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DIET OF *Arctictis binturong* (VIVERRIDAE, CARNIVORA) IN ABORLAN, PALAWAN, PHILIPPINES

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ABSTRACT – The diet of the binturong (*Arctictis binturong*) is known to lean towards frugivory in many parts of its Southeast Asian range, but its diet in the Philippines has never been studied. To determine their food preference and understand their feeding habits, 35 binturong scat samples were collected within the Aborlan-Guba Watershed of Aborlan, Palawan, Philippines from July 2017 to May 2018. All scats contained only the seeds of figs belonging to 3 species: *Ficus botryocarpa*, which had the highest frequency of presence and absolute frequency of occurrence, followed by *Ficus aurata* and *Ficus forstenii*. No animal matter was found other than an unidentified beetle and binturong hair, likely ingested through grooming. This possible specificity to figs suggests that their successful survival is linked to that of fig trees, and in turn, binturongs may provide a valuable ecosystem service as fig seed dispersers in the forest habitat on which they depend.

Keywords: Aborlan-Guba Watershed, binturong, diet, scat analysis

INTRODUCTION

The binturong, *Arctictis binturong* (Raffles, 1921), is the largest member of the subfamily Paradoxurinae (Viverridae: Carnivora: Mammalia) and is distributed across Southeast Asia. In the Philippines, it can be found only in Palawan Island in the west-central region of the country. Binturongs from this island were previously classified into their subspecies, *Arctictis binturong whitei* (Allen 1910), but a recent study has shown that it is likely not a separate subspecies (Veron et al., 2020).

When the binturong was first described, Raffles (1822) observed its diet to be omnivorous in captivity. Subsequent field studies have since noted its diet to be leaning more towards frugivory. Several studies in India (Murali et al., 2013), Malaysia (Lambert, 1990, Nakabayashi et al., 2016a, Nakabayashi et al., 2016b, Nakabayashi and Ahmad, 2018, Nakabayashi et al., 2019), Thailand (Nettelbeck, 1997), and Vietnam (Rozhnov, 1994) have shown that binturongs may have a strong preference for the fruit of fig trees, *Ficus* spp. (Family Moraceae). Studies have found that the germination time of seeds was faster after binturong gut passage, which may increase seedling survival, thus making the binturong an effective seed dispersal agent (Colon and Campos-Arceiz 2013, Nakabayashi et al., 2019).

In the Philippines, the diet of the binturong has never been studied except for a few observations by Rabor (1986) and Esselstyn et al. (2004). This is despite the International Union for Conservation of

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Nature (IUCN) categorizing binturongs as vulnerable due to 30% population decline, which is believed to be caused mainly by habitat loss and over-exploitation (Willcox et al., 2016). In its Administrative Order No. 2019-09, the Philippines Department of Environment and Natural Resources (DENR) also listed the binturong under the Other Threatened Species category in the Updated National List of Threatened Philippine Fauna and Their Categories. Due to the emerging threats to the binturong in Palawan island, describing the food preference and feeding habits of the binturong could guide the formulation of conservation strategies and policies.

MATERIALS AND METHODS

Study Area

The study was conducted from July 2017 to May 2018 in Barangay Cabigaan, Aborlan Municipality, Palawan Province, Philippines located at 9°27'57"N 118°28'37"E (Fig. 1). The study site lies within the Aborlan-Guba Watershed, and most activities were performed in and around the 2-hectare Permanent Biodiversity Monitoring Area (PBMA) of the Monitoring and Detection of Ecosystems Changes for Enhancing Resilience and Adaptation in the Philippines (MODECERA) Program. The PBMA lies within a closed-canopy secondary-growth tropical lowland evergreen rainforest that has a high density of trees at 3,517 trees per hectare and is home to threatened trees such as “manggis” (*Koompassia excelsa* (Becc.) Taub.).

