

Short Communication:

New records of rare endemic Hose pygmy flying squirrel (*Petaurillus hosei*) in Sungai Rawog Conservation Area, Sabah, Malaysia

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Abstract. Bansa LA, Mohd-Kanapiah NAA, Chung A, Jaslin ZA, Hasan NH. 2024. Short Communication: New records of rare endemic Hose pygmy flying squirrel (*Petaurillus hosei*) in Sungai Rawog Conservation Area, Sabah, Malaysia. *Biodiversitas* 25: 2937-2942. The Hose's pygmy flying squirrel, *Petaurillus hosei* (Thomas, 1900), is an International Union for Conservation of Nature (IUCN) data deficient species. Information on this species is lacking, and the sighting of this species is extremely rare in Borneo, particularly in Sabah. In Sabah, Malaysia, this species was documented only in Sepilok Forest Reserve more than 30 years ago. Furthermore, measurement records for this species are limited to only four specimens. A male *P. hosei*, was captured in the Rawog River Conservation Area, marking only the second record in Sabah and the fifth in Borneo. This individual was captured using a mist net attached to a pair of 8-meter-long telescopic poles, indicating that *P. hosei* primarily inhabits forests with medium to high canopy levels, as evidenced by their tree-dwelling habits. This individual's Head-to-Body (HB) dimensions are approximately 70.71 mm, with a tail length of 77.83 mm and hind legs measuring 19.46 mm. This species is morphologically similar to *Petaurillus emiliae* (Thomas, 1908), with single records from Baram, Sarawak, and *Petaurillus kinlochii* (Robinson & Kloss, 1911), only known from Selangor, Peninsular Malaysia. This discovery significantly contributes to the current photographic record and measurements of *P. hosei* from Sabah, Malaysia Borneo. Further research on the Sabah flying squirrel is crucial to enhance our understanding of the diversity, distribution, and behavior of this IUCN data deficient species. Therefore, comprehensive statewide survey involving mist netting and mid-level to canopy observations targeting old-growth forests is highly recommended.

Keywords: IUCN data deficient species, Malaysia Borneo, middle canopy mist netting, Sabah biodiversity, Sciuridae

INTRODUCTION

Flying squirrels are classified under order Rodentia and family Sciuridae (Thorington et al. 2002; Li et al. 2020). While they do not "fly," they glide through the air using the patagium membrane stretching between their fore and hindlimbs (Phillips and Phillips 2018). This adaptation allows them to move effortlessly between trees in search of food and to escape predators. When not gliding, squirrels can tuck away their gliding membrane and are differentiated from Colugo by their free-hanging tail (Phillips and Phillips 2018; Arifuddin et al. 2021). These characteristics make them well-adapted to their nocturnal and arboreal locomotion (Thorington et al. 2002; Hayssen 2008).

Flying squirrels are good indicators of forest health and are valuable for studying habitat changes and species diversification in the context of environmental change (Koprowski 2005; Smith et al. 2005; Vierikko et al. 2010; Lu et al. 2012). They are vulnerable to deforestation due to their nesting behavior in tree holes, making deforestation the main threat to their population (Ramos-Lara and Koprowski 2014; Turkia et al. 2018). Although flying squirrels exhibit adaptability in choosing nesting sites

(Turkia et al. 2018), they rely on mature forests and the availability of food resources such as fruit, seeds, and insects for survival (Trudeau et al. 2011; Murrant et al. 2014).

Moreover, of the 49 flying squirrel species worldwide, 14 (28.6%) are found in Borneo (Table 1). *Petaurista* spp. (*P. petaurista*; *P. elegans*) are the largest (up to 40 cm), known as the giant flying squirrels, while *Petaurillus* spp. is the smallest (up to 8 cm), called the pygmy flying squirrels (*P. hosei*; *P. emiliae*) (Phillips and Phillips 2018). Giant squirrels (*P. petaurista*, *P. elegans*), *Hylopetes spadiceus*, *Iomys horsfieldii*, and the endemic *Aeromys thomasi* are listed as least concern by the International Union for Conservation of Nature (IUCN) (Aplin and Lunde 2016; Duckworth 2016a,b; Eastern 2016; Koprowski et al. 2016a). However, three species are vulnerable (*Petinomys setosus*, *Petinomys vordermanni*, *Petinomys genibarbis*), and one (*Pteromyscus pulverulentus*) is endangered (Clayton 2016a,b,c,d). Due to their elusive behavior, five species are data deficient, namely *Aeromys tephromelas* (Lee 2016), *Hylopetes platyurus* (Kennerley et al. 2017), *Petinomys hageni* (Kennerley et al. 2016), along with two endemic pygmy

flying squirrels *P. emiliae* (Kennerley and Clayton 2016) and *P. hosei* (Koprowski et al. 2016b). Comprehensive surveys are needed for updated information, especially for the data deficient species.

