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Diet of seven anuran species (Amphibia: Anura) in Agusan Marsh, Mindanao, Philippines

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Abstract. Anurans are indicators of ecosystem health and have important functions in natural food webs. Studies on anurans in Agusan marsh are very scarce particularly inside the protected area. In order to understand the prey selection of anurans within the Agusan marsh habitat we examined the diet of seven anuran species and analyzed a total of 71 samples. From the stomach contents we found plant remains, shed-skin fragments, animals and animal fragments. We identified a total of 26 prey items. Hymenoptera, Hemiptera, Diptera, Coleoptera, Arachnida, Orthoptera, insect debris/shed skin and plant materials were found to be the abundant prey items. Plants were frequently observed in most species examined although in small amount. Results showed that *Fejervarya cancrivora* (Crab-eating frog), *Limnonectes leytensis* (Swamp frog), *Rhinella marina* (Cane toad), *Polypedates leucomystax* (Common tree frog) and *Kaloula conjuncta meridionalis* (Philippine Narrowmouth toad), have broad dietary diversity, indicating a generalist active feeding and opportunistic foraging behavior. *Rhacophorus appendiculatus* (Rough-armed tree frog) and *Occidozyga laevis* (Puddle frog) consumed fewer food items implying that these species are specialist passive feeders. The most consistently observed diet items in the frog samples in Agusan marsh were Hemiptera (bugs) and Hymenoptera (ants) found in all frog species examined. Coleoptera (bettles) was found in 90 % of the samples while Orthoptera (grasshoppers), Isoptera (termites) and Diptera (mosquitoes) were found in 70 % of the samples examined. Gastropoda, Decapoda, Siphonoptera, Scolopendromorpha, Mecoptera, Dermaptera, and Protozoa were seldom observed. The results indicate that anurans that are specialist feeders need to be monitored especially the vulnerable *R. appendiculatus* because any alteration of the habitat can affect the animals particularly the invertebrate prey of this threatened frog. The Agusan marsh as a protected wetland area must be strictly and properly managed to ensure sustainability of the remaining endemic wildlife especially the anurans and their preys.
Key Words: Feeding, frogs, prey, toads, wetlands.

Introduction. Amphibians are the most abundant vertebrates in many forests and have the potential to play a significant role in ecosystem dynamics (Wahbe & Bunnell 2003). Amphibians are important in the trophic dynamics since they are potential prey and predators of any organism. The study of the feeding ecology of amphibians is an old issue in herpetology. Notwithstanding, the lack of food resources data in many studies of amphibian feeding has led to partial understanding of frog feeding strategies (Inger & Stuebing 1989).

Amphibians are a very diverse group of vertebrates, however, in general their feeding is opportunistic with food up to gape width being ingested. Amphibians such as frogs and toads only target moving prey and prefer elongated prey such as crickets or insect larvae that move across their field of vision. However, many aquatic amphibians target food by scent and consume inert food. Gross nutritional deficiencies from vitamin imbalance were sometimes apparent. Both the calcium and phosphorus composition of many feeder insects are low or imbalanced, and many insects are high in lipids and low in protein (Browne 2009).

Insects which are the chief items of the diet of frogs and toads (anurans) are abundant in Agusan Marsh. Terrestrial and aquatic insects have been reported as preferential anuran prey items in several studies conducted over the past 20 years

(Lopez et al 2009). Ants and termites are important in the economy of burrowing frogs like *Kaloula*. But the number of prey (insects) of frogs is almost equivalent to their predators like fishes, snakes and birds which are very abundant in the Marsh of Agusan (DENR-IPAS 2003).

Dietary information is crucial for the understanding of anuran life history, population fluctuations, and the impact of habitat modification on populations (Anderson et al 1999). Understanding the habitat requirements of a species is essential to efforts aimed at its conservation. Moreover, it is important to understand the range of habitats associated with different aspects of the species' life history. A study from the central region of Argentina shows that the highest relative abundance of anurans was detected at a highly modified campsite area, which provides stable food and refuge having permanent water reservoir from precipitation (Jofre et al 2010). This study examined the diet and the preferred prey items of seven species of anurans in Agusan marsh. It also determined which of the seven anurans in the marsh have varied diets and which have specialized diets.