The climate in the area is Type III in the Modified Coronas Classification and Cluster 5 in the redefined Philippine climate zones of Corporal-Lodangcoa and Leslie (2017). Both climate type classifications describe the dry and wet seasons in this area as somewhat indistinct. However, mean precipitation is relatively lower from November to April, thus the dry season was considered as the period from November to April, while the wet season was from May to October.

Collection of Scats

Numerous hiking trails within the study site were traversed for 2-6 hours in the morning to search for binturong fecal samples or scats. Because scats were usually washed off by rain during the wet season, most of the scats were collected during the dry season. A total of 35 scats were opportunistically collected and identified as belonging to the binturong by their tubular shape, relatively large size (7-13 cm long and 3-5 cm wide) and dry weight (25-30 grams), based on records from captivity (DAP Fernandez, pers. obs.). The binturong is currently a threatened species due to its value in the pet trade and as food (BCSP, 2020). Thus, a location map of binturong scats and their exact coordinates were not provided as to not encourage poaching activities.

Scat Analysis and Identification

The scat analysis method, which is widely used in determining the diet and food habits of carnivores, was used due to its non-invasive nature (Reynolds and Aebischer, 1991). Specifically, the methodology of Khan et al. (2019) was followed. Scats were placed in individual 120-mL plastic screw-top bottles and soaked in 95% ethanol to kill potential parasites and prevent the growth of fungi. Each sample was then rinsed with tap water and filtered through a 0.5-mm stainless steel sieve. The residue was placed on a glass Petri dish, and the filtrate was filtered through a 10 x 10 cm sheet of filter paper. The Petri dish and filter paper were left uncovered to air-dry for about 1-3 days. After drying, the samples were sieved through a 1-mm stainless steel sieve followed by 0.5 mm stainless steel sieve. Solid materials collected every after sifting were spread on to a 75 x 100 cm white card stock. All identifiable matter such

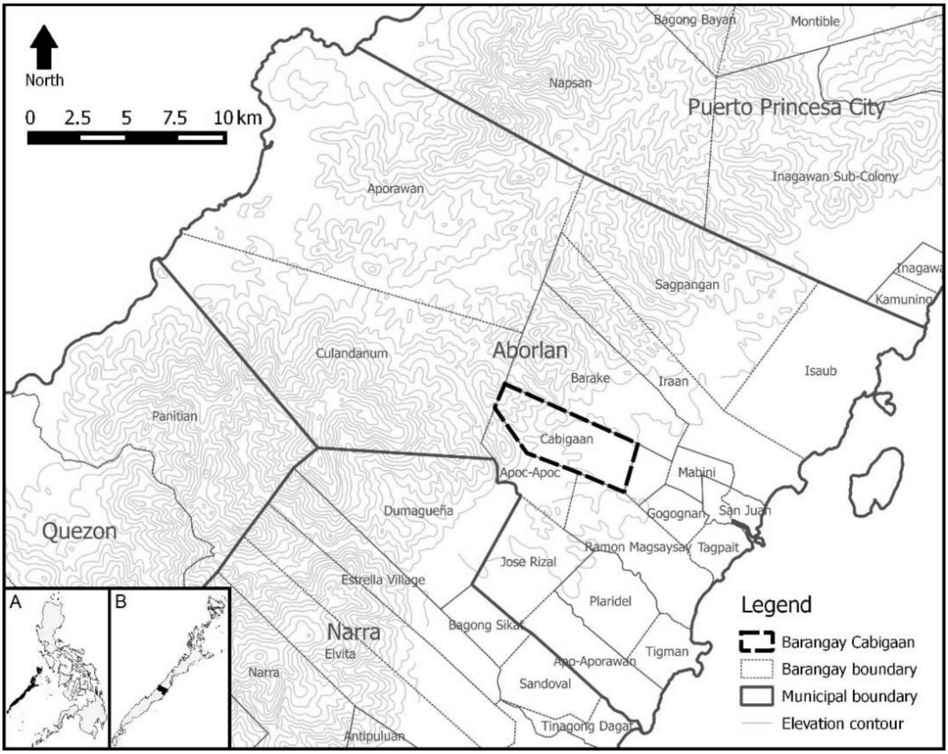

Figure 1. Location of study site in Aborlan Municipality, Palawan Province, Philippines (Philippine GIS Data Clearinghouse, philgis.org – Administrative boundaries, elevation contours).

as hair, bones, teeth, seeds, and other undigested units were sorted using fine forceps and isolated into separate labeled plastic resealable bags based on morphological similarity.

