A camera-trap survey of avifauna in a Bornean peat-swamp forest

Daniel M. Brooks,1* Adul,2 and Susan M. Cheyne2,3

ABSTRACT—As part of an ongoing camera trapping project in the Sabangau Peat-swamp Forest (Central Kalimantan, Indonesia), we present camera-trap data on the avifauna. The camera traps have captured images and videos since 2008, including 224 individual bird photos representing 142 unique events of 25 species, 11 of which are Endangered, Vulnerable, or Near-Threatened, all of which we describe in species accounts. We discuss important breeding and behavior observations for S. cheela, Lophura pyronota, C. sinensis, and Trichixos pyrropygus. Expansions for habitat and range are noted for Accipiter trivirgatus and Pitta nympha. We discuss conservation implications, as well as the usefulness of using long-term camera-trap data to monitor birds. Received 23 August 2017. Accepted 25 September 2018.

Key words: avifauna, Borneo, camera-trap survey, peat-swamp, threatened species.

Methods

Study area

The study was conducted in the Natural Laboratory for peat-swamp forest in the northeastern corner of the Sabangau Forest (2°19’S, 113°54’E; Fig. 1). This area covers 50 km² of the total 5,600 km² of forest and is 16–20 m a.s.l. The area is operated by the Centre for International Cooperation in Management of Tropical Peatlands (CIMTROP) at the University of Palangka Raya.

Borneo is one of the global top 25 biodiversity hotspots under threat (Myers et al. 2000). The island harbors 358 species of birds, 59 of which are endemic (Phillipps and Phillipps 2014). Despite the high diversity, little empirical research on the avifauna has taken place relative to other comparable regions of the world (cf. Dragiewicz et al. 2014).

The most basic knowledge of a species’ occurrence, distribution, and ecology is an essential starting point for predicting extinctions as a result of habitat loss to subsequently devise strategies that focus on conservation efforts (Margules and Pressey 2000). Camera traps have been used successfully in remote regions of Asia to help fill large information gaps for cryptic birds that are difficult to observe and that live in remote regions (O’Brien et al. 2003, Lok et al. 2005); where cameras are placed with a focus on another species (e.g., a mammal), researchers should not ignore the value of by-catch photos, especially those of avifauna.

The high rate of habitat destruction, agricultural expansion, and multiple land use policies on Borneo are the impetus for assessing anthropogenic threats faced by the scarcely documented birds of Borneo, especially bird communities in tropical peat-swamp forests (Cheyne et al. 2014). In this study, we present observations from a long-term camera trapping project (e.g., Cheyne 2010; Cheyne et al. 2013, 2014), filling information gaps of natural history and conservation for the region’s avifauna. Species accounts are presented, followed by discussion of records and conservation assessment.

**Methods**

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The study was conducted in the Natural Laboratory for peat-swamp forest in the northeastern corner of the Sabangau Forest (2°19’S, 113°54’E; Fig. 1). This area covers 50 km² of the total 5,600 km² of forest and is 16–20 m a.s.l. The area is operated by the Centre for International Cooperation in Management of Tropical Peatlands (CIMTROP) at the University of Palangka Raya.
Sabangau is the largest contiguous lowland rainforest remaining in Kalimantan and is recognized as one of the most important conservation areas in Borneo for a variety of reasons, including carbon storage, regulation of water supplies, and conservation of flora and fauna (Aldhous 2004). The area has been subjected to long-term legal and illegal logging, fire, and drainage from logging canals but is now the focus of concerted protection and restoration efforts (Morrogh-Bernard et al. 2003, Cheyne 2010).

The Sabangau area harbors a number of threatened species (Cheyne et al. 2010, 2013) and is one of the deepest (3–26 m) peat-swamp forests in the world (Page et al. 1997). Logging and fire have resulted in a patchwork of logged, recovering, and pristine forest covering 4 habitat subtypes (mixed-swamp forest, transitional/mixed-swamp forest, low interior forest, tall interior forest; Page et al. 1997).