In Sabah, Malaysia Borneo, opportunistic sightings, surveys, and expeditions have been the primary means of recording and studying flying squirrels, which remain understudied. In Sabah Wildlife Conservation Enactment 1997, this species is listed in Schedule 2 as a protected animal species with limited hunting permission and collection under permit. This species is reported to be restricted to Brunei and Malaysia (Payne et al. 2007, Thorington et al. 2012; Phillips and Phillips 2018).

Information on this species is lacking, and sightings of it are extremely rare in Borneo, particularly Sabah. This species was documented only from the Sepilok Forest Reserve in 1985 (Payne et al. 2007). In addition, measurement records on this species are limited to four specimens (Payne et al. 2007). Therefore, the purpose of this write-up is to report the latest record of this IUCN-data

deficient species in Sabah, opportunistically caught during an understory and mid-canopy bat survey in 2023.

MATERIALS AND METHODS

Study area

Sungai Rawog Conservation Area (SCRA), Malaysia, is designated a conservation area by the KTS Plantation Sdn Bhd. The forest management area is within the Segaliud Lokan Forest Reserve, a Class II Production Forest Reserve located in the middle part of Sabah. This conservation area comprises four compartments (i.e., 49, 52, 56, and 61) and is accessible from the Sandakan-Telupid's main road. Covering a total of 3,118 ha of land area, SRCA has been logged in the past. Four forest ecosystems make climax vegetation: late secondary forest, lowland mixed dipterocarp forest, kerangas forest, and Kapur Merah forest.

Table 1. Summary of the Bornean flying squirrels" information on common names, scientific names, International Union for Conservation of Nature (IUCN) red list status, and geographic range

Common name	Scientific name	IUCN status	Locality
Smoky Flying Squirrel	<i>Pteromyscus pulverulentus</i>	EN	Brunei Darussalam; Indonesia (Sumatera, Kalimantan); Malaysia (Sarawak, Peninsular Malaysia, Sabah); Thailand
Temminck's Flying Squirrel	<i>Petinomys setosus</i>	VU	Brunei Darussalam; Indonesia; Indonesia (Kalimantan, Sumatera); Malaysia; Myanmar; Thailand
Vordermann's Flying Squirrel	<i>Petinomys vordermanni</i>	VU	Brunei Darussalam; Indonesia (Kalimantan); Malaysia (Peninsular Malaysia, Sabah, Sarawak); Myanmar
Whiskered Flying Squirrel	<i>Petinomys genibarbis</i>	VU	Brunei Darussalam; Indonesia (Kalimantan, Java, Sumatera); Malaysia (Sarawak, Sabah, Peninsular Malaysia)
Red Giant Flying Squirrel	<i>Petaurista petaurista</i>	LC	Afghanistan; Brunei Darussalam; Cambodia; China; India (Bihar, Uttaranchal, Jammu-Kashmir, Uttar Pradesh, Meghalaya, Assam, Punjab, Himachal Pradesh, West Bengal); Indonesia (Sumatera, Java, Kalimantan); Lao Democratic Republic; Malaysia (Sarawak, Peninsular Malaysia, Sabah); Myanmar; Nepal; Thailand
Spotted Giant Flying Squirrel	<i>Petaurista elegans</i>	LC	Bhutan; China (Sichuan, Yunnan); India (Sikkim); Indonesia (Java, Sumatera, Kalimantan); Lao People's Democratic Republic; Malaysia (Sarawak, Sabah, Peninsular Malaysia); Myanmar; Nepal; Thailand; Vietnam
Red-cheeked Flying Squirrel	<i>Hylopetes spadiceus</i>	LC	Brunei Darussalam; Indonesia (Kalimantan, Sumatera); Lao People's Democratic Republic; Malaysia (Sabah, Sarawak, Peninsular Malaysia); Myanmar; Singapore; Thailand; Viet Nam
Javanese Flying Squirrel	<i>Iomys horsfieldii</i>	LC	Brunei Darussalam; Indonesia (Java, Sumatera, Kalimantan); Malaysia (Sabah, Sarawak, Peninsular Malaysia); Singapore
Thomas's Flying Squirrel	<i>Aeromys thomasi</i>	LC	Borneo endemic
Black Flying Squirrel	<i>Aeromys tephromelas</i>	DD	Brunei Darussalam; Indonesia (Sumatera, Kalimantan); Malaysia (Peninsular Malaysia, Sabah, Sarawak); Thailand
Jentink's Flying Squirrel	<i>Hylopetes platyurus</i>	DD	Indonesia; Indonesia (Kalimantan, Sumatera); Malaysia (Sabah, Sarawak); Thailand
Hagen's Flying Squirrel	<i>Petinomys hageni</i>	DD	Indonesia (Sumatera, Kalimantan)
Lesser Pygmy Flying Squirrel	<i>Petaurillus emiliae</i>	DD	Borneo endemic
Hose's Pygmy Flying Squirrel	<i>Petaurillus hosei</i>	DD	Borneo endemic

