999). *R. marina* secondarily preferred ants, termites, beetles and occasionally preferred larger food such as slugs, orthopterans and vertebrate prey. On the other hand, small preys like ants are preferred by smaller *K. pulchra*. *R. marina* is a generalist predator feeding on a wide range of prey size present in different landscapes ranging from anthropic areas to terrestrial areas (Lever 2001), while *K. pulchra* has relatively short jaws and has significantly shorter feeding cycle which feeds on slow and small prey (Emerson 1985). A notable record on intermediate digestion is a tail from a skink species (Family Scincidae) from the Order Squamata in one of the 20 individuals of *R. marina*. With the head and other body parts mostly digested, there was difficulty in identifying the prey up to species level. Moreover, the preferred diet of these two IAS also revealed in competition with the recorded diet of native species (Almeria et al. 2013; Ates et al. 2007; Yap 2015) indicating a potential threat to native fauna in degraded landscapes.

Plant material and presence of other inorganic matter were all occasional food items in both species. This herbivory behavior was also rampant in other studies (e.g. Ates et al. 2007; Isaacs and Hoyos 2010; Almeria et al. 2013; Ynot et al. 2017) as well. Given that frogs are natural herbivores only at the larval stage and becomes carnivores after metamorphosis (Wells 2007), it appears that ingestion of plants was most probably taken accidentally with other preferred prey or food. However, a study reported by Evans and Lampo (1966) suggested that anurans may also actively select vegetation because it may aid in the elimination of intestinal parasites, provide roughage to assist grinding invertebrate exoskeletons, provide nutrition (if digestible), and contribute an additional water source to prevent desiccation. Similarly, small stones also occurred in some stomachs but never in large quantities.

In conclusion, this study illustrates that in terms of population density of frogs, the campus is relatively dominated by two invasive alien anuran species, *Rhinella marina*, and *Kaloula pulchra*. Moreover, these species were observed to consume variety of prey items, which includes a skink (Scincidae, Squamata) inside the stomach in one individual of *R. marina*. These results suggest that the occurrence of invasive alien anuran species, in terms of its density and prey availability, presents as one of possibly many underlying threats in the campus which may affect biological diversity, especially on native wildlife species. Along with the state of rapid development in the campus, such factors must be considered in monitoring the status on the conservation of native species in the area. Further observation in the habitat and inspection of species, especially native ones, are highly recommended in inferring how population ecology and food resources can affect such state within a disturbed ecosystem.

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REFERENCES

Alcala AC. 1986. Guide to Philippine Flora and Fauna. Vol. X, Amphibians and Reptiles. Natural Resource Management Center, Ministry of Natural Resources and the University of the Philippines, Manila, Philippines.

Alcala AC, Brown WC. 1998. Philippine Amphibians: An illustrated field guide. Bookmark.

Almeria ML, Nuñeza OM. 2013. Diet of seven anuran species (Amphibia: Anura) in Agusan Marsh, Mindanao, Philippines. Anim Biol Anim Husb Bioflux 5 (1): 116-126.

Anderson AM, Haukos DA, Anderson JT. 1999. Diet composition of three anurans from the Playa Wetlands of Northwest Texas. Copeia 1999 (2):. 515-520.

Ates FB, Palafox DB, Cabelin VLD, Delima EMM. 2007. Diet composition of six anuran species (Amphibia: Anura) in Terminalia Forest, Mindanao Island, Philippines. BANWA Archives (2004-2013) 4 (2): 7-20.

Berry PY. 1964. The breeding patterns of seven species of Singapore Anura. J Anim Eco 33 (2): 227-243.

Bissattini A, Vignoli L. 2017. Let's eat out, there's crayfish for dinner: American bullfrog niche shifts inside and outside native ranges and the effect of introduced crayfish. Biol Invasions 19 (9): 2633-2646.

Bissattini A, Buono V, Vignoli L. 2018. Field data and worldwide review reveal that alien crayfish mitigate the predation impact of the American bullfrog on native amphibians. Aquat Conserv 28: 1465-1475

Bissattini A, Buono V, Vignoli L. 2019. Disentangling the trophic interactions between American bullfrogs and native anurans: complications due to post-metamorphic ontogenetic niche shifts. Aquat Conserv 29: 270-281

Boettger O. 1893. Drei neue Wasserfrösche (Rana) von den Philippinen. Zool Anz 16: 363-366.

Braga FMS. 1999. O grau de preferência alimentar: método qualitativo e quantitativo para o estudo do conteúdo estomacal de peixes. Acta Sci Maringá 21: 291-295.

Braga RR, Bornatowski H, Vitule JR. 2012. Feeding ecology of fishes: An overview of worldwide publications. Rev Fish Biol Fisher 22: 915-929.