**Cameras**

From May 2008 to December 2016, camera traps (Cuddeback Expert, Cuddeback Capture IR, Maginon WK3 HD, and Crenova 12MP 1080P) were set at sites in fixed forest areas (Table 1), yielding 40,495 trap-days. The number of functional cameras in the field varied from 23 at 11 locations to 54 at 28 locations at a given time. Of the 51 different sites where cameras were placed, 27 captured bird photos (Table 1, Fig. 2). Two cameras were placed opposite each other (7–10 m apart) to create a paired station at each location. The passive infrared sensor was set at ~50 cm height for the majority of the cameras and canopy cameras were placed 8–12 m above the ground. The Expert cameras have a pre-set minimum of 60 s delay between triggers and use a white flash, whereas the others use an infrared flash. Because the infrared cameras have no white-light flash, they were deemed better for long-term use to avoid

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Figure 1. Location of the Natural Laboratory for the Study of Peat-Swamp Forest (NLPSF) within Sabangau tropical peat-swamp forest (right, inset) and Borneo (left). Forest cover is shaded gray, non-forested areas are white. Derived from Miettinen et al. (2011).
Table 1. Locations and number of trap-days at Natural Laboratory for the Study of Peat-Swamp Forest (NLPSF), Sabangau Forest, a tropical peat-swamp forest, May 2008 to December 2016.

<table>
<thead>
<tr>
<th>Map location</th>
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km apart. All cameras were placed at varying distances from the forest edge up to 5.0 km from the forest edge in previously logged mixed-swamp forest, with 1 pair in the mixed-swamp/transitional forest 5 km from the forest edge (farthest accessible point). Cameras were not placed in deforested areas that had been burned, lacked canopy cover, or were otherwise inaccessible. To prevent damage by sun bears (Helarctos malayanus) and pig-tailed macaques (Macaca nemestrina), and to enable more precise placement of cameras, all cameras were placed in protective boxes.

### Analyses

Birdlife International (2017) was used to determine threat levels of various species. Bornean endemics were identified following Phillipps and Phillipps (2014), which is considered the most
recent and authoritative reference for Bornean avifauna (Dragiewicz et al. 2014). We used additional online references of the IUCN Redlist of Threatened Species (2018b) and specific accounts in del Hoyo et al. (2018).

We followed O’Brien et al. (2003) to distinguish independent events: (1) consecutive photographs of different individuals of the same or different species, (2) consecutive photos of individuals of the same species taken >0.5 h apart, and (3) nonconsecutive photos of individuals of the same species. In other words, any species caught on the same camera and the same day was counted as a second individual if there was >30 min between images.

Results

Of our 224 individual bird photos, 142 represented unique events of 25 species, 2 of which are endemic, and 11 of which are Endangered, Vulnerable, or Near-Threatened. Individual species accounts follow.

Storm’s Stork (Ciconia stormi)

This Endangered species was documented more than any other bird in the study, with 59 photographs comprising 35 independent events at 7 different sites. All events were in mixed-swamp interior forest, with microhabitats (Fig. 3a) including semi-open peat bog (n = 20 photographs),
closed ravine/stream \((n = 5)\), closed forest \((n = 5)\), closed peat bog \((n = 4)\), and open peat bog \((n = 1)\). Storks were on the ground or in water in 51 (86\%) of all photographs, and perched on or stepping onto a log in 8 (14\%). Behaviors (Fig. 3b) included walking \((n = 23)\), resting \((n = 9)\), wings spread/flapping \((n = 4)\), foraging \((n = 4)\), flying off/landing \((n = 3)\), startled \((n = 1)\), and preening \((n = 1)\). Single adults were represented in 27 (77\%) of all events, and single subadults in 7 (20\%); 2 birds—an adult and a subadult—were represented in 1 (3\%) early December photograph, although most subadults were photographed between mid-September \((n = 6)\) and early October \((n = 1)\). Storks were present every month except April, and 37\% of all photographs were taken during September \((n = 13)\); Fig. 3c). Storks were active between 0500 and 1700 h, with bimodal peaks of activity during the earliest part of the morning (0500–0800 h) and again during mid-afternoon (1200–1600 h; Fig. 3d).

**Crested Serpent Eagle (Spilornis cheela)**

This species of Least Concern was documented by 20 photographs comprising 12 independent events at 7 different sites. All events were in mixed-swamp interior forest, with microhabitat association relatively equitable, including closed forest \((n = 3)\), open stream \((n = 3)\), open peat bog \((n = 2)\), semi-open peat bog \((n = 2)\), and closed peat bog \((n = 2)\); Fig. 4a). Serpent Eagles perched on a log in 12 (60\%) photographs and were on the ground in 8 (40\%). Resting represented the most frequent behavior with 50\% \((n = 10)\) of all photographs; other behaviors included wing flapping \((n = 4)\), flying off/landing \((n = 3)\), positioning/balancing \((n = 2)\), and copulating \((n = 1)\); Fig. 4b). At least 2 different adults were present and were photographed solitarily in each event except for one (8\%) when they were copulating. Serpent Eagles were patchily distributed chronologically, with peak months of occurrence in May, August, and September \((n = 3)\), and present in other months including March, June, and November \((n = 1)\). Serpent Eagles were active between 0500 and 1700 h, with peak activity during midday (1100–1400 h; Fig. 4c).
Crested Goshawk (*Accipiter trivirgatus*)

This species of Least Concern was documented by 4 photographs comprising 3 independent events at 2 different sites, similar to the Goshawk. All events were in mixed-swamp interior forest, with microhabitats including closed swamp forest, semi-open forest, and semi-open peat bog (n = 1 photograph each). Goshawks were resting on logs in 3 (75%) photographs and flying away in 1 (25%). All photographs were of solitary adults during October, November, and February, with periods of activity at dawn (n = 1) or midday (n = 2).

