ORIGINAL ARTICLE

New species records from Buton Island, South East Sulawesi, including regional range extensions

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ABSTRACT

Peninsular Malaysia is currently thought to host the highest biodiversity of Old World bats of any region, with 110 species recorded. However, the availability of literature to facilitate a similarly thorough species ‘checklist’ is not as readily available for other parts of Southeast Asia, including Sulawesi, Indonesia. Here we highlight 13 new species records from the long-term bat monitoring programme on Buton Island, South East Sulawesi, expanding on Patterson et al.’s (2017) previous inventory for this study area. One species (Hipposideros galeritus) is a new record for Sulawesi, and seven species (Cynopterus c.f. minutus, Rousettus celebensis, Megaderma spasma, Hipposideros c.f. ater, Myotis c.f. horsfieldii, Myotis c.f. moluccarum, and Myotis c.f. muciloca) are new records for Buton Island. The remaining five species (Thoopterus nigrescens, Dobsonia exoleta, Acerodon celebensis, Mosia nigrescens, and Mops sarasinorum) have been previously reported from Buton but were missing from the prior site inventory. We also correct a probable mistaken species identification in the previous inventory (Cynopterus cf. titthaechelis, now identified as Thoopterus nigrescens). This brings the total of confirmed species detected on Buton to 35, equating to 46.7% of all Sulawesi’s known bat diversity in c. 3% of its land area. We highlight Buton as a key area for conserving the region’s bat species.

ABSTRAK

Semarangjung Malaysia merupakan salah satu pusat keanekaragaman hayati kelelawar tertinggi di dunia saat ini, yaitu dengan catatan sejumlah 110 jenis kelelawar teridentifikasi. Namun demikian, ketersediaan literatur untuk menunjang proses identifikasi jenis kelelawar tidak mencakupi beberapa wilayah di Asia Tenggara, termasuk salah satunya di Sulawesi, Indonesia. Penelitian ini bertujuan dari Pulau Buton, Sulawesi Tenggara. Jenis Hipposideros galeritus merupakan new record untuk Sulawesi dan tujuh spesies lainnya (Cynopterus c.f. minutus, Rousettus celebensis, Megaderma spasma, Hipposideros c.f. ater, Myotis c.f. horsfieldii, Myotis c.f. moluccarum, dan Myotis c.f. muciloca) merupakan new record di Pulau Buton. Lima spesies lainnya (Thoopterus nigrescens, Dobsonia exoleta, Acerodon celebensis, Mosia nigrescens, dan Mops sarasinorum) telah dilaporkan dari penelitian sebelumnya dari Pulau Buton, tetapi tidak ditemukan di kawasan penelitian pada inventarisasi awal. Kami juga mengoreksi adanya kemungkinan kekeliruan identifikasi spesies pada inventarisasi sebelumnya (Cynopterus cf. titthaechelis, sekarang diidentifikasi sebagai Thoopterus nigrescens). Inventarisasi ini mencatat total sebanyak 35 spesies kelelawar di Pulau Buton, atau 46.7% dari total keanekaragaman jenis kelelawar yang terdata di Sulawesi, dari hanya 3% inventarisasi yang dilakukan dari total luas daratannya. Dengan demikian, penelitian ini menekankan pentingnya Pulau Buton sebagai salah satu kawasan utama untuk upaya pelestarian spesies kelelawar.
INTRODUCTION

Southeast Asia hosts over 25% of known bat species globally, with species richness across the region underestimated by as much as 50% (Kingston 2013, Lim et al. 2017). Peninsular Malaysia is currently thought to host the highest biodiversity of Old World bats of any region, with 110 species recorded and further species discoveries expected (Lim et al. 2017, 2019). However, the availability of literature to facilitate a similarly thorough species ‘checklist’ is not as readily available for other parts of Southeast Asia, including Sulawesi, Indonesia. The lowland forests of Sulawesi, which lie within the Wallacean biodiversity hotspot (Myers et al. 2000, Myers 2003) support diverse and highly endemic vertebrate communities (Whitten et al. 2002). Sulawesi has a particularly high level of endemism in mammals, estimated at 43% (Wiartno et al. 2017). However, the ecosystems and their resident biodiversity remain poorly known (Telnov 2011, Rheindt et al. 2020). Significant knowledge gaps remain not only in terms of a complete inventory for bat species, but also in terms of their ecology and behaviour, including many species which have been recorded or inferred within the area but not further studied since. A literature review by Broto & Mortelliti (2019) found that of 144 detected mammal species in Sulawesi, for 34 no further research has been published about their ecology or behaviour. Further, of those 34 understudied mammal species, 27 (79%) of those are Chiropteran. These knowledge gaps highlight the lack of research focus on bat species in Sulawesi, despite their high diversity.

To address this shortfall, an extensive biodiversity monitoring programme on Buton Island (hereafter Buton), South East Sulawesi Province, has been running for over 20 years, run by Universitas Halu Oleo and Operation Wallacea (Martin et al. 2015). As South East Sulawesi’s largest offshore island, Buton may have similar levels of species richness and endemism to the rest of the region, although this is yet to be confirmed. An initial inventory of 23 bat species detected by these surveys was previously published by Patterson et al. (2017). However, survey work on Buton has continued in more recent years, and several more species have been detected during this time, including new spatial range records for both the island and for Sulawesi as a whole. Here, we summarise those new records, along with a correction regarding a species identification presented in Patterson et al. (2017), updating the current knowledge of the bat community of Buton and the distribution of bats within the Sulawesi region in general.

METHODS

Study area

Bat surveys were conducted within three nature reserves (each constituting uninhabited lowland monsoon forest) and a single village. Lambusango Wildlife Reserve (hereafter LWR) (65,000 ha; 5°10’–5°24’ S, 122°43’–123°07’ E) and Kakenauwe Nature Reserve (hereafter KNR) (810 ha; 5°15’ S, 122°50’ E) are situated in the south-centre of Buton. Buton Utara Nature Reserve (hereafter BUNR) (98,600 ha; 4°36’ S, 123°05’ E) is located in the north of the island (Table 1; Fig. 1). The village of Labundo-bundo (5°11’ S, 122°54’ E), situated near the LWR, is a mix of farmland, mangrove, tropical lowland forest, coastal, and forest edge habitats (Martin et al. 2015). Any incidental observations outside those areas were also recorded (Table 1; Fig. 1). An occurrence dataset including acoustic recordings (Donnelly et al. 2021) for all species will be made available on the Southeast Asian Bat Conservation Research Unit (SEABCRU) GBIF project page at the time of publication (https://doi.org/10.15468/qzn3rs). All new records presented here were detected during the 2018 Universitas Halu Oleo/ Operation Wallacea research season on Buton, running eight weeks between early June and early August.