Brown R, Diesmos AC, Sanguila MB, Siler CD, Diesmos MLD, Alcala AC. 2012. Amphibian Conservation in the Philippines. National Museum of the Philippines, Manila.

Browne RK. 2009. Amphibian diet and nutrition. Ark Science and Research. Royal Zoological Society of Antwerp, Belgium.

Bruton MN, Merron SV. 1985. Alien and translocated aquatic animals in Southern Africa: A general introduction checklist and bibliography. S Afr Natl Sci Progr Rep 113: 1-71.

Cope ED. 1862. On some new and little known American Anura. Proc Acad Nat Sci Phila 14: 151-159.

Courant J, Vogt S, Marques R, Measey J, Secondi J, Rebelo R, De Villiers A, Ihlow F, De Busschere C, Backeljau T, Rödder D, Herrel A. 2017. Are invasive populations characterized by a broader diet than native populations?. Peer J 5: 32-50.

Diesmos AC, Brown RM, Alcala AC, Sison RV, Afuang LE, Gee GVA. 2002. Amphibians and Reptiles. In: Ong PS, Afuang LE, Rosell-Ambal RG. (eds.) Philippine Biodiversity and Action Plan. DENR-Protected Areas and Wildlife Bureau, Conservation International Philippines, Biodiversity Conservation Program. University of the Philippines, Center for Integrative Development Studies and the Foundation for the Philippine Environment, Quezon City.

Diesmos A, Diesmos M, Brown R. 2006. Status and distribution of alien invasive frogs in the Philippines. J Environ Sci Manag 9: 41-53.

Emerson SB. 1985. Skull shape in frogs: Correlations with diet. Herpetologica 41: 177-188.

Evans M, Lampo M. 1996. Diet of *Bufo marinus* in Venezuela. J Herpetol 30 (1): 73-76.

Gagné SA, Fahrig L. 2007. Effect of landscape context on anuran communities in breeding ponds in the National Capital Region, Canada. Landsc Ecol 22 (2): 205-215.

Gravenhorst JLC. 1829. Deliciae Musei Zoologici Vratislaviensis. Fasciculus primus. Chelonios et Batrachia. Leipzig, Leopold Voss.

Gray JE. 1831. Description of two new genera of frogs discovered by John Reeves, Esq. in China. Zool Misc 1: 38.

Google Maps. 2017. Google Maps. https://www.google.com/maps/place/University+of+the+Philippines,+Mindanao+Campus/@7.0857312,125.4841158,15z/data=!4m2!3m1!1s0x0:0xe1cad0747134bec5?sa=X&ved=2ahUKEwisrZGc3NbiAhVBeXAKHbGMCDIQ_BIwEXoECAsQCA

Heyer WR, Donnelly MA, McDiarmid RW, Haek LAC, Foster MS. 1994. Measuring and Monitoring Biological Diversity; Standard Methods for Amphibians. Smithsonian Institute Press, Washington, D.C.

Hinkley AD. 1962. Diet of the giant toad, *Bufo marinus* (L.), in Fiji. Herpetologica 18: 253-259

Houlahan JE, Findlay CS, Schmidt BR, Meyer AH, Kuzmin SL. 2000. Quantitative evidence for global amphibian population declines. Nature 404: 752-755.

Ibanez JC, Bastian S, Ates F, Delima EM, Abano T, Coronel J, Gomez R, Allado A, Bravo R, Montero J. 2004. Conservation of threatened vertebrates at Mount Sinaka, Mindanao. Gaynawaan 2004: 1-17.

Isaacs P, Hoyos JM. 2010. Diet of the cane toad in different vegetation covers in the productive systems of the Colombian coffee region. S Am J Herpetol 5: 45-51.

IUCN. 2017. The IUCN Red List of Threatened Species. https://www.iucn.org/theme/species/our-work/amphibians

Joshi RC. 2011. Invasive alien species (IAS): Concerns and status in the Philippines. Philippine Rice Research Institute (PhilRice) Maligaya, Science City of Muñoz, Nueva Ecija 11: 1-23.

Knutson MG, Sauer JR, Olsen DA, Mossman MJ, Hemesath LM, Lannoo MJ. 1999. Effects of landscape composition and wetland fragmentation on frog and toad abundance and species richness in Iowa and Wisconsin, USA. Conserv Biol 13 (6): 1437-1446.

Kuangyang L, Zhigang Y, Haitao S, Baorong G, van Dijk PP, Iskandar D, Inger RF, Dutta S, Sengupta S, Uddin Sarker S, Asmat G. 2004. *Kaloula pulchra*. The IUCN Red List of Threatened Species. URL IUCN.2004:e.T57855A86163405.doi:10.2305/IUCN.UK.2004.RLTS. T57855A11694615.en

Lever C. 2001. The Cane Toad. The History and Ecology of a Successful Colonist. Westbury Academic and Scientific Publishing, Otley, West Yorkshire, England.