Material and Method. Sampling was done in Agusan Marsh, a wildlife sanctuary and one of the ecologically significant and rare wetland ecosystems in the Philippines. It is located in the province of Agusan del Sur, Northeastern Mindanao between 125^0 38` and $125^0$ 05` North Latitude; 8^0 07` and $8^0$ 27` Longitude in the middle of Agusan River basin. Sampling was done in four sampling sites: Terminalia forest, Sago swamp forest, Mixed-swamp forest, and peat swamp forest (Figure 1) on the rainy days of September and November, 2005. Quadrat, cruising, and pitfall trap methods were used in the sampling of anurans in the area.

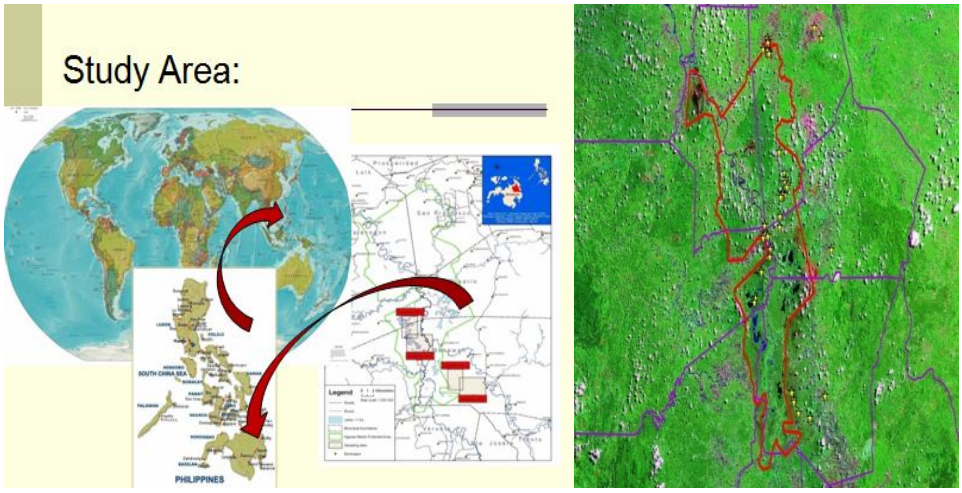

Figure 1. A GPS map of Agusan del Sur obtained during the study period by a Hungarian volunteer of Agusan province shows the four sampling sites. (Enclosed by a red solid line is the Agusan marsh protected area).

Among the 17 species of anurans recorded in the area the following seven most abundant species: *Fejervarya cancrivora* (Crab-eating frog), *Kaloula conjuncta meridionalis* (Philippine Narrowmouth Toad), *Limnonectes leytensis* (Swamp frog), *Occidozyga laevis* (Puddle frog) , *Polypedates leucomystax* (Common tree frog), *Rhinella marina (Cane toad) and Rhacophorus appendiculatus* (Asiatic Tree frog) were selected for diet examination. Diet analysis was done by dissecting the ventral part of the specimen to expose the digestive system. The whole digestive part of each specimen was removed by cutting the esophagus down to the small intestine. Each digestive tract obtained was properly labeled and preserved in 70 % ethyl alcohol. The preserved digestive tract was air-dried to remove moisture content from the preservative and the initial weight obtained using Mettler balance. The digestive tract was then opened carefully to expose its contents. The exposed area was washed with distilled water using

a wash bottle to remove the food items and fecal materials which adhered to the walls of the tract. The food items were collected into a petri dish. In order to determine the diet, the collected food items were examined under a dissecting stereomicroscope. The food items were sorted, grouped and transferred to glass slides covered with cover slips and were viewed under the stereomicroscope and photographed for documentation. Each prey was identified to the nearest possible taxonomic level based on published references and taxonomic keys. Percentage of occurrence was obtained by determining the presence or occurrence of food item in each species against the number of prey items examined.

