Ecology of Philippine Scrubfowl *Megapodius cumingii* on Palawan with notes on other islands

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Ecological observations of the Philippine Scrubfowl *Megapodius cumingii* were conducted from March 2017 to December 2019 on Puerco Island off Palawan, Philippines, using high definition cameras. Visits to other islands in the country were also conducted to determine the presence of Philippine Scrubfowl and collect information on their breeding behaviour and habitat. The characteristics of nesting areas did not vary significantly among sites except in substrate and distance to the highest waterline. The number of chicks observed from the three nesting fields monitored with CCTV cameras in the months of August–November 2019 was double the number of active nests recorded in the same area, suggesting that pairs of Philippine Scrubfowl use more than one incubation site. Chicks appear to avoid predation from migratory owls, herons and rails by nocturnal hatching and quickly moving to nearby bushes. The absence of adult Philippine Scrubfowl in certain months of the year and the observations of birds flying from Puerco to Palawan highlight the need to conduct telemetry studies to better understand the movement and ecology of the species. Conservation of the species would require better protection of the breeding sites and reduction of hunting activity.

INTRODUCTION

Megapodes are ground-dwelling birds, aptly named for their large feet, super-precocious chicks and their unique nesting habit of using environmental heat for incubation (Bashari *et al.* 2017, Kennedy *et al.* 2000). There are seven recognised subspecies of the Philippine Scrubfowl *Megapodius cumingii* (Bashari *et al.* 2017, Kennedy *et al.* 2000, Dekker & McGowan 1995, Jones *et al.* 1995), of which four occur in the Philippines (Allen 2020, Kennedy *et al.* 2000). Very little is known about the ecology of the Philippine Scrubfowl. It is known to occur from sea level up to 2,100 m (Allen 2020, Kennedy *et al.* 2000) in a variety of habitats from sandy beaches and shoreline to coconut groves as well as in tropical lowland and montane rainforest. The extent to which the species uses each habitat type remains unclear.

As with other megapode species, the Philippine Scrubfowl makes use of heat produced by the decomposition of organic matter to incubate its eggs in burrows and mounds (del Hoyo *et al.* 2014, Tabayag & Cruz 2013, Kennedy *et al.* 2000, Torres & Mendoza 2000, Sinclair *et al.* 1999, Dekker & Brom 1992), as well as by burying eggs in sand burrows directly exposed to solar radiation (Bashari *et al.* 2017). On Alibijaban Island in northern Luzon (Aala 2001), Danjugan Island in south-western Negros (King *et al.* 2003) and Sabah, the species is reported to incubate eggs using mounds. On small islands off the coasts of Palawan, it uses nesting fields on sand heated only by solar energy (Tabayag & Cruz 2013, Matillano *et al.* 2008). There have been contradictory accounts as to the breeding behaviour of the Philippine Scrubfowl. Kennedy *et al.* (2000) stated that up to 20 birds may attend a nest mound at the same time while King *et al.* (2003) and Aala (2001) reported not observing any adults attending a nest mound.

In 2019 the International Union for the Conservation of Nature (IUCN) listed the Philippine Scrubfowl as of Least Concern but pointed out that populations are declining (IUCN 2019). In the Philippines, the bird is threatened due to loss of habitat and hunting (BMB 2020), and populations are now confined to a few coastal beaches and to small, isolated islets and islands with few or no human inhabitants (Kennedy *et al.* 2000). The aim of our study was to determine the habitat characteristics of incubation sites, and describe the breeding strategies and breeding behaviour of the Philippine Scrubfowl from at least four islands in the Philippines. Incidental notes on species movement, diet, mortality and predation were also made.