Bat trapping surveys

Trapping sites were situated along established long-term biodiversity and habitat monitoring transects and adjacent habitats including forest, forest-edge, forest clearings, rivers, and farmland. Habitat types present in each study area are listed in Table 1. All trapping sites in each study area corresponded to one of these listed habitat types. Sites along transects were selected based on potential flyways (Kunz et al. 2009). Each site had between two to three nets and/or harp traps placed (Fig. 1). Sites were repeated
only once a period of three nights had passed, to minimize disturbance to that area, or unless an earlier session was cancelled due to poor weather, in which case sites were sometimes repeated on consecutive nights (Hayes et al. 2009). Mist-nets and harp traps were placed perpendicular to trails and rivers and parallel to ridges. Mist-nets varied from 3, 6, 9, and 12 m in length and were placed within 50 m of one another. Mist-net hours were calculated based on 6 m nets with one 6 m equating to 1 hour, one 9 m equating to 1.5 hours, and one 12 m equating to 2 hours of trapping effort. Three to four-bank harp traps with a frame size of 2.4 m², were placed within 100 m of one another. Harp trap hours were calculated based on one harp trap equating to 1 hour of trapping effort. In addition, we used Ecotone ultrathin monofilament nets (netting denier: 0.08 mm, mesh size: 14 x 14 mm) to improve capture rate of insectivorous bats. Nets and harp traps were set up in forest, forest-edge, forest clearings, rivers, and farmland habitats between 17:00 and 24:00 each night and checked every 15 minutes and 30 minutes, respectively. A single Titeley Scientific 7 m tall triple high system with three monofilament nets was employed in the same habitats. Additional targeted surveys were conducted in areas with potential to yield novel captures (e.g. abandoned buildings, caves and large hollow logs) and active searching of possible roosting sites (e.g. curled leaves and rocky overhangs).

Age, sex and reproductive status of all bats caught were recorded, along with the following morphometric measurements: weight (g; body mass taken using 50 g, 100 g, or 500 g Pesola spring scales depending on size of the bat), forearm length (mm; from the elbow to the carpus with wings folded), ear length (mm; measured from the base of the tragus or antitragus to the tip of the pinna), tragus length (mm; from the notch on the outside of the tragus to the tip), tibia length (mm; measured from knee joint to ankle), hindfoot length (mm; measured from the heel to the longest digit, excluding hair and/or claws), tail length (mm; measured from base adjacent to the anus to tip of tail), head-body length (mm; from snout tip to the anus), and thumb (mm; measured from the maximum distance of the straight thumb, excluding wrist, hair and/or claws). For more detailed methodology see Dietz & von Helversen (2004) and Srinivasulu et al. (2010).

Additional wing measurements for species undergoing taxonomic review were also measured: metacarpals II to V (mm; measured from the outer end of the carpus to the distal end of the metacarpal), third and fifth digits (mm; measured from the inside of the wrist to the tip of the finger), phalanx 1 of third finger (mm; measured from the distal end of metacarpal III to the distal end of first phalanx, Cynopterus sp. only), phalanx 1 of fourth finger (mm; measured from the distal end of metacarpal IV to the distal end of first phalanx, Rhinolophus sp. only), and phalanx 2 of fourth finger (mm; measured from the distal end of phalanx 1 of fourth finger to the distal end of phalanx 2, Rhinolophus sp. only). For detailed methodology see Dietz & von Helversen (2004). The forearm, tibia, hindfoot, thumb, metacarpals, phalanges and wing digits were measured using calipers to the nearest 0.1 mm, while head-body length, tail length, ear, and tragus were measured using a 150 mm stainless steel ruler to the nearest 0.1 mm. High-quality digital photographs of all captures were taken before releasing them. These photographs were incorporated into an open-access online Chicago Field Museum guide (Donnelly et al. 2020). No specimens or genetic samples were taken over the course of this fieldwork, as per permit regulations in Indonesian protected areas (Grajal 1999, Sodhi & Liow 2000).

Captured bats were identified by using a field key and cross-referenced with data in the literature (Bergmans & Rozendaal 1988, Flannery 1995, Bonaccorso 1998, Francis & Hill 1998, Suyanto & Kartikasari 2001, Payne & Francis 2007, Huang et al. 2014, Philippis & Philippis 2016, Wiantoro et al. 2017). Taxonomy followed Wilson & Mittermeier (2019) and confirmed with https://batnames.org (Simmons & Cirranello 2020). New species records were identified by comparing captures from this study with the species records in Patterson et al. (2017).

Species conservation status and range extensions

The conservation status of new species records were determined using the IUCN Red List (IUCN 2020). In addition, species endemic to the Wallacean biodiversity hotspot were noted (Myers et al. 2000). Two magnitudes of range extensions were considered (Patterson et al. 2017): major range extensions for species not previously reported from anywhere within the Sulawesi region, and minor range extensions for species known to occur on Sulawesi, but not indicated as occurring on Buton based on existing species distribution maps. Range extensions were identified by consulting each species distribution map in IUCN (2020), as well as records provided in published papers from the region or extralimital ranges (see Revilliod 1911, Bergmans & Rozendaal 1988, Flannery 1995, Suyanto & Kartikasari 2001, Riley 2002, Campbell et al. 2004, Maryanto et al. 2011, Wilson & Mittermeier 2019).