Results and Discussion. Results showed 26 food items (Table 1). The most commonly observed were Hemiptera and Hymenoptera which were found in the stomach contents of seven anuran species. Coleoptera and plant materials were found in six species. Homoptera, Isoptera, Insect debris (insect skin/shed-skin, wings, segments, legs, antennae etc.) and Orthoptera were found in five species. Nematoda, Arachnida, Diptera and Odonata were present in four species. Anoplura, Plecoptera, Ephemeroptera and Annelida were seen in three species. Dermaptera and Protozoa were observed in two species while Decapoda, Mecoptera, Scolopendromorpha, Siphonoptera, Cestoda and Gastropoda were only seen in one species of anurans.

Ates et al (2007) identified 19 food items in the guts of six anuran species where the frequently occurring food items were Hymenoptera, Formicidae Coleoptera, Diptera, and Orthoptera. Varela & Gapud (2007) in their study on aquatic insects in Agusan Marsh floodplain identified 59 species of aquatic insects like water beetles under Coleoptera (28 sp.), water bugs under Hemiptera (17 sp.) and dragonfly and damselfly under Odonata (14 sp.) in Sago and Terminalia Forests. The results of this study revealed diverse food items probably because the anurans were collected from large sampling sites and in four different forest types. The wide variety of food items also suggests that Agusan marsh anurans are wide foraging generalists. Isaacs & Hoyos (2010) also observed a similar result in *R. marina* having a generalist diet with high proportion of hemipterans, coleopterans and hymenopterans. The main items in the adult diet of generalist and opportunistic feeders consist of invertebrates including molluscs, annelids, centipedes, millipedes, arachnids, crustaceans and, especially insects (Santos et al 2004). A similar study of Allingham & Harvey (2011) in Senegal but of different species of frogs showed that the most frequently taken prey items were Orthoptera (36 %), Hymenoptera (24 %) and Arachnida (10 %) suggesting that Senegal running Frog *Kassina senegalensis* is a wide foraging generalist. Fabricante & Nuñeza (2012) who studied the diet of *R. grandocula* and *R. magnus* in the same province where Agusan Marsh is located but in a higher altitude of Mt. Sambilikan, Diwata Range, Agusan del Sur also found these frogs as generalist feeders. Santos et al (2004) reported that Orthoptera and Hymenoptera including plant debris and insect debris are the most frequently consumed food items. In Northeastern Ohio, Collier et al (1998) reported similar results of Coleoptera, Hemiptera and Hymenoptera as food consumed by *Rana pipiens* (Leopard frog). Their study indicated that the most commonly consumed prey are crawling or fossorial insects primarily of the order Coleoptera. Kovács et al (2007) identified more or less the same food items in the stomach of *Hyla arborea* but of different proportion. The least observed food items were Gastropods (snails) which were only observed in *R. marina* Decapoda (crabs), Siphonoptera, Anura (frog) and Mecoptera (scorpions) were only observed in *F. cancrivora* while waterboat man (Hemiptera) was only present in *O. laevis* being an aquatic frog. Scolopendromorpha (centipede) was present only in *L. leytensis* while Cestoda (flatworm) was only present in *K. conjuncta*. Protozoa and soil particles were also seldom observed. Collier et al (1998) reported that saltatory and flying insects are ingested less frequently. The fact that flying insects are ingested less frequently in their study may reflect the difficulty involved in the successful capture of these invertebrates. Sit-and-wait predators, such as *R. pipiens* (Rittschof 1975), normally consume more active than inactive prey (Huey & Pianka 1981). Prey items such as snails and slugs, consumed only by juveniles, are often tied to moist habitats and therefore may have been unavailable as prey to adults in the drier grasslands.

