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Distribution and diet of the common palm civet (*Paradoxurus philippinensis*) in the Mt. Makiling Forest Reserve, Luzon Island, Philippines

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In the Mt. Makiling Forest Reserve (MMFR) the common palm civet (*Paradoxurus philippinensis*) is both perceived as a carnivore which feeds on domestic animals and a frugivore which spreads coffee within the forested areas. This study aimed to determine the distribution and diet of common palm civets within the MMFR. Night transect walks/spotlighting, trapping and scat collection were conducted during the sampling periods. There was a total of four captures, one juvenile and three female adults indicating a potentially breeding population of civets in the area. Transect and trapping data concur with the number of fecal samples collected indicating that more civets occupy the higher elevations of Mt. Makiling. Figs, anahaw and wild banana were identified as the most common food items for civets across the various elevational gradients. Our results suggest that common palm civets are present in MMFR at all elevations but are mainly found within 600-900 masl of the lower montane forest, away from human dwellings. Common palm civets are thus frugivorous but spread of coffee in MMFR may not be attributed to them.

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INTRODUCTION

The common palm civet (*Paradoxurus hermaphroditus*) occurring in the Philippines along with those in Borneo and Mentawai Islands, Indonesia are morphologically and genetically distinct and are herein referred to as *Paradoxurus philippinensis* (Veron et al. 2015, Patou et al. 2010). They are found in agricultural and forested areas from sea level up to at least 2400 m elevation, in lowland, lower montane and, upper montane (or mossy) forests. They are active mostly at night, both on the ground and frequently in trees, feeding on a wide range of fruits, invertebrates and vertebrates (Heaney et al. 2016). The species appears to be widespread and abundant however, they are also hunted for bushmeat via snares (Scheffers et al. 2012) and prized as a captive natural processor of coffee to produce the expensive civet coffee.

Medium-sized mammals in the Philippines are far fewer and less studied than small mammals. They are difficult to trap and thus presence in an area is usually based on ethnobiological interviews. Beyond being hunted as food and occasionally as a pet, they are perceived as predators of domestic animals and are thus persecuted by locals. The common palm civet is an important seed disperser that may carry larger seeds (>100 milligrams) to more distant areas (Bartels 1964; Hughes et al.

1994; Mudappa et al. 2010; Nakashima et al. 2010a; Nakashima et al. 2010b; Subrata and Syahbudin 2016), especially in human-modified forests where larger mammals and birds have been decimated. This underscores its potential to disperse important forest tree species within fragmented forests or potentially introduce undesirable plants such as coffee into intact forests (Joshi et al. 2009).

The Mt. Makiling Forest Reserve (MMFR) is a state-owned forest reserve with an area of about 42.44 km^2 currently under the jurisdiction of University of the Philippines Los Baños (UPLB) by virtue of Philippine Republic Act No. 6967. The MMFR is classified as an ASEAN Heritage Park, featuring a diverse array of wild flora and fauna (Uriarte et al. 2013). Within MMFR is a community (Barangay Bagong Silang) in the agro-forestry area. Areas adjacent to the community have been cleared and planted with coconut, coffee, bananas and various fruits and vegetables, the products of which are sold to nearby areas. Coffee have apparently also been expanding in forested areas possibly though broadcast method (throwing away seeds) or seed dispersal by civets. The findings of this study will provide important information for management decisions of the Makiling Center for Mountain Ecosystems regarding the common palm civet-coffee association.

MATERIALS AND METHODS

Study site

MMFR is a protected area in Luzon Island, Philippines, located 65 kilometers (km) southwest of Metro Manila (14°08'14" N and 121°11'33" E), spanning parts of Los Baños, Bay, and Calamba City in Laguna Province and Santo Tomas in Batangas Province. The topography is generally rugged, with 70% of the total area having an elevation higher than 400 masl. Agroforest vegetation is common at lower elevations, as the generally fertile clay loam soil is ideal for farming, while the rest of the mountain is covered mostly in tropical lowland evergreen rainforest.

Five (5) transect routes, each with a ground length of 2 km and at least 300 meters (m) away from each other (Fig. 1), were laid mainly along hiking trails within the Molawin-Dampalit sub-watershed of MMFR from about 50 masl to 1,100 masl. Ribbon markers were placed every 50 meters as guide for observers during spotlighting.