Approximately 1 gram of sample from each resealable bag was placed on a Petri dish and observed under 2X or 4X magnification using a digital microscope (T-1050 kena 3-in-1, Ken-A-Vision Manufacturing Company, Inc.). Undigested matter was then identified by its size, shape and distinguishing features. Differences of the species were pronounced using the naked eye but even presented major differences when subjected microscopically. Evaluation of *Ficus* seed samples was conducted by a licensed forester specializing in the taxonomy of the genus. At least three characteristics were utilized: 1) color, 2) orientation and arrangement of the seed based on placentation, and 3) seed size. As of writing, there is no available taxonomic guide for the identification of *Ficus* using seeds. Distinguishing characters of the seeds were mainly supplemented by the photographic evidence from cross-section of syconia from Co's Digital Flora of the Philippines (Pelser et al., 2011), and identification was further supplemented by the precursory treatments for Moraceae from Berg (1989, 2003, 2004).

To determine the contribution of each food species to the diet of the binturong, their frequency of presence (FP) and absolute frequency of occurrence (FO) were computed as:

$$FP = \frac{\text{number of scats containing certain a food item}}{\text{total number of scats}} \times 100\%$$

$$FO = \frac{\text{number of occurrences of a food item}}{\text{total number of occurrences of all food items}} \times 100\%$$

with “food items” being a certain species, common name, or other higher taxon, if the item cannot be identified to species level (e.g. grass, insect, mollusk, etc.).

RESULTS

Plant Matter as Primary Food Items

All 35 binturong scats collected contained primarily plant matter. Strands of binturong hair were found in eight scats and the remains of an unidentified beetle (Order Coleoptera) was found in 1 scat. *Ficus* species were the only seeds identified (Fig. 2). These are: 1) *Ficus aurata* (Miq.) Miq., 2) *Ficus botryocarpa* Miquel, and 3) *Ficus forstenii* Miquel. Identification of fig species utilized samples of seeds and synconia, the fleshy receptacle of figs, filtered from dried scat between 0.5 to 1.00 mm sieve sizes. Samples <0.5 mm were composed mostly of bracts, florets, and pubescence. *F. botryocarpa* had the highest frequency of presence and absolute frequency of occurrence, followed by *F. aurata*, and with *F. forstenii* having the lowest values (Table 1).

Table 1. Frequency of presence and absolute frequency of occurrence of seed species identified in binturong (*Arctictis binturong*) scats (n=35) collected in Aborlan, Palawan, Philippines.

Species	Frequency of Presence (%)	Absolute Frequency of Occurrence (%)
Ficus botryocarpa	68.57	60.00
Ficus aurata	40.00	35.00
Ficus forstenii	5.71	5.00

Figure 2. Seeds found in binturong (*Arctictis binturong*) scats in Aborlan Municipality, Palawan Province, Philippines: a) *Ficus aurata,* b) *Ficus botryocarpa,* c) *Ficus forstenii* (left) with *Ficus botryocarpa* (right).