Table 1

Prey items of anurans in Agusan Marsh

Prey items	*Anuran species*						
Taxon	*Rhinella marina*	*Fejervarya cancrivora*	*Kaloula conjuncta*	*Limnonectes leytensis*	*Occidozyga laevis*	*Polypedates leucomystax*	*Rhacophorus appendiculatus*
Anoplura	x	x	-	x	-	-	-
Arachnida	-	-	x	x	-	x	x
Coleoptera	x	x	x	x	x	x	-
Decapoda	-	x	-	-	-	-	-
Dermaptera	-	x	-	-	-	x	-
Diptera	x	x	-	x	-	x	-
Ephemeroptera	-	x	-	x	x	-	-
Hemiptera	x	x	x	x	x	x	x
Homoptera	x	x	x	x	-	x	-
Hymenoptera	x	x	x	x	x	x	x
Isoptera	x	x	x	x	-	x	-
Mecoptera	-	x	-	-	-	-	-
Odonata	x	-	-	x	x	x	-
Orthoptera	x	x	x	x	-	x	-
Plecoptera	-	-	-	x	x	x	-
Scolopendromorpha	-	-	-	x	-	-	-
Siphonoptera	-	x	-	-	-	-	-
Gastropoda	x	-	-	-	-	-	-
Cestoda	-	-	x	-	-	-	-
Nematoda	-	x	x	x	-	-	x
Annelida	-	-	x	x	-	x	-
Protozoa	-	-	-	-	-	-	-
Insectdebris / Shed skins	x	x	x	x	x	-	-
Plant materials	x	x	-	x	x	x	x
Soil particulates	x	x	-	-	-	-	-
Anura (Frog)	-	x	-	-	-	-	-
Total (26)	13	19	11	17	8	13	6

F. cancrivora, an exotic species, had the most varied number of food items (19). *L. leytensis* was found to eat 17 food items while *R. marina* and *P. leucomystax were found* to ingest 13 food items. These species can be considered generalist predators as well as opportunistic because they consume a wide range of prey items. Frogs were commonly observed in the stomach contents of *F. cancrivora* suggesting that *F. cancrivora* exhibits cannibalism. Evidence of cannibalism in the diet of *F. cancrivora* was also observed in the diet examination of Measey (1998). This frog is known to eat its own eggs during mating. Small vertebrates, such as fish, rodents, birds, and frogs, may occasionally be consumed by larger frogs (Duellman & Trueb 1986). Crump (1992) reported that of all species examined only *F. cancrivora* also eats small crabs. In Singapore, the diet of *F. cancrivora* collected near brackish water was predominantly crustacean and included crabs (*Sesarma* spp.), while the diet of those collected near fresh water comprised mainly of insects. Gut contents of frogs included all the small animal species found in the respective environments (Elliott & Karunakaran 2009). Hirai & Matsui (2000) found significant correlations between the diet composition and prey availability suggesting that the species they studied, *H. japonica* is an opportunistic predator since the most easily available prey such as ants, beetles, dipterans, caterpillars, and spiders were consumed by this frog. Kovács et al (2007) showed that *H. arborea* has a broad dietary diversity which was expected as a consequence of exploiting the habitat both vertically and horizontally, possibly allowing access to a broader spectrum of prey. Odonata, Coleoptera, and Hymenoptera and other arthropods, such as Acari and Araneae, were eaten by almost all frog species.

Macroinvertebrates like mosquitoes, fireflies, black and red ants, beetles and a lot more were observed to be very abundant in Agusan Marsh (Figure 2). Insects like the ants and termites are the chief items in the diet of frogs especially the burrowing frogs, *Kaloula.* The number of prey is almost equivalent to the predators of frogs like snakes, fishes and the abundant species of birds in the marsh.

Figure 2. Landscape view of one of the sampling sites in Agusan Marsh, Agusan del Sur, Philippines.

Arthropods especially insects which were observed in the stomach contents of the studied specimens are abundant in Agusan marsh as also reported by Varela & Gapud (2007). These are some of the most important creatures in the wetlands because they take advantage of the many niches in the wetland environment. These creatures are at the beginning of the food chain help to support all kinds of lifelike anurans, fishes, birds and crocodiles. Feeding mechanism of most anuran amphibian involves detection of prey by visual cues followed by capture and retrieval with the tongue (Measey 1998).

The frog species with the least number of prey items was *R. appendiculatus* being an arboreal frog with limited prey items encountered. This frog was observed to be very careful in its movement within the microhabitat to avoid detection by the abundant predators like birds and reptiles in the trees. *O. laevis* was found to have only eight food items. This is an aquatic frog and aquatic frogs have a number of competitors in terms of food. In the marsh, fishes, birds and reptiles are abundant and they prey on these frogs for food.