METHODS

Study sites

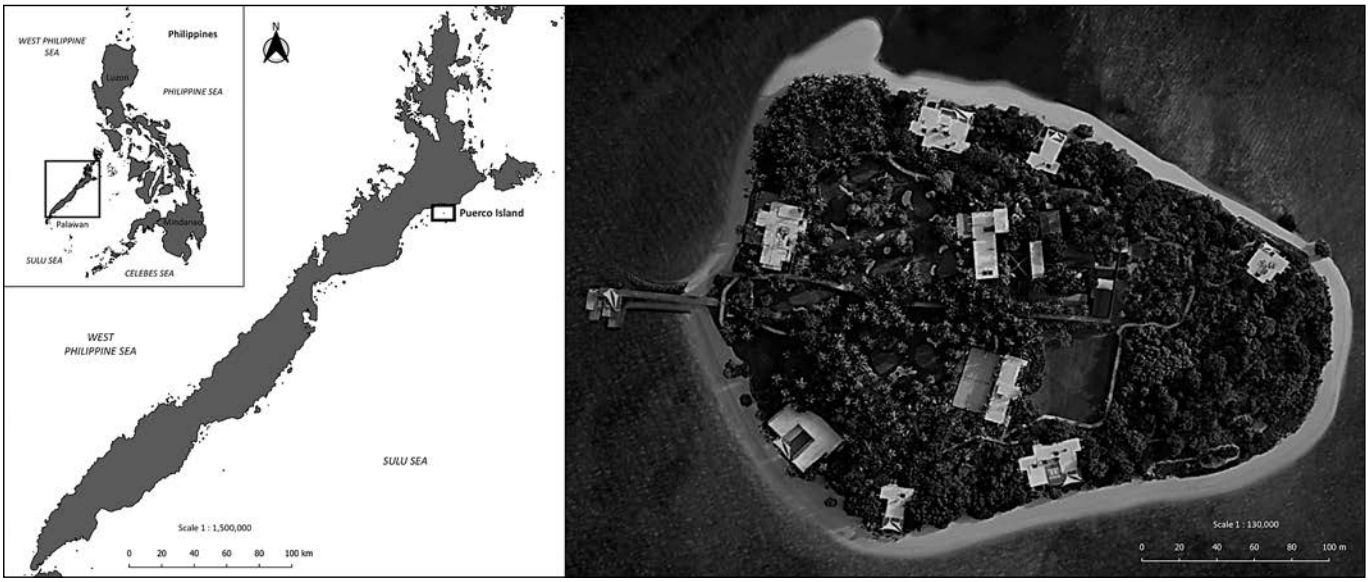
Observations on the breeding ecology of the Philippine Scrubfowl, with a focus on nesting behaviour, presence of young and immature birds, counting of individuals, and interviews with key local personnel, were conducted on four islands, namely: Baguan Island in the Turtle Islands Wildlife Sanctuary; Danjugan Island Marine Reserve and Sanctuaries in Cauayan, Negros Occidental; Greater Santa Cruz Island in Greater and Little Santa Cruz Islands Protected Landscape and Seascape; and Puerco Island, more popularly known as Banwa Private Island, in Roxas, Palawan.

Puerco Island (10.318°N 119.481°E), better known as Banwa Private Island, falls within the political jurisdiction of the municipality of Roxas, Palawan (Figure 1). The pear-shaped 6.6 ha island is surrounded by sandy beaches, seagrass beds and coral reefs. It is at least 7 km away from the nearest point on Palawan. Prior to 2016, the vegetation on the island was dominated by coconut *Cocos nucifera*, *Acacia auriculiformes, Leucaena leucocephala, Pandanus tectorius,* shrubs and grasses. Over years of development, native plants were introduced, including beach forest trees such as *Pongamia pinnata*, *Terminalia catappa, Pterocarpus indicus* and *Syzygium* sp. A 200 m^2 section on the eastern side of the island is a known nesting site of the Philippine Scrubfowl and was designated by the organisation managing the island, Aquos Management Inc., as 'Tabon Bird Sanctuary'. Permissible activities in this part of the island are limited to monitoring and observations in designated bird hides. Observations of the breeding Philippine Scrubfowl were conducted from March 2016 to December 2019.

Baguan (6.104°N 118.447°E), a 29 ha island, is designated as a strict protection zone of the Turtle Islands Wildlife Sanctuary, in the southernmost part of the Philippines. It is the only uninhabited island within the six-island municipality of Turtle Islands in the province of Tawi-Tawi. It is mostly flat, with a hilly portion reaching an elevation of 40 m. It is a breeding ground for Green Sea Turtle *Chelonia mydas*. *Buchanania arborescens*, coconut and other coastal species dominate the terrestrial flora. The island was visited on 22–23 August 2019.

Danjugan Island (9.871°N 122.377°E) is 43 ha in size and is recognised as a marine reserve and sanctuary of the municipality of Cauayan, Negros Occidental. The island supports beach forest on hilly karsts with mangroves, intertidal mudflats and saltwater lagoons. The south-western section of the beach is a nesting site

Figure 1. Location of Puerco Island (also known as Banwa Private Island) in the Philippines.



of the Philippine Scrubfowl and has been named as Tabon Beach. Observations were conducted on 17–18 January 2013, in May 2014, May 2016, August 2016 and on 16–19 May 2020.

Greater Santa Cruz Island (6.865°N 122.062°E) is one of two islands in the Greater and Little Santa Cruz Islands Protected Landscape and Seascape off Zamboanga City, Zamboanga Del Sur, in Mindanao. It covers 256 ha with seawater lagoons and mangroves. About 10% of the beach area is open to tourists during the day and the rest has been classified as a strict protection zone. Philippine Scrubfowl have been reported breeding in several areas in the north-eastern section of the island. Observations were conducted on 8 October 2016, 14 August 2017, 10 December 2017 and 15 December 2019.