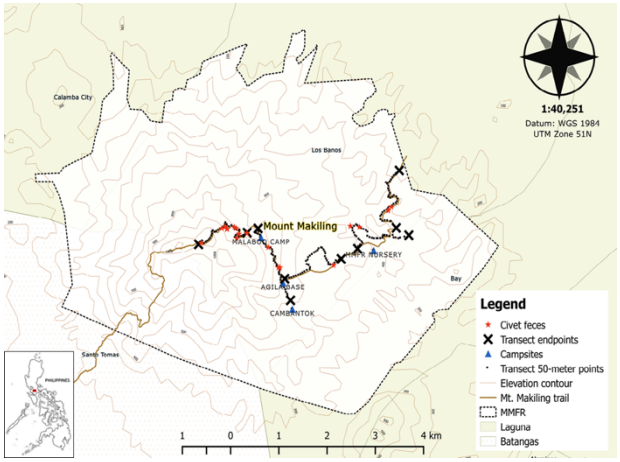

Figure 1: Map of the study area with the locations of the transect routes and the scats collected. Broken line indicates the limits of Mt. Makiling Forest Reserve in Luzon Island, Philippines.

Transects 1, 2 and 3 pass through secondary growth tropical lowland evergreen rainforest with patches of agroforestry (Fig. 2). The entire length of Transect 1 traverses a concrete part of the trail. Transect 2 traverses a small (~100 m^2) 'kaingin' area mainly planted with coffee and other common fruit-bearing trees while the rest of the trail reaches the upper portions of the Mudspring area and about 200 meters of concrete road. Transect 3 traverses a 2-hectare permanent biodiversity monitoring area and approximately 400 m of concrete trail.

Figure 2: Transect routes utilized in Mt. Makiling Forest Reserve in Luzon Island, Philippines.

Transect 4 traverses through 300 m of agroforestry area with fruiting trees while the rest of the transect goes through tropical lower montane rainforest. Transect 5 traverses a narrow trail with vegetation transitioning from tropical lower montane to tropical upper montane rainforest or "mossy forest" in the steep sloped ascent to the peak of the mountain.

Night transect surveys

Night transects were conducted to determine the number of individuals and occurrences of the common palm civet within the MMFR. Simultaneous surveys were conducted from April 19-23, 2017 and November 2-5, 2017 with a total of 36 km traversed. Headlamps and flashlights with maximum brightness of 200 lumens were used in spotting palm civets. Mt. Makiling is also home to the Malay civet (*Viverra tangalunga* Gray 1832). This morphologically differs with the palm civet in being larger and having black and white spots and bands (Heaney et al. 2016). According to the locals, the Malay civet is rarely sighted since it occupies larger territories, the boundaries of which are demarcated by the location of their latrines ('kumon'), unlike common palm civets that have isolated feces and do not defecate in latrines. Thus, we were able to reliably identify palm civets and for each encounter the following data were recorded: (1) coordinates of sighting location, (2) time of detection, (3) perpendicular distance of the civet from the transect, and (4) height of civet in vegetation. Eyeshines were the main indicator of presence at night, while feces are notable during the day. Upon sighting of eyeshine, binoculars were used to determine the species of the animal. Locations of all sightings or indirect signs of palm civets were recorded using a GPS device and were used in mapping their distribution within MMFR.

Trapping

Trapping of palm civets was conducted on November 2017 for the wet season and April 2018 for the dry season. Fifteen 60×30×30 centimeter (cm) box traps (material: GI wire, ga. 16)

with a single opening and tripped by a foot treadle were set in each transect to capture live palm civets. Ten of the traps were baited with ripe bananas of the *bongolan* variety and the other five traps were baited with live chicks. Each chick bait was placed in a separate compartment attached to the end of the trap and was ensured to be provided daily with food and water. Traps were deployed on the ground, about 250-300 meters apart, alternating the type of bait. Trap visits were conducted once every morning for 10 days each season to check for captured individuals and for rebaiting. A landslide on October 2017 prevented us from trapping in Transect 5 during the wet season. Thus, overall sampling effort was computed for 4 and 5 active transects for the wet and dry season, respectively.