Lin ZH, Ji X. 2005. Sexual dimorphism in morphological traits and food habits in tiger frogs, *Hoplobatrachus rugulosus* in Lishui, Zhejiang. Zool Res 26: 255-262.

Linnaeus C. 1758. Systema Naturae per Regna Tria Naturae, Secundum Classes, Ordines, Genera, Species, cum Characteribus, Differentiis, Synonymis, Locis. 10th ed. Volume 1. L. Salvii, Stockholm, Sweden.

Macale D, Vignoli L, Carpaneto GM. 2008. Food selection strategy during the reproductive period in three syntopic hylid species from a subtropical wetland of NE Argentina. Herpetol J 18: 49-58

McKinney ML. 2008. Effects of urbanization on species richness: a review of plants and animals. Urban Ecosyst 11 (2): 161-176.

Peralta A, Pagente, JMQ, Balaba KL. 2015. *Hoplobatrachus rugulosus* (East Asian Bullfrog): Philippines, Mindanao Island, Bukidnon Province. Valencia City, Barangay, Batangan.

Sanguila MB, Cobb KA, Siler CD, Diesmos AC, Alcala AC, Brown RF. 2016. The amphibians and reptiles of Mindanao Island, Southern Philippines, II: The herpetofauna of northeast Mindanao and adjacent islands. Zookeys 624: 1-132.

Schlegel H. 1837. Abbildungen neuer oder unvollständig bekannter Amphibien, nach der Natur oder dem Leben entworfen, herausgegeben und mit einem erläuternden Texte begleitet. Part 1. Arnz & Co, Düsseldorf.

Schoener TW. 1989. Should hindgut contents be included in lizard dietary compilations? J Herpetol 23: 455-458.

Shaw G. 1802. General Zoology or Systematic Natural History. Volume III, Part 1. Amphibia. Thomas Davison, London.

Smith MA. 1930. The reptilia and amphibia of the Malay Peninsula. Bull Raffles Mus 3: 96-97.

Sparling DW, Linder G, Bishop CA. 2000. Ecotoxicology of amphibians and reptiles. Environment Toxicol Chem. Pensacola. FL.

Sularte R, Boyles LZ, Calomot NH, Demetillo MT, Ombat LA, Ngilangil MCM, Binag GM. 2015. **S**pecies distribution and abundance of amphibians in two vegetation types of Agusan Marsh, Philippines. Division of Agusan del Sur-La Paz II District Office, Panagangan, La Paz, Agusan del Sur.

Sy EY. 2013. Geographic Distribution: *Kaloula pulchra*, first record on Mindanao Island, Philippines. Herpetol Rev 44 (4): 621.

Toft CA. 1981. Feeding ecology of Panamanian litter anurans: Patterns in diet and foraging mode. J Herpetol pp. 139-144.

Tschudi JJ von. 1838. Classification der Batrachier mit Berücksichtigung der fossilen Thiere dieser Abtheilung der Reptilien. Petitpierre, Neuchâtel.

Vignoli L, Luiselli L. 2012. Dietary relationships among coexisting anuran amphibians: A worldwide quantitative review. Oecologia 169 (2): 499-450.

Vignoli L, Bissattini A, Luiselli L. 2017. Food partitioning and the evolution of non-randomly structured communities in tailed amphibians: a worldwide systematic review. Biol J Linn Soc 120 (3): 489-502.

Wells KD. 2007. The ecology and behavior of amphibians. The University of Chicago Press, Chicago, IL.

Whitaker JO, Rubin D, Munsee AR. 1977. Observations on food habits of four species of spadefoot toads, genus S*caphiopus*. Herpetologica. 33: 468-475.

Wiegmann AFA. 1834. Amphibien. In: Meyen FJF (eds.). Reise um die Erde ausfeführt auf dem Königlich Preussischen Seehandlungs-Schiffe Prinzes Louise, comandiert von Captain W. Wendt, in den Jahren 1830, 1831 und 1832 von Dr. F. J. F. Meyen. Dritter Theil Zool Bericht pp. 433-522.

Yap CH. 2015. Diet of five common anurans found in disturbed areas in northern peninsular Malaysia. [Dissertation]. Universiti Sains Malaysia, Georgetown, Penang.

Ynot CPA, Tan SN, Lim NK, Baron EM, Mohagan AB. 2017. Diet of cane toads (*Rhinella marina*) collected from areas adjacent to human dwellings in Davao City, Philippines. Imp J Interdiscip Res 3 (11): 640-642.