Recent studies have suggested that many species show some degree of diet specialization (Simon & Toft 1991; Toft 1995) whereas others can feed on a variety of "non-orthodox" items. For example, herbivory may be a relatively common behaviour in some species, such as *Xenohyla truncata* which feeds on fruits for a significant part of its adult stage (Silva et al 1989).

Six of the nine anuran species examined have plant materials such as seeds, pieces of tree branches, leaves, and flowers in their digestive tract. *K. conjuncta*, a burrowing species appears to be an "ant-specialist" with high consumption of ants and termites (Inger & Stuebing 1989). Fabricante & Nuñeza (2012) reported that plant debris was least frequently observed in *L. magnus* and *R. grandocula*. Although consumption of plant material has been reported in studies on anuran feeding habits, plants are not regarded as an important resource in the anuran diet and some authors suggest the ingestion of plant parts as incidental while foraging for invertebrate preys. But the idea that anurans may actually select plant resources as food item must be considered. According to Anderson et al (1999), plant contents may help in the elimination of parasites and provide roughage to assist in grinding up arthropod exoskeletons or provide nutrients and an additional source of water. Inger & Stuebing (1989) reported that no frogs feed on plants but sometimes fragments of plants may be swallowed accidentally. Kovács et al (2007) noted in their study of *H. arborea* diet in Romania that once feeding intensity and the rate of feeding activity increased, the occurrence of stomachs with plant materials become higher.

Information on plant consumption contributes to the understanding of behavioral patterns. The presence of anthers, stamens, pollen, seeds, and leaves in the stomachs indicates that vegetation is used not only as a reproductive site, but also as foraging territory. Reports on herbivores in tropical frogs have become more frequent in the past years. Silva et al (1989) demonstrated that *X. truncata* includes bromeliad fruit and seeds in its diet, especially during the dry season, when invertebrates are less abundant. Plants can also constitute a significant part of the diet of adults of *Rana hexadactyla* (Das 1996).

A number of insect debris were seen but severely fragmented and could not be identified as to what taxonomic group it belongs. Insect debris and shed skin (Figure 3) were observed in almost all samples except in *P. leucomystax* and *R. appendiculatus*. The anurans were caught late at night and they were processed the following morning. The presence of insect debris and shed skin indicates that digestion occurs very fast that almost completely digested food items were seen in the morning. The reason why frogs have faster digestion on their prey is because they have short digestive tract (Inger & Stuebing 1989). Since a number of prey items could not be identified, some insect orders may have been underestimated as food items (Santos et al 2004).

Figure 3. Food items found in anurans stomach content, photographed under the stereomicroscope.

Kovács et al (2007) reported that the occurrence of shed skins/insect debris in the stomach of frogs has been reported previously and might be reflective of epidermal protein recycling. A frog diet study in Romania commonly observed shed skin and vegetal fragments in stomach contents (Hodisan et al 2010). Another study showing the importance of food diet in frogs is that of Staudt et al (2010) which revealed that the toxic diet of strawberry poison frog (*Oophaga pumilio*) may be linked to territoriality. This frog is dependent on the presence of formicine and myrmicine ants, which constitute the main food source of the frogs. These ants contain in their skin highly toxic alkaloids (pumiliotoxins), which the frogs incorporate in their skin that may serve as predator deterrence.

Table 2 shows the percentage occurrence of prey item in each species of frog examined. The major food items observed in the digestive tract of *F. cancrivora* species were plant materials (60 %), Hymenoptera- ants (45 %), Coleoptra- beetles (40 %), Hemiptera- bugs (35 %), Decapoda- crabs, Diptera- mosquitoes and Orthoptera- grasshoppers & crickets (25 %).

Santos et al (2004) reported that Insecta, Arachnida, and plants were preferred items for most species examined. A slight increase in diet diversity occurred in the rainy season. The species of frogs examined by Santos et al (2004) showed a generalist feeding behavior. López et al (2009) identified 33 taxonomic categories from gastrointestinal contents of the frog species examined and from the 33 prey items determined in the frog diet, Dipterans had the highest percentage occurrence (40.85 %), followed by hemipterans (22.07 %), with the bulk of this order represented by the family Lygaeidae (17.84 %). Homoptera (13.62 %) and coleoptera (8.45 %) also contribute importantly to the diet of anurans.