Upon successful capture of an adult civet, each trap was covered with cloth and transported to the base camp. Each animal was fasted for 12 hours prior to sedation and its weight taken. A licensed veterinarian administered with 5-10 mg/kg of tiletamine hypochloride-zolazepam hypochloride (Zoletil®, Virbac Laboratories, France) intramuscularly using a disposable 1-cc syringe with a 25-gauge needle. Respiration rate was recorded and monitored.

Once completely sedated (approximately 4-6 minutes), each animal was carefully removed from the trap and laid on a table covered with clean white muslin cloth (Fig. 3). The right lateral, left lateral, anterior, posterior, dorsal and ventral regions of the animal were photographed. Morphometrics were taken using a standard tape measure, and the hair of the nape of the neck was shaved to mark each animal. Age class of the animal was inferred through observation of reproductive and dental conditions. Reproductive condition was noted through visual inspection of its external genitalia and secondary sexual characteristics. Dental condition was noted through visual inspection of its teeth. Young adults typically have sharp, white permanent teeth, while old adults often have well-worn, stained teeth. Upon return of palpebral and swallowing reflexes, each civet was placed back inside the trap for recovery. After full recovery, animals were provided with water and a piece of banana and were then released back into the site of capture.

Figure 3: Processing of a common palm civet captured in Mt. Makiling Forest Reserve in Luzon Island, Philippines.

Scat collection and processing for diet analysis

Fecal samples were collected along transect routes in the morning for diet analyses. All fecal samples were preserved in 70% ethanol. For the diet analysis, each sample was sun- or air-dried prior to processing in the laboratory. The samples were then soaked in warm 70% ethanol for an hour, filtered, and air-dried. Once completely dry, each sample was examined in a petri dish to isolate hair, seeds, and other debris (e.g. shells, plant fibers, etc.). Isolated seeds were brought to the Laboratory and Experimental Services Division of the DENR Ecosystems Research and Development Bureau in University of the Philippines Los Baños, Laguna, for identification.

RESULTS AND DISCUSSION

Distribution

Five sightings of common palm civets were recorded from transect surveys covering a total of 36 km in MMFR (Table 1). Three (3) individuals were observed in Transect 4, one (1) in Transect 1, and one (1) in Transect 2. No sightings were recorded from Transect 3 and Transect 5.

Common palm civets in MMFR seem to be adaptable to a certain level of disturbance as all transects where sightings were recorded are regularly used by hikers, forest reserve employees and the local community residing in the mountain. According to Johnson et al. (2009), the closely-related *Paradoxurus hermaphroditus* has been recorded from 735 to 1,743 masl in northern Laos. Sightings were only recorded during the evening transect walks. Common palm civets are typically known to be nocturnal (Wilting et al. 2010) or crepuscular (Azlan 2003), however some studies have recorded them during the daytime (Cheyne et al. 2010).

Four (4) individuals were sighted in the mid-canopy level about 5 to 11 meters from the ground, while only one (1) was seen at ground level, concurring with other studies that found palm civets to be semi-arboreal and establish their day-beds on trees (Joshi et al. 1995). This hints of a possible vertical habitat partitioning between this species and the Malay civet. This species also occurs in MMFR, but, unlike the common palm civet, it is usually found foraging or hunting on the ground (Heaney et al. 2016) and establishing day-beds on the forest floor (Colon, 2002).

Crossing of human-established trails and roads, as observed in the individual sighted within Transect 2, seems to be a typical behavior among common palm civets (Jennings et al. 2015; Nakabayashi et al. 2014). However, this may make them vulnerable to vehicular injury or road kill, particularly on the concrete roads in MMFR where there are sharp curves, no streetlights and local residents who sometimes drive motorcycles at night.

Total trapping effort in MMFR was 1,350 trap-nights with an overall trapping success of only 0.296%. This very low value underscores the difficulty of capturing such cryptic carnivores. This may also reflect a large home range. Four (4) common palm civets were captured, consisting of one (1) juvenile and three (3) adults (Table 2). Physical examination showed that the adults were all female, while the juvenile was not examined and released immediately. All individuals were captured above 400 masl, concurring with the location of most of the sightings which

Table 1: Sightings of common palm civets using transect surveys in Mt. Makiling Forest Reserve, Luzon Island, Philippines.