RESULTS

A total of 950 individual bats comprising 32 species were captured or observed during 1,672 hours of trapping effort (235.4 harp hours over 26 nights and 1,437 net hours over 77 nights) across survey localities on Buton Island (Table 2; Fig. 3). Thirteen species were not previously reported in Patterson et al. (2017). Of these, one species is listed as Vulnerable and one species considered Data Deficient (IUCN 2020). We report one major range extension, seven minor range extensions and provide an annotated species inventory of new records for Buton (Fig. 2) including morphometric data for new species records (Table 3 & 4), and photographic records of all species (Donnelly et al. 2020). As Indonesian bats remain understudied, additional measurements for the remainder of the species are provided (Table 5 & 6).

Species accounts

Pteropodidae

Cynopterus c.f. minutus (Miller 1906)

The Cynopterus species on Buton belong to the C. brachyotis complex, a cryptic group in need of genomic revision (Giannini et al. 2019). Three species from this
complex are indicated to occur in Sulawesi (C. sphinx, C. luzoniensis and C. minutus) (Campbell et al. 2004, Rosell-Ambal et al. 2019) (Fig. 2). C. brachyotis does not occur on Sulawesi, with its eastern limits set to Borneo and Bali (Kitchener & Maharadatunkamsi 1991). C. c.f. brachyotis referred by Patterson et al. (2017) likely refers to C. luzoniensis; however, C. luzoniensis from Sulawesi do not group with the originally described species from the Philippines and instead may represent C. minor, pending taxonomic recognition (Giannini et al. 2019). It may also be that future genetic analysis shows some Sulawesian Cynopterus populations to be new species (B. Lim pers. comms). As such, all members of this complex are denoted c.f. both here and in Patterson et al. (2017).

A total of 119 individual Cynopterus were captured in our survey work, constituting at least two species (Table 3 & 5). It was not possible to assign a species to all individuals, although preliminary discriminant analyses suggest that the 2nd metacarpal may differ between Cynopterus species on Buton (Donnelly unpublished data).

Individuals identified as C. minutus appear to have a longer 2nd metacarpal measurement (>30 mm) than C. c.f. luzoniensis (<30 mm) (Table 4 & 6), which may be an effective means of differentiating them. It is also possible that C. sphinx is present on Buton, as individuals with forearm measurements greater than 65 mm were caught. Given overlapping morphometrics, further genomic analyses are required.

A total of 21 individuals were assigned to C. c.f. minutus based on the length of the second metacarpal. These records would represent a minor range extension for the species, as it is known to occur on mainland South East Sulawesi, but not Buton (Ruedas & Suyanto 2019). Captures were represented from both forest habitats and farmland close to forest edge at Labundo-bundo, Lapago, North Buton camp, and Waculaea study sites (Table 1 & 2; Fig. 3A, 3B). Lactating and post-lactating individuals were caught throughout July. Males with engorged testes and orange mantles were captured throughout June and July. Individuals captured on Buton mostly fall within the morphometric ranges described for C. minutus in Wilson & Mittermeier (2019) with the
exception of the forearm reaching lengths greater than 60 mm (Table 3). Given the cryptic nature of *Cynopterus*, it is probable that individuals of *C. c.f. minutus* were indeed caught in the fieldwork of Patterson et al. (2017) but were grouped with *C. c.f. brachyotis*. *

_A Wallacean endemic indicated as occurring on Buton (Ruedas et al. 2008) and identified as *Cynopterus c.f. titthaecheilus* by Patterson et al. (2017).

Revision of the photographic records identifies the individuals caught by Patterson et al. (2017) as *Thoopterus nigrescens*. There are morphological similarities between the *Cynopterus* genus and *Thoopterus*. *Thoopterus* were originally described and grouped with *Cynopterus* (Grey 1870). Specifically, photo records provided in Patterson et al. (2017) show no white rim around the ears or white finger bones; diagnostic features of all *Cynopterus* species. Further, identification of these individuals as *T. nigrescens* match known spatial distributions, with *C. titthaecheilus* not being reported from the Sulawesi region (Tsang 2016). We recommend removing *C. c.f. titthaecheilus* from the overall inventory of Buton.

_Thoopterus nigrescens* (Gray 1870)

A Wallacean endemic indicated as occurring on Buton (Ruedas et al. 2008) and identified as *Cynopterus c.f. titthaecheilus* by Patterson et al. (2017).

Individuals previously captured by Patterson et al. (2017) had brown-coloured fur, with long greyish-light brown dense fur on the ventral side, and black wings. They were quite muscular, with short muzzles and round robust heads, matching previous descriptions (Flannery 1995).

This species may be mistaken for *Thoopterus suhanaiahe* which have longer forearms and wider calcar than _T. nigrescens_ (Maryanto et al. 2012). *Harpyionycteris celebensis* may also be mistaken for _T. nigrescens_ in the field as they overlap in all standard measurements but differ only in the shape of their muzzle, with *Thoopterus* having a broad short muzzle and *Harpyionycteris* being narrower and longer (Giannini et al. 2019). The presence of *Thoopterus nigrescens* on Buton has been previously confirmed by Maryanto et al. (2012).

_Rousettus celebensis* (Andersen 1907)

Currently, three _Rousettus_ species are known to occur on Sulawesi (*R. amplexicaudatus, R. celebensis*, and _R. linduensis_). At time of publication, _Rousettus_ was identified as the incorrect genus for this species and belongs to the new genus _Pilonycteris_ (Nesi et al. 2021). Future publications should therefore refer to this species as _Pilonycteris celebensis_ (Nesi et al. 2021). A Wallacean endemic, _R. celebensis_ on Buton is a minor range extension.
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Table 2 - Species summaries and trapping effort for each survey locality during the 2018 sampling period. * Species considered to have a minor range extension (previously reported from South East Sulawesi but not on Buton Island). ** Species considered to have a major range extension (not previously reported from Sulawesi). † Species assessed as threatened or near threatened by the IUCN (2020). ‡ Species endemic to the Wallacean biodiversity hotspot as defined by Myers (2003). # Species known only from photographic records, with no individuals caught.