Note: LC: Least Concern; NT: Near Threatened; VU: Vulnerable; EN: Endangered. Source: Aplin and Lunde (2016); Clayton (2016a,b,c,d); Duckworth (2016a,b); Eastern (2016); Kennerley and Clayton (2016); Kennerley et al. (2016); et al. (2017), Koprowski et al. (2016a,b) and Lee (2016)

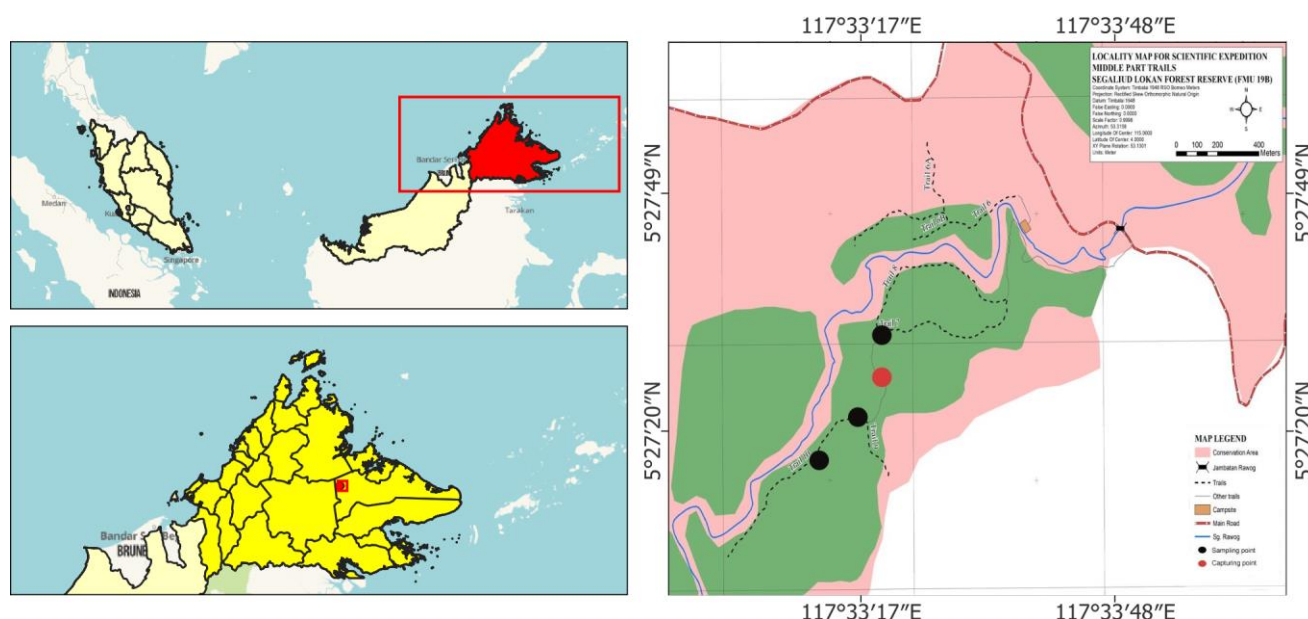


Figure 1. The location of the Sungai Rawog Conservation Area, Sabah, Malaysia, with four mist netting points covering the intersection of trail 8, 7, 9, and 10, is in black, and the detected points are in red

In general, SRCA has a flat terrain with an altitude of 30 to 120 m a.s.l. SRCA consists of two soil associations, Brantian and Sook. No distinct dry periods have been recorded in this area. The mean annual temperature is 27°C. This area also serves as an important riparian buffer for the Rawog River that drains from Deramakot Forest Reserve in the West and to IOI Estate in the East (SFD and KTS 2019).