DATE	TRANSECT	TIME OF DETEECTION	ELEVATION (masl)	AGE CLASS	HEIGHT IN VEGETATION (m)	REMARKS
20-Apr-17	2	20:28	390	Unknown	0	Crossing the road
22-Apr-17	4	20:42	740	Adult	11	On a pandan plant
22-Apr-17	4	20:46	750	Adult	8	Detected on a tree on the way to Camp Malaboo
23-Apr-17	4	21:02	740	Adult	8	Feeding on a *Ficus* tree
2-Nov-17	1	19:34	320	Juvenile	5	On a palm tree

were at higher elevations of Mt. Makiling (approx. 600-900 masl).

Our night transect and trapping results indicate the presence of a potentially breeding population of common palm civets in MMFR. They are more commonly found within the tropical lower montane rainforest of Mt. Makiling, away from human dwellings. This distribution may be influenced by the availability and abundance of fruits and suitable day-bed sites such as reported by Nakashima et al. (2013), while other factors may include habitat disturbances (e.g. human interference, natural disasters like recent landslide incidents in MMFR, etc.). The low trapping success from the sighting and trapping data gathered during the wet season (October-November 2017) and dry season (April-May 2018) demonstrate the need for longer observation periods in order to generate sound estimates of the palm civet population in MMFR.

Table 2: Common palm civets captured in Mt. Makiling Forest Reserve, Luzon Island, Philippines.

DATE	TRANSECT	SEX	AGE
25-Oct-17	3	Unknown	Juvenile
21-Apr-18	4	Female	Young adult
21-Apr-18	4	Female	Adult
3-May-18	5	Female	Adult

Diet analysis

Table 3: Seeds isolated from palm civet feces collected from the five transects in MMFR.

TRANSECT	ELEVATION RANGE (masl)	NUMBER OF FECAL SAMPLES COLLECTED		TOTAL
		Dry season	Wet season	
1	180-365	3	0	3
2	385-430	4	1	5
3	420-510	1	2	3
4	510-700	3	0	3
5	735-1090	11	18	29
Total		22	21	43

A total of 43 fecal samples was collected during the wet and dry sampling periods (Table 3). There was little variation in the number of scats collected between the wet and dry season samplings. Most of the scats were collected in Transect 5, and were found along the trail on the ground, while a few were deposited on fallen logs or on rocks near water. Feces have been reported to be in areas characterized by low stem density and canopy cover (Nakashima et al. 2010) as well as roadsides which are scent-marked probably as communication sites (Nakabayashi et al. 2014). Scats were not clumped in distribution and a higher number of samples were collected from montane to mossy forests. This further agrees with transect and trapping data, and suggests that common palm civets occur more often at higher elevations of Mt. Makiling.

Table 4: Seeds isolated from palm civet feces collected from the five transects in MMFR.

SPECIES	NUMBER OF FECAL SAMPLES			FREQUENCY (%)
	Dry season*	Wet season	Total	
Anahaw (*Saribus rotundifolius*)	3	3	6	13.95
Ficus sp.	7	1	8	18.60
Amugis, round (*Koordersiodendron pinnatum*)	2	1	3	6.98
Saging matsing (*Musa acuminata*)	8	7	15	34.88
Sarawag (*Pinanga insignis*)	1	1	2	4.65
Unidentified	0	8	8	18.60
**Fecal sample negative from seeds	1	0	1	2.33

*No seeds were isolated from 1 of the 22 fecal samples collected during the dry season.

Some studies have observed that palm civets primarily feed on fruits but also prey on small vertebrates and invertebrates outside the fruiting season (Joshi et al. 1995). In Singapore, orthopterans comprised 14.5% of palm civet diet indicating that azfrugivorous diet is supplemented with carnivory and that the understorey is also utilized by this arboreal species during foraging (Fung et al. 2018). Like fruit bats, palm civets are nocturnal species that mainly feed on fruits that provide high-energy diets. Our results show that in Mt. Makiling, there was no evidence of carnivory during the sampling periods. When seeds were present in the scats, they numbered from one (Amugis: 30 mm) to hundreds (*Ficus* spp.: 1 cm) of seeds. Such findings may indicate that there is a broad range of seeds that are available to the palm civet.