Breeding observations

Breeding observations on the Philippine Scrubfowl on Puerco were conducted using high-definition closed circuit television (CCTV) cameras that were strategically located to allow observations with minimal disturbance. Three CCTV cameras (numbered 3, 4 and 5) were installed in April 2017 and two more (numbered 1 and 2) were added in August 2017 when the nesting field expanded into the dense pandan (*Pandanus* sp.) grove (Figure 2). Four more nesting fields close to the shoreline emerged in February 2018 where no CCTV cameras were installed. In 2018, the nesting field adjacent to CCTV camera 4 was abandoned as the trees beside the nesting field had grown and covered at least 50% of the area.

The CCTV cameras were operated continuously for 24 hours for a minimum of eight days per month, e.g. 9–16 March, 8–17 April, 26 May–3 June 2017; 20 January, 16–30 April, 16–24 May, 3–12 September, 16–21 October 2018; and 6 September–30 December 2019. Printed photos of the nesting field taken from the CCTV footage were used to count individuals and pairs at each burrow between 06h00 and 07h30, when most of the breeding population was likely present. The positions of the individuals and burrows were noted and compared over time. A review of the night video footage was also carried out to count the number of chicks emerging from nests. We marked the position of the chicks when they first emerged from the sand via a printed photo. Counts for CCTV 5 and 3 were combined as they covered different parts of the same nesting field. Estimated counts of active nests and individuals for the four remaining areas without CCTV were conducted between 07h30 to 08h00 at least once a month using a bird hide in the middle of the four nesting fields (green diamond, Figure 2). It was not possible to determine if the same birds returned to the same nest each day. Our data on chicks emerging from the nests were limited to areas covered with CCTV cameras covering the months of March to June 2017 and August to December 2019. Our observations amount to a total of 4,008 hours (1,344 h in 2017, 672 h in 2018 and 1,992 h in 2019).

Opportunistic visits to other similar islands in the Philippines were made to locate all known breeding mounds (active and abandoned) where possible. General characteristics of the breeding habitat and breeding mounds were noted and observations on feeding and breeding behaviour were made. Informal interviews with local personnel (e.g. environment officers, park rangers, security personnel, local tour guides) were also conducted.

Nest site characteristics

In this study, we use the term 'nest mound' (Figure 3, upper) to describe a pile of loam, sand or coral rubble raked to form a mound (Dekker & Brom 1992) and use the term 'nesting field' (Figure 3, lower) to describe areas of communal nesting on sun-exposed beaches with holes or pits (Indrawan *et al.* 1998). Nests were deemed active when they contained fresh tracks, were free of debris and showed signs of fresh digging or raking marks (Sinclair 2002). Abandoned nests were identified by a combination of the following features: moderate to heavy accumulation of fallen leaves on the entire mound, moderate to heavy growth of grasses and other plants, the absence of pits and holes, no fresh tracks, and occurrence of extensive root growth in the nest (Radley *et al.* 2018, Wiles & Conry 2001).

We characterised nests according to 10 physical variables selected on the basis of previous studies on megapodes (Radley *et al.* 2018, Sinclair 2002, Wiles & Conry 2001, Sinclair *et al.* 1999) (Table 1). Breeding sites were visited in the middle of the day when there is least activity on the nest to measure habitat characteristics. Using the centre of the nesting field and burrow as a reference (Radley *et al.* 2018), we measured 5 m radial distances towards the north, south, west and east at each nest site (Sinclair 2002). We broadly categorised substrate type as sand, loam or coral rubble and visually estimated the percentage composition of each substrate for each mound and field. Height and longest length of the mounds were measured using a roll tape. Percentage canopy cover was measured using a canopy densiometer, while the diameter at breast height (dbh) of trees was measured using a tape measure. The total number of trees with >10 cm and <10 cm dbh was counted and the average height of trees was estimated. Distance to the nearest tree, shrubs and to the highest waterline was measured using a roll tape. Forest type was broadly categorised as beach forest, beach

Figure 2. Distribution map of the breeding sites of the Philippine Scrubfowl *Megapodius cumingii* on Puerco Island. Note that numbered 'T' refers to trees and 'P' refers to pandan (*Pandanus* sp.) groves.