Procedure

During the Sungai Rawog Conservation Area Scientific Expedition 2023, an understory and mid-canopy bat sampling survey was carried out along the established trails from 4 to 8 September 2023. The sampling trails can be accessed on foot by crossing the river (Sungai Rawog) from the campsite. Two high and two low nets were deployed using mist nets (2.5x9x4) for bat capture. The high nets were set using 8-meter telescopic stainless-steel poles along trails targeting high-flying bats, with the lowest shelf positioned at least 1.5 meters above the ground, following best practices (de Moura et al. 2023). Additionally, two mist nets were placed at a height of 4 meters, with the lowest shelf 0.5 meters above the ground, to capture understorey bats (Figure 1). The nets were set at 5:00 p.m., left overnight and monitored. On the first day, the nets were inspected every hour from 6:00 p.m. to 10:00 p.m. to assess bat activity. However, initial observations indicated minimal to no bat activity during the first two days. Based on these observations, the frequency of net checks was adjusted to twice daily, at 8:00 p.m. and 6:00 a.m. on the third day.

During the 6:00 a.m. check on the morning of September 8, 2023, a non-target species was found in the high net. The species was promptly identified, and immediately released without sample collection. This is in

accordance with the ethical guidelines set by the expedition's ethical committee in principle with the IACUCs and the conditions of the Sabah Biodiversity Centre (SaBC) access permit, which allowed only bat sampling. To ensure swift handling and minimize animal's stress, only one person handled the pygmy squirrel. The specimen was efficiently processed, with measurements and photographic documentation completed within approximately 10 minutes before its release. The Head-to-Body (HB), tail, and hindfoot measurements were initially marked in photographs using a torchlight as reference. The actual measurements were then taken with the Mitutoyo digital caliper at ± 0.02 mm accuracy, measuring the lengths marked on the torchlight. The pygmy squirrel was released by putting it on a branch at the site of capture and observed until it was out of sight to ensure its safe departure.

RESULTS AND DISCUSSION

Results

One male adult Hose's pygmy flying squirrel (*Petaurillus hosei*) was recorded during the survey. It was caught in the morning around 6:15 a.m. using a mist net set in a lowland clearance opening surrounded by dipterocarp trees near the stream. The Head-to-Body (HB) size was approximately 70.71 mm, the tail 77.83 mm, and the hindfoot 19.46 mm. It has buffy white cheeks, a grey tinge beneath the eye, and a whitish spot behind each ear (Figure 2). The upper part is very dark grey with pale buff streaks, and the underpart is off-white on grey underfur (Figure 3). The tail is feather-like, buffy at the base, becoming blacker near the end, with a white tip (Figure 4).



Figure 2. A close-up of the face shows buffy's white cheeks and a whitish spot behind the ear. The side view shows a grey tinge beneath the eye, a patagium membrane, and a whitish spot behind the ear



Figure 3. The ventral view shows the off-white on grey underfur ventral surface with male genitalia

Discussion

The first *P. hosei* specimen was recorded from Toyul River, Baram District, Sarawak, and is preserved in the Natural History Museum, London (Corbet and Hill 1992; GBIF Secretariat 2023). The Head-Body (HB) length ranges from 75-90 mm, the tail from 80-98 mm, and the weight averages 21 g (GBIF Secretariat 2023). Other records show HB lengths of 80-87 mm, tail lengths of 80-98 mm, and weights of 31 g (Payne et al. 2007; Phillips and Phillips 2018).

For the individual caught in SRCA, the HB length is 70.71 mm (within range), and the tail length is 77.83 mm (slightly below the typical range), adding a new measurement for this species. This species has dark grey upper parts with pale buff streaks, off-white underparts with grey under-fur, buffy white cheeks, grey beneath the eyes, and a tail that darkens from buffy at the base to a white tip (Yasuma et al. 2003; Payne et al. 2007; Phillips

and Phillips 2018). The caught Hose's pygmy flying squirrel matches descriptions from Yasuma et al. (2003), Payne et al. (2007), and Phillips and Phillips (2018).