Wallace’s Hawk-Eagle (*Nisaetus nanus*)

This Vulnerable species was documented by 4 photographs comprising 3 independent events at 2 different sites, similar to the Goshawk. All events were in mixed-swamp interior forest, with microhabitats including closed swamp forest, semi-open forest, and semi-open peat bog (n = 1 photograph each). Hawk-eagles were on the ground in 3 (75%) photographs and perched on a log in 1 (25%). Foraging took place twice (50%), with single photographs of resting and alarm-response with wings out. A solitary adult male was photographed during midafternoon in September, and 2 different solitary adult females were photographed during early afternoon in June–July. The females were assumed to be different birds because they had different appearances and were photographed 2 yr apart at different sites.

Black Partridge (*Melanoperdix niger*)

This Vulnerable species was documented by 4 photographs representing independent events at 3 different sites. All events were in closed forest, <20 m from forest edge (n = 3 photographs), or in mixed-swamp interior forest (n = 1). Partridges were walking on logs in 3 (75%) photographs and foraging on the ground in 1 (25%). Solitary adult males (Fig. 6a) were photographed 3 times (75%), and an adult male–female pair was photographed once (25%). Three (75%) photographs were taken during June and 1 (25%) in October. Two (50%) photographs were taken during early morning (0700–0730 h) and 2 (50%) were taken during afternoon (1245–1500 h).

Bornean Crestless Fireback (*Lophura pyronota*)

This Vulnerable, endemic species was documented by 7 photographs representing independent events at 3 different sites. All events were in primary, closed mixed-swamp interior forest, associated with streams in 3 (43%) photographs. Pheasants were walking in all photographs except for one, where the bird was resting. Solitary adult males were photographed 4 times (57%), adult male–female pairs twice (29%), and a group of 2 males with a female once (14%). Photographs were taken once per month (except where noted) during January (n = 2), March, April, September,
November, and December. Four (57%) of the photographs were taken around dawn (0530–0700 h), 2 (29%) near dusk (1600–1800 h), and 1 (14%) late morning (1100 h).

**White-Breasted Waterhen (Amaurornis phoenicurus)**

This species of Least Concern was documented by a single photograph in closed swamp forest <20 m from forest edge, walking on a log over a swamp during midafternoon in May.

**Bornean Ground Cuckoo (Carpococcyx radiceus)**

This Near-Threatened, endemic species was documented by 2 photographs at different sites in primary mixed-swamp interior forest, from early to late afternoon in late November and December.

**Greater Coucal (Centropus sinensis)**

This species of Least Concern was documented by 24 photographs comprising 23 independent events at 4 different sites. All events were in
Bonaparte’s Nightjar (*Caprimulgus concretus*)

This Vulnerable species was documented by 5 photographs representing 4 independent events at the same site, all in primary transitional mixed-swamp forest. Nightjars were flying (n = 2 photographs), landing/taking off from a perch (n = 2), or resting (n = 1). Photographs were taken of solitary adult females (n = 2), 2 adult females (n = 1), or an adult male–female pair (n = 1), in which the male was flying much higher than the female (Fig. 6c). This series of photographs took place 9–13 January 2009 during strictly nocturnal (2000–0230 h) periods.

Stork-billed Kingfisher (*Pelargopsis capensis*)

This species of Least Concern was documented by a series of 4 photographs representing the same event in closed mixed-swamp forest <20 m from forest edge. The kingfisher was masticating (to consume) a large ranid on top of a log on 4 March 2014 between 1331 and 1337 h.

Black Hornbill (*Anthracoceros malayanus*)

This Near-Threatened species was documented by 28 photographs representing 6 independent events of an adult male–female pair at the same interior mixed-swamp closed dipterocarp forest site, 8 m off the ground in a large fructing tree (appeared to be *Ficus* sp.). Hornbills were resting in 61% (n = 17) of all photographs and actively consuming fruit in the remainder (n = 11) during 19–21 May 2015 between morning and early afternoon.