F. aurata is a small erect tree species that bear bright yellow to orange figs. The figs are very small with syconia that are hirsute and occur axially. Presence of the epidermal extensions in the filtered scat samples primarily led to the immediate recognition of *F. aurata*. No other species under the subgenus present in the Philippines would have the same pubescence as that of *F. aurata*. On the other hand, the orientation of the seed also pointed out the identity of *F. aurata*. In addition, upon examining the samples microscopically, the seeds presented discoloration of the seed coat which is characteristic of the change of color of carotenoids due to acid during endozoochory (Fig. 2a). Moreover, the seeds of this species are smooth conal to globular in configuration which is not to be confused with the angular configuration of *F. ampela*s.

F. botryocarpa is a tall and erect tree species that bear green to yellow green figs. The figs are medium sized that typically occur cauliflorously on the trunk and major branches of the *F. botryocarpa*but can also be geocarpic. In the identification process using the seeds found in binturong scats, at least three *Ficus* species were candidates due to the immediate appearance and coloration of the seeds: 1) *F. deltoidea*, 2) *F. septica*, and 3) *F. botryocarpa*. However, the streaking of patterns of red to deep red are more pronounced in *F. deltoidea* and absent in *F. septica*. Moreover, the seeds point upward as compared with the downward orientation in *F. deltoidea* and linear in *F. septica*. Present in the samples are bracts and florets which are characteristic of gyno-dioecious species that ruled out *F. deltoidea* because of the monoeicy of the latter. On the other hand, the seeds are relatively larger as compared with that of *F. septica* and with pronounced angular configuration forming two to three sides of the seed (Fig. 2b).

F. forstenii is a small species that are semi-epiphytic. The synconia are deep red in color that are of the same size as that of *F. ampelas*. Coloration of seeds is the same as that of *F. aurata* because of endozoochory. However, the main difference between *F. forstenii and F. ampelas* , is the more pronounced protrusion of the apex of the seed that is longer (Fig. 2c). This feature is characteristic of monoecious species that can be related to efficient entrapment of pollinator wasps in lieu of fewer scales (bracts) in the ostiole. In addition, the angle of orientation of the seeds is upward with up to 30° that is not seen in any species of the Philippine fig under the subgenus (i.e. usually linear to only a very small degree of angular orientation). The seeds are also relatively smaller as compared to *F. aurata* which indicate further the lesser investment for seed size because of its arboreal habit.

Other Observations

All scats were found in tree branches as observed in Malaysian Borneo where binturongs preferred to defecate on tree forks and branches (Nakabayashi et al., 2019). In India binturongs were observed to feed on the upper canopy and rarely go down the ground unless these transferred from one tree to another (Murali et al. 2012). Presence of synconia in all scats collected suggested that binturongs ate whole fruits (Nakabayashi et al., 2019). Apparently, binturongs plucked fruits using their mouth or grabbed and steered fruit-bearing branches towards their mouth as reported by Murali et al. (2012). Seed samples in the scats found were only from ripe fruits of fig trees. This finding, as supported by the fruit pulps and mature seeds, concurs with other studies reporting that binturongs only feed on ripe fruits of a fig tree (Murali et al. 2012, Nakabayashi et al., 2017).

DISCUSSION

The presence of plant matter in all scats collected indicates that the binturong in this area of Palawan may be exclusively frugivorous. As a member of Order Carnivora, the binturong has many morphological features that evolved from a primarily carnivorous ancestor. However, because fruits are lower in protein compared to meat, they have developed numerous adaptations to frugivory with their fast digestive retention time of only about 6.5 hours (Lambert et al., 2014) and hypometabolic ability to reduce their peripheral circulation in order to decrease energy usage (McNab, 2002).

Although there was some animal matter present in the form of hair strands and a beetle, these are unlikely to be food items of the binturong. The color, size, shape, cuticular pattern and medullary pattern of all the hair strands collected from scats matched the characteristics of binturong hair from a concurrent study on the hair morphology of mammals in Palawan Island (DAP Fernandez, pers. obs.). As there is no known record of cannibalism among binturong, the presence of hair in their scats is probably from grooming. Observations in India have shown that a group of binturongs can spend an average of 13.33% of their day auto-grooming (Murali et al., 2012). Meanwhile, the remains of the beetle found in one the scats could not be identified due to absence of distinct parts. The presence of this insect in binturong scat may be due to either coprophagy by the beetle or accidental ingestion by the binturong if the beetle was eating the same fruit. To date, there is no published account of binturongs hunting for prey in the wild. Even when small arboreal mammals were present, Murali et al. (2012) observed that binturongs exhibited no aggression or predation attempt.