The toad*, R. marina,* showed the following prey items: Hemiptera, bugs (70 %) and Diptera, mosquitoes (50 %). *R. marina* forages primarily nocturnally in mature forests and roadways. It feeds on ants, beetles, and earwigs in southern Florida, but has been found with dragonflies, grasshoppers, true bugs, crustaceans, gastropods, plant matter and even dog and cat food in its stomach (Krakaguer 1968). The major diet items of cane toads are insects, including grasshoppers, caterpillars and ants, together with millipedes and land snails. Hinkley (1963) found a small frog in the stomach of cane toad, showing cannibalism in this species. According to Pizzatto & Shine (2008), cannibalism is common under specific ecological conditions especially during dry season and also triggered by prey movement. Terrestrial arthropods make up the bulk of the diet, but snails, crabs, small vertebrates (mammals, birds, lizards and frogs), pet food and human feces may also be consumed. Cane toads will gorge themselves if food is in abundance. Unusual items that cane toads have been observed eating include rotting garbage, coral snake (*Micrurus circinalis*), fledgling birds and a lit cigarette butt (Lever 2001). The cane toad is opportunistic in its feeding habits and will consume almost anything that it is able to catch. *R. marina* in the coffee production region of Colombia is also considered as a generalist with a high proportion of hymenopterans, coleopterans, and hemipterans and a high incidence of plant material, nematodes, and minerals in the gastrointestinal contents (Isaacs & Hoyos 2010).

K. conjuncta appears to be predominantly ant-eater with 100 % occurrence of Hymenoptera (ants) with minimal termites (37.5 %), beetles and spider (25 %) since this frog is a burrower and stays on rotten logs where these insects are abundant. The Swamp frog (*L. leytensis*) had plant materials (75 %), beetles (60 %) and grasshopper and crickets (40 %) as its major food items. The aquatic *O. laevis* had plant materials (71 %), ants and stoneflies (57.14 %) and mayflies (28.57 %). The gut contents of *O. laevis* had many aquatic dietary components of zoobenthos and zooplankton making them more similar to fish than other anuran species (Measey 1998). In Malaysia, Kinabalu, Sabah (Inger & Stuebing 1989) reported that *O. laevis* eats insects and freshwater prawns.

Ants and nematodes (54.54 %), dragonflies, spiders, beetles, cockcroaches, leafhoppers and plant materials (27.27 %) were observed in *P. leucomystax* while in *R. appendiculatus*, nematodes (80 %), ants (60 %), spiders (40 %), bugs (4 0%) and plant materials (60 %) were found.