| Family               | Species                              | Labundo-bundo | Linoswu | Lapago | Rakenuwe | North Buton | Wacucla | Mo Uso |
|----------------------|--------------------------------------|---------------|---------|--------|-----------|-------------|---------|--------|
| Pteropodidae         | Cynopterus c.f. minutus*              | 10            | 3       | 6      | 2         |             |         |        |
|                      | Rousettus celebensis† **             | 6             | 2       | 11     |           |             |         |        |
|                      | Dobsonia exoleta‡                    | 10            |         |        |           |             |         |        |
|                      | Acerodon celebensis† ‡ **           |               |         | 3      |           |             |         |        |
| Megadermatidae       | Megaderma spasma*                    | 10            | 3       | 2      | 4         |             |         |        |
| Hipposiderida        | Hipposideros galeritus**             | 1             |         |        |           |             |         |        |
|                      | Hipposideros c.f. ater                | 1             |         |        | 2         |             |         |        |
| Emballonuridae       | Mosia nigrescens                     |               |         |        |           |             | 1       |        |
| Molossidae           | Mops sarasinorum                     |               |         |        |           |             | 3       |        |
| Vespertilionida      | Myotis c.f. horsfieldii*             |               |         |        |           |             |         | 19     |
|                      | Myotis c.f. moluccarum               | 3             | 1       |        |           |             |         |        |
|                      | Myotis c.f. muricola*                |               |         |        |           |             |         |        |
| Total species        |                                      | 20            | 1       | 12     | 6         | 17          | 11      | 8      |
| Total individuals    |                                      | 138           | 1       | 65     | 32        | 375         | 220     | 133    |
| Net hours            |                                      | 283.8         | 0       | 485.6  | 179.4     | 539.0       | 165.7   | 59.3   |
| Harp trap hours      |                                      | 4.5           | 0       | 37.6   | 0.0       | 97.0        | 70.2    | 26.0   |

A total of 15 individuals were captured throughout Labundo-bundo, Wacucla, North Buton camp and Lapago (Table 1 & 2; Fig. 3C), making them a widespread, regularly encountered species. Males with engorged testes, orange shoulder patches and strong musky odour were captured from early June to early July, with lactating and post-lactating females captured late June to early July. The frequency of captures in this study suggests *R. celebensis* was possibly captured by Patterson et al. (2017) but misidentified as *R. amplexicaudatus*. The *R. celebensis* caught in this study were differentiated from *R. amplexicaudatus* by their smaller forearm length (Table 3), longer pelage, and furred tibia (which are naked in *R. amplexicaudatus*).

*Dobsonia exoleta* (Andersen 1909)

Hutson et al. (2019) indicated *Dobsonia exoleta* as potentially occurring on Buton according to genetic evidence. Our surveys confirmed the presence of two species of *Dobsonia*: *D. exoleta* and *D. crenulata* (reported in Patterson et al. 2017). Disentangling different species within *Dobsonia* remains challenging due to the overlap in standard measurements and ongoing taxonomic revision for the Sulawesi region, with most identifying features relying heavily on cranial and dental measurements (Flannery 1995). In this study, fur colour was used to differentiate species, with *D. exoleta* exhibiting bright yellow fur and *D. crenulata* dull brown (Giannini et al. 2019). Given overlapping morphometrics, further genomic analyses are required.

Ten individuals were assigned to *D. exoleta* (Table 3 & 4) and two to *D. crenulata* (Table 5 & 6). It is also possible that individuals previously identified as *D. crenulata* by Patterson et al. (2017) may in fact have been a mix of both *D. crenulata* and *D. exoleta* considering the high number of individuals of *D. exoleta* captured in the 2018 field season. Individuals were hand-netted from limestone caves located in both Labundo-bundo and Lapago (Table 1 & 2; Fig. 3D). Males with engorged testes were captured along with three juveniles. No females showed signs of breeding.

**Acerodon celebensis** (Peters 1867)

A Wallacean endemic and a globally Vulnerable species previously mapped as occurring on Buton (Tsang & Sheherazade 2016); however, not detected by Patterson et al. (2017). Three individuals were observed feeding on figs in a *Ficus* tree in Mo Uso (Table 1 & 2; Fig. 3E). Anecdotal records also exist of *A. celebensis* in small groups observed in the vicinity of Labundo-bundo (F. Mantan pers. comms). Identification was based on the pigmentation of the wing membrane between the second and third digit being considerably lighter than the rest of the membrane.
Megadermatidae

*Megaderma spasma* (Linnaeus 1758)

A geographically widespread species that is easily identified in the field by their long ears, biforked tragus, and woolly blue-grey fur. A minor range extension that has not been previously detected on Buton, however, is reported as occurring on mainland South East Sulawesi (Francis 2019, Srinivasulu et al. 2019).

A total of 15 individuals were recorded across all field sites except Mo Uso (Table 1 & 2; Fig. 3F), from a range of habitats including farmland and closed canopy forest. Roosts found included derelict buildings, rotting logs and caves. Breeding males, post-lactating females and a single juvenile were captured mid-June to early July. Despite our fairly regular recording of this species, it was not reported by Patterson et al. (2017). This species is known to employ both active and passive echolocation for hunting and navigating, which can increase the likelihood of evading nets and harp traps (Wang & Müller 2009). It may be that the sensitive echolocation and agility of *M. spasma* (being a gleaning species) prevented capture in the standard nets used previously (Patterson et al. 2017). The use of finer monofilament Ecotone nets (which *M. spasma* may find more difficult to avoid), along with targeted mist-netting and hand-netting in specific microhabitats where the species was suspected to occur (including roosts) may have increased detection in this study.

Hipposideridae

*Hipposideros galeritus* (Cantor 1846)

This species has not been reported occurring east of Wallace’s line (Srinivasulu & Srinivasulu 2019, Wilson & Mittermeier 2019, IUCN 2020). Bates et al. (2007) refer to *H. galeritus* specimens from Kakanawe Forest Reserve on Buton despite this species not being reported elsewhere in the Sulawesi region. Our records on Buton corroborate Bates et al. (2007) and highlight the presence of *H. galeritus* on Buton. Captures of *H. galeritus* in this study thus represent a major range extension.

One individual was caught in farmland in close proximity to forest near Labundo-bundo (Table 1 & 2; Fig. 3G). The individual had two supplementary leaflets. The tail was relatively long with five visible tail vertebrae, in comparison to those of *H. cervinus* which only had four vertebrae. The shape of the noseleaf also differed, with the intermediate noseleaf being wider than the posterior noseleaf. These descriptions are in line with *H. galeritus* described from other regions (Jenkins & Hill 1981). This individual was caught in a harp trap and showed no sign of breeding.