In Sabah, there is a limited record of *P. hosei*. This species had been recorded in Sepilok, with four individuals found in a nest hole on the edge of tall dipterocarp forests, approximately 6 meters above the ground, in a dead tree (Payne et al. 2007). Other than that, an internet photograph of this species has been recorded in the Maliau Basin Conservation Area (MBCA) (uluulublog 2020). The photograph recorded in MBCA showed white spots behind its ear with a variation on the upper part buffs. Two other locations outside Sabah, namely Tasek Merimbun and Sarawak, southward to Niah Caves (Phillips and Phillips 2018) and in Sepilok, Sabah (Payne et al. 2007). With this, the current study contributed to the second record for Sabah and the fifth record for Borneo for this species.

This species, *P. hosei*, shares similar features with *P. emiliae* but is larger. It has a white spot behind each ear and a grey tint below the eyes, as described by Yasuma et al. (2003), Payne et al. (2007), and Phillips and Phillips (2018). On the other hand, *P. emiliae* is similar to *P. hosei* but is 15% smaller in linear dimensions and has cheeks that are entirely buffy white without any grey below the eyes. This species is only known from one adult male and female in Baram District, Sarawak, in 1901. There are no documented records of this species in Sabah. However, there have been photographs taken in the Danum Valley Conservation Area (McLean 2017; creativeblok3 2023) and Deramakot Forest Reserve (Duijvestijn 2023) that show the possibility of *P. emiliae*'s presence in Sabah. Those photographs showed a lack of characteristics of *P. hosei*, such as a whitish spot behind the ears, a grey tinge beneath the eye, and distinctive pale buff streaks. Identifying rare species based on limited photo records is challenging as the angle may not show complete characteristics. The limited photographic records of live *P. hosei* and *P. emiliae* can cause confusion between these two data-deficient pygmy flying squirrel species.



Figure 4. The upper part of the dark grey has pale buff streaks, the presence of patagium membrane, and a feather-like tail, buffy at the base, blacker near the end, with a white tip. It was released after being examined

Other than those two species of pygmy flying squirrels, there were approximately eight recognized species within the *Petaurillus* genus. These species included *P. kinlochii* (Rodentia: Sciuridae), *P. abraensis*, *P. nobilis*, *P. plagiatus*, *P. sanghirensis* and *P. steeri* (Cheong et al. 2021). It was mentioned that *P. hosei* may be the same species as the Selangor Kinloch's pygmy flying squirrel *P. kinlochii* (Phillips and Phillips 2018). However, no study has been done to confirm this, as no attempt has been made to study both species in Malaysia. Based on the description from Cheong et al. (2021), both species exhibit similar morphology, such as white spots behind ears, tail structure, and measurement range. Nonetheless, further study, especially molecular studies, is needed to confirm the relationship between these two species.

Studying arboreal pygmy squirrels is challenging due to their cryptic nocturnal behavior and lack of specific capture designs. They generally inhabit forest areas with many trees for nesting and foraging. Pygmy flying squirrels are occasionally captured in mist nets at night but can be found by locating their nest holes in tree trunks, which are difficult to find (Payne et al. 2007). Besides mist netting, pygmy flying squirrels can be documented through direct observations and canopy-level camera trapping, though encounters are rare. Based on the current survey, *P. hosei*'s capture was opportunistic, with the net set 8 meters above the ground, initially aimed at bats. In this survey, the mist net was placed near a stream bank in an open area surrounded by tall dipterocarp trees, possibly within the gliding path, indicating a drinking area with nests nearby. Further research is needed to understand pygmy flying squirrels' diversity, distribution, and behavior in Sabah through statewide surveys focusing on mist netting and mid-to-canopy level observations.

SRCA within the Segaliud Lokan Forest Reserve, though sustainably managed for timber and having experienced past logging, still provides crucial habitat for arboreal species like the elusive Hose's pygmy flying squirrel. The capture of *P. hosei* in SRCA suggests it uses lowland dipterocarp forests. This highlights the protection and restoration of heavily degraded areas are essential for supporting biodiversity. Still, habitat use by *P. hosei* in disturbed habitats remains unknown, highlighting the need for further studies to update the scarce information on the species' characteristics and ecology.

This study presents the most recent photographic and measurement records of the IUCN data-deficient species *P. hosei*, which was opportunistically captured in the SRCA, Sabah, Malaysia, on the island of Borneo. Additionally, our findings recommend the use of mid-canopy nets positioned at least 8 meters above the ground as an effective method for forest sampling surveys, particularly in old-growth forests, to better assess the presence and study the *P. hosei*.

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