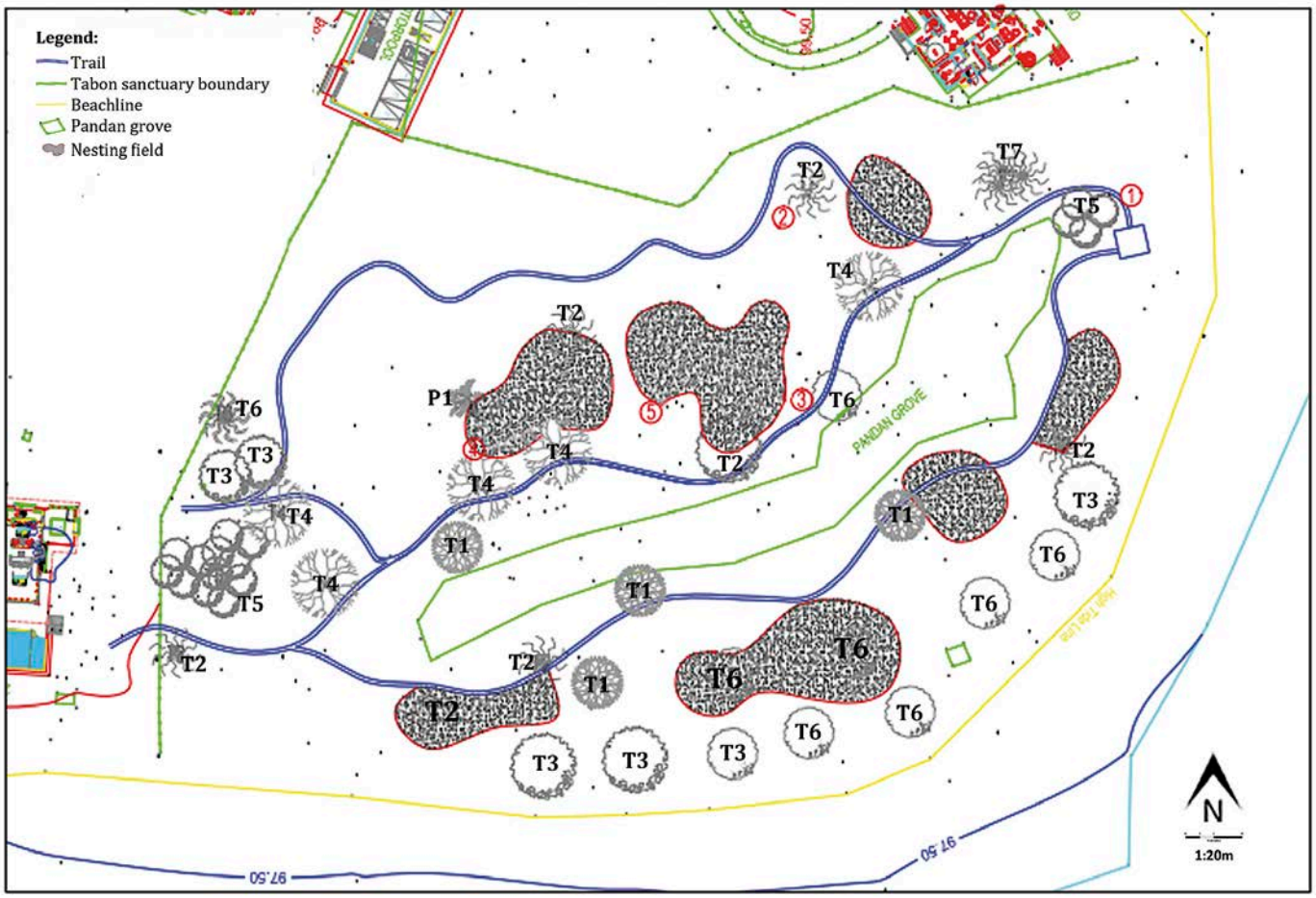


Table 1. Summary of habitat variables describing nest characteristics at four island sites. Abbreviations: dbh – diameter at breast height, NA – not applicable.