*Hipposideros c.f. ater* (Cantor 1846)

A geographically widespread species found throughout South and South-east Asia. Currently there are seven subspecies recognized and the group is in need of taxonomic revision (Soisook et al. 2019). A minor range extension previously reported as occurring throughout mainland Sulawesi but not on Buton (Csorba et al. 2008).

Only three individuals (two males and one female) were caught during the sampling period in Labundo-bundo, Waculuea, and North Buton camp (Table 1 & 2; Fig. 3H). Only one male showed signs of breeding mid-July. Individuals caught did not have supplementary leaflets and the internarial septum was swollen in the middle. Fur was golden cream and white at the base. Our measurements and description fall in line with what is known for this species (Table 3), but currently there is great variation in the shape of the internarial septum amongst subspecies, suggesting that with further revision, cryptic species may arise (Soisook et al. 2019).

Emballonuridae

*Mosia nigrescens* (Gray 1843)

Previously indicated as occurring on Buton (Bonaccorso & Leary 2008) but not reported in Patterson et al. (2017).

This species was recorded once, a single female adult showing no signs of reproduction, captured in a triple high mist-net system in closed canopy forest near limestone rocky overhangs in North Buton camp on 21/06/18 (Table 1 & 2; Fig. 3I). *Mosia* are fast-flying aerial insectivores with large eyes (Bonaccorso 2019) like *Megaderma spasma*, making them difficult to capture via standardized survey techniques and therefore requiring more targeted survey efforts.

*M. nigrescens* differed from *Emballonura monticola* in its size and dirty blonde pelage, with forearm length being noticeably shorter (Table 3 & 5).

Molossidae

*Mops sarasinorum* (Lesson 1842)

A Data Deficient species that may be conspecific with *M. mops* (Taylor et al. 2019). It has been previously indicated to occur on Buton (Rosell-Ambal et al. 2016) but not previously reported Patterson et al. (2017).

We recorded this species three times (Table 3), all captured in the triple high system near farmland while commuting over an open brackish river channel near Labundo-bundo (Table 1 & 2; Fig. 3I). None showed any evidence of breeding. Individuals were vibrant chestnut-orange in colouration. The tail extended beyond the edge of the uropatagium. The upper lip was wrinkled and there was a band of skin running across the top of the head, joining both ears with a tuft of fur in the middle on the underside. The anterior edge of the pinna was also lined with fur.

Vespertilionidae

*Myotis c.f. horsfieldii* (Temminck 1840)

A widespread species found across South and South-east Asia, including Sulawesi (Phelps et al. 2019). The presence of these individuals on Buton indicates a minor range extension.

Twenty-four individuals were captured within riparian habitat in both mist-nets and harp traps placed at North Buton camp and Waculuea (Table 1 & 2; Fig. 3K). Only males showed signs of breeding, with enlarged testes.
Fig. 3 - The distribution of trapping and observations of new bat species records on Buton Island, South East Sulawesi. The number of individuals for new species (species names and total number of captures/observations provided on Y axis) were counted at each trapping site located within survey localities (see Fig. 1 for survey localities on Buton Island). Depth of colour is proportional to the number of individuals captured for each species at each trapping site and with detail listed in Table 2. Lines indicate survey locality boundaries (see Fig. 1 for further detail). Scale bars differ between columns. Map derived from Google Maps (2021). * Denotes photos provided by Sarah Curran.
These individuals were placed into the Leuconoe subfamily, with wing attachment being on the side of the foot just below the ankle. Upper premolars P$_2$ and P$_3$ were in line with the toothrow, with P$_3$ being smaller than P$_2$, corresponding with *M. horsfieldii* (Francis & Hill 1998). Fur was dense, charcoal grey dorsally, and silver/grey-white ventrally. Measurements of Buton individuals matched with Burgin et al. (2019) (Table 3). Currently, this species represents a complex and is in need of taxonomic revision (Burgin et al. 2019).

*Myotis c.f. moluccarum* (Thomas 1915)

Distribution for this species is scattered throughout Wallacea and New Guinea (Reardon & Bonaccorso 2008). Individuals captured on Buton represent a minor range extension. Both *M. c.f. moluccarum* individuals were captured in coastal habitat at sea level.

One individual was incidentally found roosting on a ceiling c. 2.5 m off the ground in a hotel in Linsowu, while the other was caught in a mist-net near Labundo-bundo (Table 1 & 2; Fig. 3L) trawling over a brackish river channel. This distribution suggests that this species is widespread across Buton.

Close examination of the hindfoot, metacarpals and forearm revealed measurements to be longer than that of *M. c.f. horsfieldii* (Table 3 & 4). Upper premolars did not differ from *M. c.f. horsfieldii*, and wing attachment to side of the foot also placed them in the Leuconoe subfamily. Fur had more of a brown tinge, both dorsally and ventrally, compared to *M. c.f. horsfieldii*. None of the individuals showed signs of breeding. Taxonomy is still being resolved for this species, which has previously been included within *Myotis adversus* specimens and considered a part of the *M. horsfieldii* species group (Burgin et al. 2019).

*Myotis c.f. muricola* (Gray 1846)

A widespread species found across much of South and South-east Asia. This report represents a minor range...
### Table 3 - Summary of morphometric measurements for bats captured on Buton Island, South East Sulawesi, which represent new additions to our species inventory. Taxonomy follows Wilson & Mittermeier (2019). Species photos are provided in Donnelly et al. (2020). Morphometric values of adult individuals shown as mean ± standard deviation. N/A indicates no measurements collected. * Species considered to have a minor range extension (previously reported from South East Sulawesi but not on Buton Island). ** Species considered to have a major range extension (not previously reported from Sulawesi). † Species assessed as threatened or near threatened by the IUCN (2020). ‡ Species endemic to the Wallacean biodiversity hotspot as defined by Myers (2003).