Maroon Woodpecker (*Blythipicus rubiginosus*)

This species of Least Concern was documented by a single photograph in mixed-swamp interior forest. The adult male was 9 m high at the entrance to a tree cavity, suggesting breeding activity, on 30 November 2015 at 0843 h (Fig. 6d).
Great Slaty Woodpecker (*Mulleripicus pulverulentus*)

This Vulnerable species was documented by a series of 3 photographs representing the same event in mixed-swamp interior forest. The adult woodpecker was perched on a tree trunk 9 m high on 15 September 2015 at 0744 h.

Fairy Pitta (*Pitta nympha*)

This Vulnerable species was documented by a series of 3 photographs representing different events at the same site in mixed-swamp interior forest (e.g., Fig. 6e). An adult pitta was observed on top of a log 17–19 October and 26 November 2008 at ~0700 h ($n = 2$ photographs) and 1400 h ($n = 1$).

Velvet-fronted Nuthatch (*Sitta frontalis*)

This species of Least Concern was documented by a series of 5 photographs representing 2 independent events at the same site, both of adult birds hopping on logs in the morning ~0800 h. A male was in mixed-swamp forest <20 m from forest edge on 17 November 2015, and a female was in closed forest 11 m above the ground on 2 February 2016.

Black-capped Babbler (*Pellorneum nigrocapitatum*)

This species of Least Concern was documented by a single photograph of a single adult in mixed-swamp interior forest on a buttress root, on 1 December 2016 at 0750 h.

White-rumped Shama (*Trichastoma rostratum*)

This species of Least Concern was documented by 9 photographs representing independent events at 4 different sites. All events were <20 m from forest edge ($n = 7$ photographs) or mixed-swamp interior closed forest ($n = 3$). Solitary adults were perched on a thin branch 0.8–1 m over a stream during June, from midmorning to midafternoon.

Mangrove Whistler (*Pachycephala cinerea*)

This species of Least Concern was documented by a single photograph of a single adult in closed mixed-swamp interior forest <20 m from forest edge, perched 1.2 m off the ground on 20 May 2010 at 1545 h.

White-rumped Shama (*Kittacincla malabarica*)

This species of Least Concern was documented by a single photograph of a single adult male in closed mixed-swamp interior forest, resting on top of a log on 8 August 2013 at 1331 h.

Rufous-tailed Shama (*Trichixos pyrropygus*)

This Near-Threatened species was documented by 14 photographs representing 3 independent events at 3 different interior mixed-swamp sites. All photographs were of adult males entering/exiting tree cavities 8–9 m off the ground. The first event was a series of 11 photographs at dawn on 31 July, the second event of 2 photographs also at dawn on 1 October, and the final event of a single photograph during afternoon on 30 January (Fig. 6f).

Sunda Pied Fantail (*Rhipidura javanica*)

This species of Least Concern was documented by 4 photographs representing independent events at 2 different sites. All events were <20 m from forest edge ($n = 3$ photographs) or in mixed-swamp interior closed forest ($n = 1$). Solitary adults were perched on a thin branch 0.8–1 m over a stream during June, from midmorning to midafternoon.

Discussion

Records

Earlier work of Storm’s Stork at this same study site (Cheyne et al. 2014) shows similar patterns of habitat use. Previously unknown natural history information (Hancock et al. 1992, Mann 2008) quantified herein for this species includes an adult to subadult ratio of 4:1 (per Karanth et al. 2011), annual residents most abundant during September, and diurnal activity patterns with bimodal peaks morning and midafternoon.

Previously unknown natural history information (Clark et al. 2018) quantified herein for the Crested Serpent Eagle includes resting as the most frequent
of several behaviors and diurnal activity patterns with midday peaks.

Clark and Marks (2018) considered Crested Goshawk not to be associated with peat-swamp forest, although our photographs document the contrary.

Posa and Marques (2012) suggest that the Bornean Crestless Fireback is monogamous, based on observations of male–female pairs. While we recorded adult male–female pairs, we also recorded a group of 2 adult males with a female, indicating multi-male pairings in an otherwise largely territorial genus. While this occurrence may suggest polyandry, an alternative explanation is subordinate males serving in a cooperative capacity to a dominant male, as has been observed in congeners (e.g., Zeng et al. 2016). Additionally, the activity patterns of this species are unknown (Madge and McGowan 2002); most of the photographs herein suggest this species is largely crepuscular.