Habitat characteristics	Puerco (n=8)	Baguan (n=3)	Greater Santa Cruz (n=13)	Danjugan (n=4)	*H* statistic
% sand	90.2 ± 1.6 (87–93)	26.0 ± 5 (20–35)	26.0 ± 2 (25–30)	30.0 ± 21 (10–60)	2.2
% loam	1.4 ± 1.7 (1–5)	5.0 ± 1 (3–6)	48.0 ± 7 (40–60)	15.0 ± 23 (10–50)	9.4***
% coral rubble	8 ± 2.7 (5–12)	19.0 ± 13 (5–40)	20.0 ± 7 (10–30)	55.0 ± 31 (20–90)	5.6
% canopy cover	21.0 ± 37 (0–70)	5.0 ± 2.9 (5–5)	14.0 ± 12 (0–30)	40.0 ± 37 (5–75)	4.6
Mound height in metres	NA	3.1 (0.5–1.9)	1.4 ± 0.7 (0.2–2.3)	0.9 ± 0.7 (0.1–1.8)	10.5**
Length of mound in metres	NA	5.8 ± 0.8 (5–7)	7.0 ± 3.0 (0.2–2.8)	5.0 ± 2.7 (1.2–9.0)	0.5
Height of trees in metres	7.0 ± 1 (6–8)	4.5 ± 0.5 (4–5)	4.5 ± 0.8 (3–6)	7.0 ± 37 (5.5–8.5)	2
Trees with dbh >10 cm (range in metres)	20.0 ± 1 (1–4)	79.0 ± 10 (16–36)	276.0 ± 7 (12–24)	69.0 ± 9 (14–33)	1.2
Trees with dbh <10 cm (range in metres)	16.0 ± 1 (1–4)	7 ± 0.5 (2–3)	53.0 ± 2 (1–8)	23.0 ± 0.5 (7–8)	2.2
Pandanus coverage (%)	5.3 ± 8.5 (0–20)	1.7 ± 2.3 (0–5)	NA	7.5 ± 8.3 (0–20)	8.4*
Distance to highest waterline (range in metres)	31.0 ± 26 (3–70)	260.0 ± 134 (106–350)	41.0 ± 16 (21–80)	65.5 ± 14 (59–75)	9.8***
Distance to nearest tree (range in metres)	3.0 ± 1 (1–5)	2.5 ± 0.5 (2–3)	2.0 ± 0.9 (0–3.5)	0.6 ± 1 (0–3)	3.6
Distance to nearest shrubs (range in metres)	3.0 ± 0.1 (0.5–10)	5.5 ± 0.5 (5–6)	3.0 ± 1 (1.5–5)	0.5 ± 4 (0.5–1)	4.8
Nest type	Nesting field	Mound	Mound	Mound	
Habitat type	Beach forest	Beach forest	Beach forest with mangroves	Beach forest with mangroves	

*P<0.01; **P<0.001; ***P<0.0001

Figure 3. Nest mound on Greater Santa Cruz (upper) and nesting field on Puerco Island (lower).

forest with mangroves, and exposed sandy beach. The habitat characteristics of nests were compared and tested for differences using the Kruskal-Wallis ANOVA test, as data were not normally distributed (McKnight & Najab 2010).

RESULTS

Breeding habitat

Two subspecies of the Philippine Scrubfowl, *M. c. pusillus* and *M. c. cumingii*, are known to use solar radiation to incubate their eggs. Birds on Danjugan, Greater Santa Cruz and Baguan built mound-type nests with variable shapes including conical, semi-conical or flattened tops, while on Puerco the species used irregularly-shaped nesting fields with burrows dug into solar-heated sandy beaches (Figure 3, lower). There was limited variation in habitat characteristics among nesting mounds from different islands except in percentage of loam in mounds (H=9.4, df =2, p<0.009), distance to highest waterline (H=9.8, df=2, p<0.007) and pandan (*Pandanus* sp.) coverage (H=8.4, df=2, p<0.01). At all four sites, burrow (n=7) and mound nests (n=3) exhibited a moderate to heavy concentration of leaf litter when the surrounding trees covered more than 50% of the nest area.

Observations of breeding behaviour

Pairs of Philippine Scrubfowl on Puerco worked on the sand burrows from 05h20 to 09h45 and moved to the nearby bushes before resuming around 15h00 to 17h40 (n=285). The birds undertook similar activities daily from January to early October each year. They spent an average of three days, with a range of 2–4 days (n=118), to dig burrows, lay eggs and cover them with sand. Birds on Puerco only used sand as nesting material.

Philippine Scrubfowl on the islands of Baguan, Greater Santa Cruz and Danjugan all used nest mounds made of loam, sand, coral rubble, organic debris or a combination thereof (Table 1). After laying an egg, the parents were no longer observed on the nest but were regularly observed searching for food less than 10 m from the nest mound.

On at least two occasions (12 March 2017 and 13 June 2017), a male pursued a female for several minutes before copulation that lasted approximately 5 sec (Figure 4, left). One female was observed laying an egg in the middle of the burrow (at least 50 cm below the surface) around 18h38 on 15 March 2017 (Figure 4, centre and right). This took less than 5 min and the female immediately covered the egg with sand before leaving to roost in a nearby tree. A bird in Baguan was seen digging a 1 m-deep burrow in one section of a 2 m-wide mound on 23 August 2019. At around 18h12, it laid

Figure 4. Copulation inside a nest burrow (left) and female Philippine Scrubfowl laying an egg inside a nest burrow (centre and right) on Puerco Island.