| Family          | Species            | Sex (n) | Forearm (mm) | Weight (g) | Ear length (mm) | Tragus (mm) | Tibia (mm) | Hindfoot (mm) | Tail (mm) | Head-body length (mm) | Thumb (mm) |
|-----------------|--------------------|---------|--------------|------------|-----------------|-------------|------------|---------------|-----------|-----------------------|------------|
| Pteropodidae    | Cynopterus c.f. minutus* | Male (10) | 60.11 ± 1.98 | 28.69 ± 3.21 | 13.64 ± 1.96 | 0 ± 0       | 30.18 ± 5.16 | 15.38 ± 1.96 | 10.98 ± 1.94 | 10.98 ± 1.94 | 10.98 ± 1.94 | 10.98 ± 1.94 |
|                 |                    | Female (10) | 61.86 ± 3.31 | 29.28 ± 4.52 | 13.64 ± 1.96 | 0 ± 0       | 30.18 ± 5.16 | 15.38 ± 1.96 | 11.82 ± 1.81 | 11.82 ± 1.81 | 11.82 ± 1.81 | 11.82 ± 1.81 |
|                 | Rousettus celebensis‡* | Male (4) | 71.63 ± 2.03 | 63.63 ± 3.74 | 10.70 ± 1.65 | 0 ± 0       | 33.80 ± 2.36 | 22.27 ± 1.69 | 10.98 ± 1.94 | 10.98 ± 1.94 | 10.98 ± 1.94 | 10.98 ± 1.94 |
|                 |                    | Female (10) | 73.68 ± 1.40 | 50.70 ± 3.47 | 10.70 ± 1.65 | 0 ± 0       | 34.00 ± 1.41 | 23.78 ± 1.46 | 11.82 ± 1.81 | 11.82 ± 1.81 | 11.82 ± 1.81 | 11.82 ± 1.81 |
|                 | Dobsonia exocellata‡* | Male (9) | 116.74 ± 1.87 | 227.67 ± 2.08 | 23.78 ± 1.46 | 0 ± 0       | 55.08 ± 2.11 | 24.88 ± 1.96 | 17.11 ± 1.35 | 17.11 ± 1.35 | 17.11 ± 1.35 | 17.11 ± 1.35 |
|                 |                    | Female (1) & Mosia nigrescens | 119.4 | 208.0 | 17.0 | 0 | 52.0 | 15.1 | 27.0 | 165.0 | 23.90 |
| Megadermatidae   | Megaderma spasma * | Male (13) | 55.02 | 6.5 | 10.0 | N/A | 6.7 | 41.0 | 52.0 | 2.90 |
|                 |                    | Female (4) | 55.03 | 6.5 | 10.0 | N/A | 6.7 | 41.0 | 52.0 | 2.90 |
| Hipposideridae   | Hipposideros galeritus‡** | Male (2) | 38.75 ± 0.64 | 26.50 ± 2.12 | 16.15 ± 0.31 | 0 ± 0       | 17.0 ± 0.28 | 16.8 ± 0.27 | 17.0 ± 0.28 | 17.0 ± 0.28 | 17.0 ± 0.28 | 17.0 ± 0.28 |
|                 |                    | Female (1) | 39.2 | 6.0 | 11.0 | 3.0 | 17.4 | 6.2 | 25.9 | 14.45 | 17.6 |
|                 | Hipposideros c.f. atter | Male (1) | 33.2 | 6.0 | 11.0 | 3.0 | 17.4 | 6.2 | 25.9 | 14.45 | 17.6 |

* New species records from Buton Island, South East Sulawesi, including regional range extensions.
Table 3 - Continuation.

| Family          | Species          | Sex          | Number (1) | Ear length (mm) | Forearm (mm) | Weight (g) | Head-body length (mm) | Hindfoot (mm) | Tail (mm) | Head-body length (mm) | Tail (mm) | Hindfoot (mm) | Tragus (mm) | Trogus (mm) | Tethribis (mm) | Sex (n) | Weight (g) | Head-body length (mm) | Tail (mm) | Hindfoot (mm) | Tragus (mm) | Trogus (mm) | Tethribis (mm) |
|-----------------|------------------|--------------|------------|-----------------|--------------|------------|-----------------------|--------------|-----------|-----------------------|-----------|--------------|-------------|------------|------------------|---------|------------|----------------------|-----------|--------------|-------------|------------|------------------|
| Vespertilionidae| Myotis c.f. muricola* | Male         | 2 (3)      | 36.57 ± 1.75   | 6.00 ± 0.00  | 4.00 ± 0.00 | 42.56 ± 5.36          | 22.2 ± 2.72  | 2.2 ± 0.40 | 42.56 ± 5.36          | 22.2 ± 2.72 | 2.2 ± 0.40 | 42.56 ± 5.36 | 22.2 ± 2.72 | 2.2 ± 0.40 | 42.56 ± 5.36 |
| Mops sarasinorum| M. browni         | Male         | 2 (3)      | 37.63 ± 0.67   | 10.43 ± 1.47 | 4.32 ± 1.26 | 16.78 ± 0.07          | 16.67 ± 1.12 | 9.8 ± 0.95 | 16.78 ± 0.07          | 16.67 ± 1.12 | 9.8 ± 0.95 | 16.78 ± 0.07 | 16.67 ± 1.12 | 9.8 ± 0.95 | 16.78 ± 0.07 |
| Mops            | c.f. horsfieldii  | Female       | 2 (3)      | 38.49 ± 0.62   | 11.16 ± 0.95 | 4.30 ± 1.13 | 16.67 ± 1.12          | 16.67 ± 1.12 | 9.8 ± 0.95 | 16.67 ± 1.12          | 16.67 ± 1.12 | 9.8 ± 0.95 | 16.67 ± 1.12 | 16.67 ± 1.12 | 9.8 ± 0.95 | 16.67 ± 1.12 |
| Mops sarasinorum| M. ater           | Male         | 2 (3)      | 37.63 ± 0.67   | 10.43 ± 1.47 | 4.32 ± 1.26 | 16.78 ± 0.07          | 16.67 ± 1.12 | 9.8 ± 0.95 | 16.78 ± 0.07          | 16.67 ± 1.12 | 9.8 ± 0.95 | 16.78 ± 0.07 | 16.67 ± 1.12 | 9.8 ± 0.95 | 16.78 ± 0.07 |