Previously unknown natural history information (Payne 2018) quantified herein for the Greater Coucal includes annual residents that are most abundant during June and diurnal activity patterns with midmorning and midday peaks. Additionally, we recorded one component of a hitherto unknown display for this species (Payne 2018). Whether the display is an alarm response or courtship is unknown, but we assumed the latter, especially because this was the only photograph of 24 involving a pair rather than solitary individuals, and it was taken on 25 February (Fig. 6b), within the range of the breeding season (Payne 2018).

Although the Vulnerable Bonaparte’s Nightjar is more common in this region than other parts of its range (Philpips and Phillipps 2014), its biology is virtually unknown (Cleere and Sharpe 2018). All photographs were in primary transitional mixed-swamp forest during peak nocturnal (2000–0230 h) periods. A variety of adult sex-class groups were represented, including solitary adult females, or pairs composed of each sex or 2 females. The male flew higher than the female (Fig. 5c), and the nightjars were not perched resting in most cases.

Winkler and Christie (2018) indicate the Maroon Woodpecker breeds during January, probably extending through August in Borneo. Our observation of a male prospecting or associated with an active nest cavity 9 m high (Fig. 6d) extends the breeding season in Borneo earlier, beginning in November.

The records herein of adult Fairy Pittas over 41 d (e.g., Fig. 6e) constitute a range expansion of ~100 km to the south (IUCN 2018a).

Nothing is known of the nesting habits of Rufous-tailed Shama apart from being in breeding condition February–June in Northern Borneo (Collar 2018). The 3 independent events recorded herein suggest that adult males partake in nest building and/or attendance in tree cavities 8–9 m off the ground, with breeding occurring January–October (e.g., Fig. 6f).

Conservation implications

Nearly one-half of the species that were camera-trapped are under some level of threat, including the Endangered Storm’s Stork, 6 Vulnerable species (Wallace’s Hawk-Eagle, Black Partridge, Bornean Crestless Fireback, Bonaparte’s Nightjar, Great Slaty Woodpecker, Fairy Pitta) and 4 Near-Threatened (Bornean Ground Cuckoo, Black Hornbill, White-chested Babbler, Rufous-tailed Shama; Birdlife International 2017). Additionally, Bornean Crestless Fireback and Bornean Ground Cuckoo represented Bornean endemics (Philpips and Phillipps 2014).

The study site was a legal logging concession for 30 yr from the 1970s to early 1990s. Although it was established as a protected research forest in 1994, illegal logging and fires took place beginning in 1996 until combatted by local patrol teams in 2004. At that time (2004) it was established as a national park in the wider landscape (Rieley et al. 2004).

Unfortunately, today illegal logging, harvesting of non-timber forest products, and removal of live birds for the songbird trade remain widespread. Moreover, road development throughout Borneo is increasing access to reserves. Nonetheless, some of the species currently present may serve as barometers of site integrity and forest quality. For example, Vulnerable gamebirds such as the Black Partridge and Bornean Crestless Fireback (Lophura pyironota), as well as terrestrial cuckoos, are often the first species to disappear in a region that is overharvested by humans consuming protein (Madge and McGowan 2002) or nestlings for medicinal purposes (Payne 1997), respectively. The fact that these large terrestrial species are
present suggests that harvest is within sustainable limits.

Species such as Black Hornbill and Brown Wood Owl are large obligate cavity-nesting species present in the region that require relatively large nest trees (Kemp 1995, Marks et al. 1999); other larger species will also use cavity nests, including Buffy Fish Owl and Stork-billed Kingfisher (Fry and Fry 1992, Marks et al. 1999). Several other species, including the Maroon and Great Slaty woodpeckers, Velvet-Fronted Nut-hatch, and White-rumped and Rufous-tailed shamas, are also cavity-nesting species (Winkler et al. 1995, Harrap 2008, Collar 2018). In sum, the presence of several large and smaller cavity-nesting species in the study region, despite many being able to thrive in disturbed forest, suggests sufficient nest cavities for these species.

Several species of songbirds were present, including Black-capped and White-chested babblers, Mangrove Whistler, White-rumped and Rufous-tailed shama, and Sunda Pied Fantail. The presence of at least several species suggests that trapping for commerce in the Asian songbird trade (Eaton et al. 2015) has not completely caused local extinction of these species.

Conclusion

Peat-swamp forests are home to a wide diversity of avifauna and are likely crucial for the conservation of many species. Because these forests are increasingly impacted by annual fires, logging, and conversion, it is imperative that we document the wildlife in these areas to increase conservation focus and actions. The use of camera traps represents a unique method of studying birds and providing data on behavior, breeding, and range. We encourage all researchers using camera traps to publish their data on avifauna.

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Literature cited