Figure 5. Aggressive behaviour displayed by Philippine Scrubfowl on Puerco Island, showing raised wing (left) and, leaping in the air and using the feet to strike (centre and right).

Figure 6. Total number of breeding Philippine Scrubfowl at three nesting fields on Puerco Island, with the total number of active nests from late August to late November 2019.

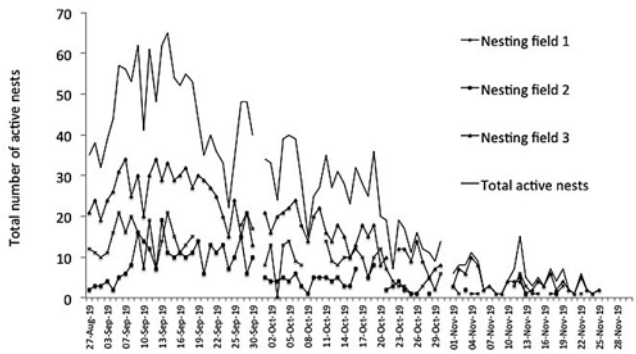
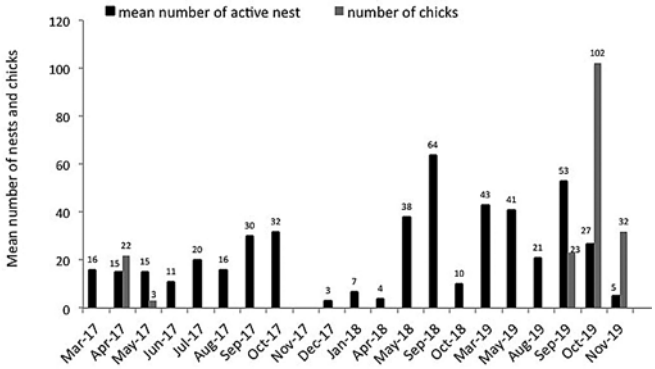


Figure 7. Mean number of active nests and number of chicks observed from three nesting fields covered by CCTV cameras between September and November 2019 on Puerco Island.



an egg and started covering the nest with sand. This burrow was completely covered by 19h15.

The birds were very territorial within nesting sites. On 16 March 2017, one intruder was met with raised wings (Figure 5, left), followed by a lunge that turned into a scuffle (Figure 5, centre and right) whereby birds leapt into the air, struck out with their powerful feet (del Hoyo *et al*. 1994) and chased each other outside the nesting field. When alarmed, birds outstretched their neck, momentarily froze and quickly ran off into the nearest vegetation for safety or flew to nearby trees.

Breeding population

There were only six individuals of Philippine Scrubfowl reported on Puerco in 2012 (Tabayag & Cruz 2013). In 2016, 24 active burrows were counted using CCTV cameras in three nesting fields. The following year, the nesting fields had expanded, and 34 burrows were counted. This increased to 98 in 2018 with the addition of four more nesting fields close to the shoreline (Figure 2). In 2019, the total number of burrows in the three nesting fields with CCTV cameras reached 64 (Figure 6) and the total number of active burrows reached 154. September consistently recorded the highest number of active burrows. No nesting activity was observed between late November and December from 2017 to 2019 (Figures 6 & 7).

A total of 22 chicks were observed at two nesting fields monitored from April to May 2017. From September to December 2019, a total of 157 chicks were counted at three nesting fields, with 102 chicks recorded in October 2019 alone. This was double the mean number of active nest recorded on the same nest fields. Few more chicks emerged in November, with no records in December 2019. Chicks emerged between 18h30 and 06h00 (n=178) and peaked from 21h00 to 01h00 (n=121). All our observations were of solitary chicks except for two occasions (11 and 12 April 2017) when a pair of chicks emerged at the same time from the same nest burrow. On both Greater Santa Cruz and Baguan, chicks were reported by local wardens in the months of July–August.

Figure 8. Barred Rails *Hypotaenidia torquata* raiding a partially exposed egg inside the nest burrow of Philippine Scrubfowl (left), and Northern Boobook *Ninox japonica* feeding on chick (right) on Puerco Island.

Diet and movements

At all sites, Philippine Scrubfowl generally moved around in pairs while searching for food and when roosting on the lower branches of trees close to the nests at night. Immature birds moved around the island solitarily and farther away from the nests. Movement of newly hatched chicks was limited to the nesting field. They ran for cover when flushed and stayed motionless under shrubs and debris unless approached. Food taken by the adults included fallen fruits of *Morinda citrifolia*, seeds, shoots, larvae, termites, beetles, worms and snails. On Puerco, two dead individuals showed sand or grit in their gizzards.