Note: All dimensions are given in millimeters (mm).
Table 4 - Summary of morphometrics of bats captured on Buton Island, South East Sulawesi, which represent new additions to our species inventory. Taxonomy follows Wilson & Mittermeier (2019). Species photos are provided in Donnelly et al. (2020). Additional wing morphometric values of adult individuals shown as mean ± standard deviation. N/A indicates no measurements collected. * Species considered to have a minor range extension (previously reported from South East Sulawesi but not on Buton Island). ** Species considered to have a major range extension (not previously reported from Sulawesi). † Species assessed as threatened or near threatened by the IUCN (2020). ‡ Species endemic to the Wallacean biodiversity hotspot as defined by Myers (2003).

| Family            | Species                           | Sex (n) | Metacarpal I (mm) | Metacarpal II (mm) | Metacarpal III (mm) | Metacarpal IV (mm) | 3rd Digit (mm) | Phalanx 1 of 3rd finger (mm) | Phalanx 2 of 3rd finger (mm) |
|-------------------|-----------------------------------|---------|-------------------|-------------------|-------------------|-------------------|----------------|-----------------------------|-----------------------------|
| Vespertilionidae  | Pteropus c.f. minutus*             | Male (10)| 36.01 ± 1.05      | 36.76 ± 1.84      | 36.92 ± 1.94      | 36.75 ± 1.13      | 37.76 ± 1.84 | 41.7 ± 2.34                  | 43.0 ± 2.73                  |
|                   |                                   | Female (10)| 36.31 ± 1.87      | 35.56 ± 1.23      | 36.75 ± 1.40      | 35.92 ± 1.30      | 38.76 ± 1.84 | 41.8 ± 2.47                  | 43.0 ± 2.73                  |
|                   |                                   | Male (1)  | 40.8              | 41.0              | 41.0              | 41.0              | 41.0          | 41.0                        | 41.0                        |
|                   |                                   | Female (1) | 40.8              | 41.1              | 41.1              | 41.1              | 41.1          | 41.1                        | 41.1                        |
|                   | Cynopterus c.f. minitus*           | Male (1)  | 36.81 ± 1.26      | 37.56 ± 1.78      | 36.75 ± 1.40      | 35.92 ± 1.30      | 38.76 ± 1.84 | 41.8 ± 2.47                  | 43.0 ± 2.73                  |
|                   |                                   | Female (1) | 36.81 ± 1.26      | 37.56 ± 1.78      | 36.75 ± 1.40      | 35.92 ± 1.30      | 38.76 ± 1.84 | 41.8 ± 2.47                  | 43.0 ± 2.73                  |
|                   |                                   | Male (1)  | 40.8              | 41.0              | 41.0              | 41.0              | 41.0          | 41.0                        | 41.0                        |
|                   |                                   | Female (1) | 40.8              | 41.1              | 41.1              | 41.1              | 41.1          | 41.1                        | 41.1                        |
|                   | Dobsonia c.lateralis‡*             | Male (1)  | 66.82 ± 2.47      | 62.86 ± 2.56      | 66.69 ± 1.97      | 42.67 ± 2.31      | 41.4 ± 2.24 | 191.56 ± 6.80                | 181.198                      |
|                   |                                   | Female (1) | 66.82 ± 2.47      | 62.86 ± 2.56      | 66.69 ± 1.97      | 42.67 ± 2.31      | 41.4 ± 2.24 | 191.56 ± 6.80                | 181.198                      |
|                   |                                   | Male (1)  | 61.4              | 65.5              | 65.5              | 65.5              | 65.5          | 65.5                        | 65.5                        |
|                   |                                   | Female (1) | 61.4              | 65.5              | 65.5              | 65.5              | 65.5          | 65.5                        | 65.5                        |
|                   | Myotis c.f. horsfieldii*           | Male (11) | 31.60 ± 1.05      | 32.76 ± 1.13      | 33.63 ± 1.34      | 32.70 ± 1.77      | 32.30 ± 1.65 | 138.4 ± 4.35                 | 44.1 ± 5.73                  |
|                   |                                   | Female (7) | 31.60 ± 1.05      | 32.76 ± 1.13      | 33.63 ± 1.34      | 32.70 ± 1.77      | 32.30 ± 1.65 | 138.4 ± 4.35                 | 44.1 ± 5.73                  |
|                   |                                   | Male (2)  | 35.75 ± 1.06      | 35.25 ± 1.06      | 35.80 ± 0.40      | 33.83 ± 1.78      | 32.24 ± 1.05 | 149.27 ± 1.17                | 49.27 ± 1.17                |
|                   |                                   | Female (7) | 35.75 ± 1.06      | 35.25 ± 1.06      | 35.80 ± 0.40      | 33.83 ± 1.78      | 32.24 ± 1.05 | 149.27 ± 1.17                | 49.27 ± 1.17                |
|                   |                                   | Male (2)  | 36.00 ± 0.99      | 36.35 ± 1.63      | 36.80 ± 0.40      | 33.83 ± 1.78      | 32.24 ± 1.05 | 149.27 ± 1.17                | 49.27 ± 1.17                |
|                   |                                   | Female (1) | 36.00 ± 0.99      | 36.35 ± 1.63      | 36.80 ± 0.40      | 33.83 ± 1.78      | 32.24 ± 1.05 | 149.27 ± 1.17                | 49.27 ± 1.17                |
|                   |                                   | Male (3)  | 29.77 ± 1.91      | 25.70 ± 2.72      | 29.77 ± 1.91      | 25.70 ± 2.72      | 29.77 ± 1.91 | 25.70 ± 2.72                  | 25.70 ± 2.72                |
|                   |                                   | Female (1) | 29.77 ± 1.91      | 25.70 ± 2.72      | 29.77 ± 1.91      | 25.70 ± 2.72      | 29.77 ± 1.91 | 25.70 ± 2.72                  | 25.70 ± 2.72                |
|                   | Myotis c.f. murocata*              | Male (1)  | 28.0              | 27.7              | 27.7              | 27.7              | 27.7          | 27.7                        | 27.7                        |
|                   |                                   | Female (1) | 28.0              | 27.7              | 27.7              | 27.7              | 27.7          | 27.7                        | 27.7                        |