Table 2

Percentage occurrence of prey items in the gut of anurans

Food content / *Taxon*	*% occurrence of prey items*						
	Rhinella marina	*Fejervarya cancrivora*	*Kaloula conjuncta*	*Limnonectes leytensis*	*Occidozyga laevis*	*Polypedates leucomystax*	*Rhacophorus appendiculatus*
Anoplura (ticks)	1 (10 %)	1 (10 %)	-	1 (5 %)	-	-	-
Arachnida (spiders)	-	-	2 (25 %)	1 (5 %)	-	3 (27.27 %)	2 (40 %)
Coleoptera (beetles)	4 (40 %)	8 (40 %)	2 (25 %)	12 (60 %)	1 (14.2 %)	3 (27.27 %)	-
Decapoda (crabs)	-	5 (25 %)	-	-	-	-	-
Dermaptera (tarsal segments)	-	1 (5 %)	-	3 (15 %)	-	1 (9.09 %)	-
Diptera (mosquito)	5 (50 %)	5 (25 %)	-	7 (35 %)	-	2 (18.18 %)	-
Ephemeroptera (mayflies, praying mantis)	-	3 (15 %)	-	1 (5 %)	2 (28.57 %)	-	-
Hemiptera (bugs)	7 (70 %)	7 (35 %)	-	-	1 (14.2 %)	3 (27.27 %)	2 (40 %)
Homoptera (cockcroaches, leafhoppers)	1 (10 %)	1 (5 %)	-	1 (5 %)	-	3 (27.27 %)	-
Hymenoptera (ants)	4 (40 %)	9 (45 %)	8 (100 %)	15 (75 %)	4 (57.14 %)	6 (54.54 %)	3 (60 %)
Isoptera (termites)	2 (20 %)	2 (10 %)	3 (37.5 %)	3 (15 %)	-	-	-
Mecoptera (scorpions)	-	2 (10 %)	-	-	-	-	-
Odonata (dragonflies, damselflies)	2 (20 %)	-	-	7 (35 %)	2 (28.57 %)	3 (27.27 %)	-
Orthoptera (grasshopper, cricket)	2 (20 %)	5 (25 %)	1 (12.5 %)	8 (40 %)	-	1 (9.09 %)	-
Plecoptera (stoneflies)	-	-	-	5 (25 %)	4 (57.14 %)	2 (18.18 %)	-
Scolopendromorpha (centipede)	-	-	-	1 (5 %)	-	-	-
Siphonoptera (fleas)	-	1 (5 %)	-	-	-	-	-
Gastropoda (snails)	4 (10 %)	-	-	-	-	-	-
Nematoda	-	3 (15 %)	1 (12.5 %)	1 (5 %)	-	6 (54.54 %)	4 (80 %)
Annelida (earthworm, leech)	3 (10 %)		-	1 (5 %)	-	-	-
Protozoa	-	3 (15 %)	-	-	-	-	1 (20 %)
Insectdebris / Shed skins	3 (10 %)	5 (25 %)	2 (25 %)	7 (35 %)	1 (14.2 %))	3 (10 %)	5 (25 %)
Plant materials	2 (20 %)	12 (6 %)	2 (25 %)	15 (75 %)	5 (71.4 %)	3 (27.27 %)	3 (60 %)
Soil particulates	2 (20 %)	2 (10 %)	-	-	-	-	-
Anura (frog)	-	2 (10 %)	-	-	-	-	-

Similarly, Inger & Stuebing (1989) reported that *F. cancrivora* stomach contents indicate a highly varied diet of small invertebrates, including crabs while *F. limnocharis* consumes beetles, ants, millipedes and snails. *P. leucomystax* eats a variety of insects and other invertebrates*. R. appendiculatus* eats soft-bodied insects and spiders. In this study, *R. marina, F. cancrivora, F. limnocharis, and P. leucomystax* having larger bodies were found to consume larger prey. According to Biavati et al (2004), in Neotropical Savanna, volume and number of prey were greatest in larger individual. There is an association between prey size and frog size. Small frogs often consume primarily mites and collembolans, larger frogs consume more ants. Dietary specialists eat ants and termites or smaller prey while dietary generalists tend to eat larger prey and ingest fewer ants (Inger & Stuebing 1989).

Conclusions. The abundant prey items of anurans were Hymenoptera, Hemiptera, Diptera, Coleoptera, Arachnida, Orthoptera, insect debris/shed skin and plant materials. *F. cancrivora, L. leytensis, R. marina, P. leucomystax,* and *K. conjuncta* were observed as generalist and opportunistic feeders because of the broad dietary diversity. *R. appendiculatus* and *O. laevis* consumed fewer food items and were considered specialist feeders that need to be monitored especially the vulnerable *R. appendiculatus*.

The plant debris frequently observed in most anuran samples suggests that diet studies can contribute to the understanding of the anuran behavioural patterns as vegetation may be used by the frogs in Agusan marsh as reproductive sites and foraging territory. The variety in prey items of *R. marina* and *F. cancrivora* suggests differences in microhabitats indicating that the data on diet consumption can support both ecological and behavioural studies. There is a need to control the population of these two invasive frog species *R. marina* and *F. cancrivora* considered as very good opportunistic feeders in Agusan marsh since they could outcompete the endemic and vulnerable anuran species. This is important for the conservation of the endemic anuran species of the marsh especially since human settlements are closely encroaching into the protected area and the invasive frog species are present only in sites where humans are present. The arboreal *R. appendiculatus,* a vunerable frog species requires the continuous presence of vegetation particularly trees as their main habitat and where their food items are also present.

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