We observed small groups of three to five individuals of Philippine Scrubfowl flying less than 5 m above the water from Puerco in the direction of Roxas in Palawan in late October–November 2017, November 2018 and October 2019. On one occasion in late October 2019, a pair flew from the island towards Palawan and, after about almost a kilometre, flew back to circle around Puerco, where they were joined by another individual before flying out to Palawan. Local fishermen have also reported observing birds flying at dusk from the islands to Palawan. We have no information if the birds reached Palawan or moved to other nearby islands in the bay.

Predation and mortality

At least four predators of Philippine Scrubfowl eggs and immature birds were identified on Puerco Island: Barred Rail *Hypotaenidia torquata*, Pacific Reef Egret *Egretta sacra,* Black-crowned Night Heron *Nycticorax nycticorax* and the migratory Northern Boobook *Ninox japonica*. There were two occasions in 2017 when a nesting adult partially exposed an egg (Figure 8, left) and a group of Barred Rails fed on it. On another occasion, a Pacific Reef Egret (dark phase) was seen feeding on an exposed egg and a Black-crowned Night Heron on a newly hatched chick. Finally, a Northern Boobook was photographed feeding on a Philippine Scrubfowl chick during the day (Figure 8, right). Predation by monitor lizards was observed on Greater Santa Cruz, Baguan and Danjugan. The Reticulated Python *Malayopython reticulatus* was also reported as a potential predator on Danjugan.

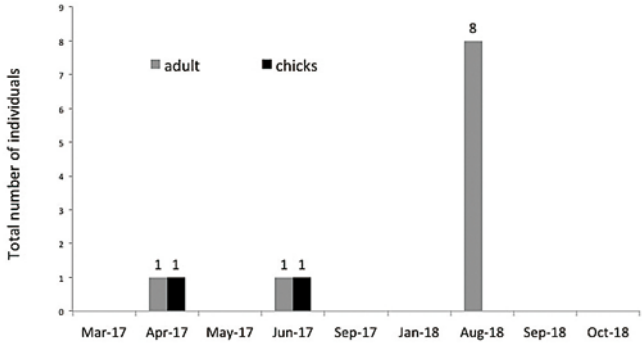
On Puerco, sudden movements of people on the nesting fields during the breeding season would alarm the birds and cause them to scatter. On 18 August 2018, this led to birds colliding with trees and walls of buildings, resulting in the deaths of eight individuals (Figure 9). Two chicks died from predation, while the deaths of two adults were of an unknown cause.

DISCUSSION

The number of chicks observed from the three nesting fields monitored with CCTV cameras in the months of August–November 2019 on Puerco was twice the number of active nests recorded in the same area. Close examination of the CCTV footage of 35 burrows showed that these were re-used the next day following the emergence of chicks. The average use of the burrow was three times (range=2–8) in a span of three months. Without the benefit of identifying individual birds, it is highly likely that incubation sites were used more than once by one pair throughout the breeding season. The 2:1 proportion of the number of chicks that successfully hatched and the number of active burrows in the same area suggests two incubations per pair. In north Sulawesi, Philippine Scrubfowl use approximately four incubation sites clustered within their territories (Sinclair *et al.* 1999).

The use of loam, sand, coral rubble and humus in building breeding mounds has been documented for a number of megapode species, including Philippine Scrubfowl (Dekker & Brom 1992, del Hoyo *et al.* 1994, Sinclair *et al.* 1999, Wiles & Conry 2001, Sinclair 2002, Stuebing *et al.* 2013). In this study across four Philippine islands, we found that subspecies *pusillus* of the Philippine Scrubfowl only use mounds composed of coral rubble and loam soil. This result is consistent with the observations of Aala (2001) on Alibijaban Island in Quezon. Birds on Puerco of the subspecies *megapodius* use only nesting fields compose primarily of sand. This observation was also consistent with the findings of Bashari *et al.* (2017) and Sinclair *et al.* (1999) from Sulawesi.

Figure 9. Philippine Scrubfowl adult and chick mortality on Puerco Island.



We found significant difference in loam substrate composition of breeding mounds between sites (H=9.4; p<0.001). Sixteen of the total nest mounds (n=20) were all primarily composed of loam. Micronesian Scrubfowl *M. laperouse* also preferred sand and loam to coral rubble and leaf-litter in mound building (Olsen & Eberdong 2016, Wiles & Conry 2001). Loam and sand make a good choice as nesting materials as they can be quickly and easily raked with less risk of injury and are favourable for hatching chicks (del Hoyo *et al.* 1994). Due to the limited sample size of the number of mounds examined and the focus of the breeding observations on nesting fields on one small island (Puerco), our conclusions regarding preferred nesting substrate for Philippine Scrubfowl should be treated with caution.