The results of this study revealed that binturongs in this area of Palawan have developed a degree of specificity for *Ficus* species. Given that binturongs are generally visual feeders, the discernment of food items does not involve putting much in consideration the color, placement, and structure of figs. This is in congruence with observations in India that they fed on *F. drupacea* (Murali et al., 2012) and in Malaysian Borneo, where they fed on *F. benjamina*, *F. borneensis*, *F. delosyce*, *F. forstenii, F. stupenda,* and *F. punctata* (Nakabayashi et al., 2016b, Nakabayashi and Ahmad, 2018, Nakabayashi et al., 2019). Moreover, Shanahan et al. (2001) also pointed out that mammalian frugivory on figs does not take into consideration the said characteristics, and that the food preference of binturongs may be linked to the nutrient rewards and the abundance of fruiting figs rather than the color or placement of figs.

On the other hand, the diet of the binturong does not follow the dispersal syndromes to frugivory proposed by Lomáscolo et al. (2010) using the visual and placement preferences of avian and mammalian species. In the proposed syndromes, avian discernment of figs relies on contrasting coloration that are typically axially located in the tree. Conversely, mammalian frugivory is related to vicarious selection via olfactory signals which are typical to bats and monkeys. Cauliflorous and geocarpic placement are most often related to the mammalian feeding habits because of their movement (i.e. creeping, crawling, saltatorial, etc.) from the base to the main branches of the tree (Lomáscolo et al., 2010, Harrison et al., 2012). With the known arboreal lifestyle of binturongs, the latter could be more favored but can occasionally be indulgent with axially placed figs when species having this configuration are abundant.

It should be noted, however, that the scats collected in this study were from a single season with only 35 samples. Furthermore, the precise attribution of scats to individual binturongs was not possible. In future research, molecular techniques can be employed not only to identify how many individuals are represented but also to detect the presence of prey items that are not represented by morphological remains. Attribution can also be achieved with the help of GPS tacking and or camera trapping, both of which have the added benefit of providing more information of the feeding habits and other behaviors of the binturong. It would be interesting to have a multi-year analysis in order to connect possible changes in *Ficus* phenology, due to climate change or other factors, to the ability the binturong to adapt to the changes in its environment as it has been suggested that binturongs may recall locations and fruiting periods of fig trees as opposed to simply relying on olfactory cues (Nakabayashi and Ahmad, 2018).

This study provides useful information on the food preference of wild binturong to be able to provide a higher quality care to binturong in captivity and to further understand the life and survival of binturong in the wild. The binturong's preference for figs suggests that the successful survival of the binturong is linked to that of fig trees, and in turn, binturongs may provide a valuable ecosystem service as fig seed dispersers in the forest habitat on which they depend. Conservation managers should carefully consider these factors when implementing strategies such as protected area zoning, captive breeding, and release programs for binturongs. Deforestation, hunting for food, and illegal trade are still the most pressing threats to the binturong. Fortunately, there is a growing interest regarding binturong conservation in the Philippines, and organizations like Arctictis Binturong Conservation, Palawan Council for Sustainable Development, and Western Philippines University have been working together on the forefront of field studies, education, and other efforts to further understand and protect the binturong.

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STATEMENT OF AUTHORSHIP

M.S. Allam and D.A.P. Fernandez conceived and designed the study. M.S. Allam conducted fieldwork. M.S. Allam and J.L.I. Balon performed laboratory and data analyses. All authors participated in writing and reviewing the manuscript.

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