This study clarifies the notion that palm civet in Mt. Makiling are carnivorous animals that prey upon domesticated animals such as chickens. Our results indicate that the species is primarily frugivorous and correspond with the findings of Joshi et al. (1995), Grassman (1998), and Jothish (2011). Six species of seeds were isolated from the samples, one of which is an unidentified species (Table 4). Identified seeds are found native to the Philippines and are mostly forest species. The fruits of Anahaw (*Saribus rotundifolius*), figs (*Ficus* spp), and wild banana (*Musa acuminata*) were the most common food items. Others include the Pinang palm or Sarawag (*Pinanga insignis*) and Amugis (*Koordersiodendron pinnatum*). A study by Gruezo and Soligam (1990) found *P. insignis, Caryota rumphiana* var. *philippinensis, Coffea arabica* and *Ficus minahassae* in 12 fecal samples from MMFR.

Ficus spp. are keystone species that provide nutritious, abundant and a steady supply of fruits for various wildlife species (Kinnaird et al. 1999). Nocturnality allows civets to forage longer on figs and rely on olfaction rather than on visual cues giving them a competitive advantage over other frugivores (Nakabayashi et al. 2016). Another keystone species part of the diet of the palm civet is wild banana (*Musa acuminata*), or "saging matsing" in the local vernacular. The wild banana is a pioneer species that can rapidly establish and provide frugivorous wildlife with a steady supply of food. They are likened to figs as "keystone species", because their characteristics may contribute to an increase in wildlife biodiversity (Marod et al. 2010). This species is the progenitor of hybrids that make up modern bananas and plantains. They have also been identified as crop wild relatives in crop improvement programmes and contain a wealth of genetically important traits due to their adaptation to a diverse range of habitats (Vincent et al. 2013), thus making them important in terms of food security. Figs and wild banana are the most numerous seeds found in common palm civet scats in MMFR, numbering in the hundreds per scat.

Forest palms are also included in the palm civet diet. Anahaw (*Saribus rotundifolius*) is a forest palm (Family Arecaceae) which is both an economically and ecologically important palm (Dichoso 2010). Aside from its fruit which is a typical food item for wildlife species such as the 'butaan' (*Varanus olivaceus*), a monitor lizard endemic to the Philippines (Sweeney et al. 2017), its leaves are used as a tent by several bat species while leaf extracts also contain antibacterial compounds (Essien et al. 2017). This plant is categorized as Other Threatened Species (OTS) under DAO 2017-11. Based on our results, the fruits of the palm Sarawag (*Pinanga insignis*) was less utilized by the palm civets. The study by Gruezo and Soligam (1990), on the other hand, identified this as a preferred food of civets and possibly dispersed due to the enhanced germination upon transit of food within the civet's digestive tract. Palms form important components in most forest types, *P. insignis* is widespread throughout the Philippines while *S. rotundifolius* is distributed mainly on the eastern side of Luzon Island (Fernando 1990).
Another important fruit in the diet of the palm civet is the 'amugis' (*Koordersiodendron pinnatum*). This indigenous tree

with an edible sweet fruit and wood used for construction and other industrial purposes (Fernando et al. 2004) also has an exudate with medicinal properties (Gentallan Jr. et al. 2018). This tree is classified as OTS under DAO 2017-11.

Three species of coffee (*Coffea arabica*, *C. liberica*, and *C. canephora*) cover some areas of the Cambantoc and Molawin-Dampalit subwatersheds of MMFR (Borja 2015). These areas cover transects 2 and 3. However, despite the fact that palm civets are apparently well-known by locals to eat coffee in these areas, our observations indicate otherwise. Coffee have been found to be less preferred by the palm civets and the seeds collected from feces did not germinate (Gruezo and Soligam 1990). Thus civets are not good dispersers of coffee.

CONCLUSION

Common palm civets are present in MMFR. They may be found at all elevations but are mainly distributed above 600 masl within the lower montane forest, away from human dwellings. Common palm civets in MMFR are frugivorous and eat a variety of important forest species. However, the spread of coffee in MMFR may not be attributed to them.

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CONTRIBUTIONS OF THE AUTHORS

APODG and DAPF devised the project, the main conceptual ideas, and proof outline. GCSC worked out almost all of technical details in the field and performed laboratory work. APODG wrote the manuscript with input from all authors. All authors discussed the results and commented on the manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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