In comparing the distance of scrubfowl nests to the highest waterline across sites, our study showed a similar trend from observations in Sabah (Stuebing *et al.* 2013), Micronesia (Olsen & Eberdong 2016, Wiles & Conry 2001) and north Sulawesi (Sinclair *et al.* 1999), where mounds were within less than 110 m from the beach. For instance, the average distance of Philippine Scrubfowl mounds and nesting field was 55 m ± 82, with a range of 2–350 m (n=20). The concentration of the nests within low-lying coastal sites raises concern over the species' vulnerability to extreme tides and sea levels rising (Radley *et al.* 2018, Olsen & Eberdong 2016).

The increase in the breeding population on Puerco can be attributed to increased protection efforts. There was no egg poaching or bird hunting except for predation by four species of birds, i.e. Barred Rail, migratory Northern Boobook, Black-crowned Night Heron and Pacific Reef Egret. Apparently to reduce predation loss, Philippine Scrubfowl lay eggs at dusk and quickly cover the egg with sand, while the newly hatched chicks emerge from the nests in the evening. Added to this, chicks quickly move to hide in shrubs, contradicting the suggestion that they require a rest before moving (del Hoyo *et al.* 1994). The emergence of chicks at night and their quick movements to hide in bushes may be a strategy of Philippine Scrubfowl to avoid predation.

It has been suggested that burrow-nesting Philippine Scrubfowl on sun-exposed nesting fields only visit the site when an egg is to be laid (Dekker & Brom 1992). Our observations on Puerco showed birds attending the nesting fields daily, staying in bushes located close to the nesting field during the warmest part of the day and roosting on the lower branches of trees next to the nesting fields at night. Aala (2001) also observed adults regularly visiting the nest mounds on Alibijaban Island, while birds were also seen regularly moving around the nest mounds on Danjugan, Greater Santa Cruz and Baguan.

Birds move unperturbed on the islands even with human presence but were highly sensitive inside the nesting colonies. The mere sign of humans caused sudden flight movements that resulted in the deaths of eight individuals on Puerco Island. Bashari *et al.* (2017) and Indrawan *et al.* (1998) have also reported similar behavioural responses within nesting sites in Indonesia. However, recent infrastructure developments on Puerco and Danjugan Island did not appear to affect the bird's population. Tourists and infrastructure development on four islands in Palau also showed minimal impact on populations of Micronesian Scrubfowl *M. laperouse senex* (Radley *et al.* 2018).

Movement and dispersal of scrubfowl between islands has been reported for a number of species (Pratt *et al.* 1980, Healey 1994, Jones *et al.* 1995, del Hoyo *et al.* 1994, 2014, Dekker *et al.* 2000, Wiles & Conry 2001). Micronesian Scrubfowls are known to fly several kilometers between islands (Pratt *et al* 1980, Wiles & Conry 1990, Jones *et al.* 1995) and Melanesian Scrubfowl *M. eremita* are known to fly across the sea towards undisturbed lowland forest (del Hoyo *et al.* 1994). This has long been suspected of the Philippine Scrubfowl (Kennedy *et al.* 2000). The apparent absence of the species from Puerco Island in the months of November and December, along with our observations of individuals and small groups of Philippine Scrubfowl flying away from the island towards Palawan in the early evening in November, suggests local movements of the species. It is still unclear where the birds from Puerco Island go, and whether they reach Palawan. There is no information on the movement and dispersal of individuals in the islands of Baguan, Danjugan and Greater Santa Cruz. We suspect that island size, presence and absence of beach forests and availability of food sources may play a role in the movement and dispersal of the species. Radio-tagging or ringing individuals (mature and juvenile) will help generate much-needed information on the life history of the species on smaller islands and in forested areas of Palawan. More studies are needed to understand local movements of the species and the extent of habitat use on smaller islands and in forests on the adjacent mainland.

Management recommendations

The Philippine Scrubfowl used to be widespread in the Philippines but is now largely confined to smaller islands (Allen 2020, Kennedy *et al.* 2000). Sandy beach areas, both open and forested, on small islands appear to be an important breeding habitat of the species, particularly in Palawan and its satellites. The development and modification of beach landscapes on small islands and coastal areas pose a threat to the Philippine Scrubfowl. Setting aside nesting habitats for protection, coupled with control of hunting activity, would aid in conservation and boost the population of the species.

There is also a need for further study of the ecology and population monitoring of the different subspecies within protected areas. The differences in breeding strategies, morphology, distribution, habitat associations and possibly genetic differences may warrant a need to revisit the taxonomy of the Philippine Scrubfowl across its distribution.

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