New species records from Buton Island, South East Sulawesi, including regional range extensions.
| Family         | Species                  | Sex (n) | Forearm (mm) | Weight (g) | Ear length (mm) | Tragus (mm) | Tibia (mm) | Hindfoot (mm) | Tail (mm) | Head-body length (mm) | Thumb (mm) |
|---------------|--------------------------|---------|--------------|------------|-----------------|-------------|------------|---------------|-----------|------------------------|------------|
| Emballonuridae| Emballonura monticola    | Male (15) | 45.10 ± 1.56 (42.5-47.5) | 5.73 ± 0.96 (4.0-8.7) | 10.68 ± 1.80 (8.0-15.0) | 3.22 ± 1.09 (2.0-5.8) | 18.10 ± 0.93 (16.0-19.2) | 6.54 ± 1.41 (4.2-8.7) | 12.68 ± 2.86 (8.0-19.0) | 47.12 ± 3.56 (39.7-52.0) | 4.51 ± 0.91 (3.0-6.4) |
|               |                          | Female (3) | 45.10 ± 2.46 (43.0-47.8) | 6.00 ± 0.87 (5.5-7.0) | 12.07 ± 2.61 (10.0-15.0) | 3.43 ± 0.75 (3.0-4.3) | 17.53 ± 1.38 (16.5-19.1) | 6.43 ± 0.86 (5.5-7.2) | 16.07 ± 2.61 (14.0-19.0) | 43.0 ± 1.31 (41.8-44.4) | 4.0 ± 0.69 (4.0-5.2) |
| Miniopteridae | Miniopterus cf. blepotis | Male (1) | 40.57 ± 2.06 (38.2-42.0) | 5.83 ± 1.76 (4.0-7.5) | 9.80 ± 0.70 (9.0-10.3) | 4.77 ± 0.68 (4.0-5.3) | 17.33 ± 2.47 (14.0-20.9) | 7.03 ± 1.17 (6.0-8.3) | 35.90 ± 8.31 (28.7-45.0) | 40.93 ± 2.05 (38.9-43.0) | 3.55 ± 0.78 (3.0-4.1) |
|               |                          | Female (1) | 34.6 | 5.0 | 7.50 | N/A | 12.3 | 5.70 | 34.6 | 38.70 | 4.20 |
|               | Miniopterus cf. australis| Male (3) | 45.3 | 11.0 | 6.50 | N/A | 16.90 | 6.90 | 45.50 | 50.90 | 6.20 |
|               |                          | Female (1) | 34.6 | 5.0 | 7.50 | N/A | 12.3 | 5.70 | 34.6 | 38.70 | 4.20 |
| Hipposideridae| Hipposideros diadema     | Male (4) | 83.88 ± 1.42 (82.5-85.8) | 37.88 ± 5.45 (31.0-42.5) | 28.13 ± 2.74 (26.0-33.0) | 0 ± 0 | 34.90 ± 1.58 (33.0-36.3) | 10.75 ± 3.31 (9.7-14.8) | 46.85 ± 6.54 (41.3-54.0) | 94.55 ± 11.72 (81.5-110.0) | 7.45 ± 0.70 (6.8-8.2) |
|               |                          | Female (2) | 80.00 ± 1.70 (78.8, 81.2) | 28.25 ± 0.35 (28.0, 28.5) | 26.0 ± 3.11 (23.8, 28.2) | 0 ± 0 | 33.50 ± 3.82 (30.8, 36.2) | 11.25 ± 3.04 (9.1, 13.4) | 43.70 ± 2.97 (41.6, 45.8) | 85.55 ± 0.21 (85.4, 85.7) | 6.60 ± 0.85 (6.0-7.2) |
| Hipposideros  | pellingensis††           | Male (8) | 93.23 ± 4.63 (86.2-100.1) | 54.31 ± 6.19 (48.0-63.5) | 28.46 ± 2.06 (24.1-30.6) | 0 ± 0 | 41.04 ± 4.15 (31.1-44.1) | 16.61 ± 3.50 (11.3-20.5) | 58.51 ± 5.04 (52.1-69.0) | 94.75 ± 3.90 (90.1-101.0) | 7.43 ± 0.43 (7.0-8.0) |
|              |                        | Female (19) | 45.77 ± 1.42 (44.0-50.5) | 7.29 ± 1.77 (5.5-13.0) | 11.58 ± 1.78 (9.6-17.1) | 0 ± 0 | 17.69 ± 2.00 (15.1-24.6) | 6.09 ± 0.98 (4.1-8.2) | 20.42 ± 2.94 (15.8-26.1) | 44.87 ± 3.72 (39.2-52.8) | 2.58 ± 0.76 (1.6-4.4) |
| Tyroncteridae | Tyroncteris robustula    | Female (1) | 25.6 | 6.75 | 7.0 | 2.0 | 11.3 | 5.2 | 23.0 | 46.0 | 0.9 |
| Kerivoula     | Kerivoula c.f. hardwickii| Male (6) | 30.05 ± 0.70 (29.0-31.2) | 3.92 ± 0.20 (3.5-4.0) | 11.02 ± 1.01 (10.0-12.0) | 6.18 ± 1.36 (4.0-8.0) | 13.74 ± 1.05 (12.2-14.9) | 5.50 ± 0.70 (4.5-6.3) | 31.39 ± 3.00 (28.4-37.0) | 40.48 ± 5.95 (28.9-45.0) | 4.35 ± 0.37 (4.0-4.9) |
| Kerivoula     | Kerivoula c.f. papillosa | Male (10) | 46.21 ± 0.98 (45.2-48.5) | 11.65 ± 0.97 (10.0-13.0) | 14.54 ± 2.18 (12.0-19.0) | 7.48 ± 1.87 (4.0-10.0) | 23.07 ± 1.49 (20.3-24.9) | 9.31 ± 1.54 (6.7-11.9) | 48.70 ± 5.63 (40.1-57.0) | 53.37 ± 6.97 (42.7-66.0) | 7.98 ± 0.94 (6.3-9.4) |
|               |                          | Female (5) | 46.28 ± 1.68 (44.0-47.7) | 12.30 ± 0.67 (12.0-13.5) | 14.0 ± 1.22 (12.0-15.0) | 7.20 ± 1.64 (6.0-10.0) | 22.36 ± 0.66 (21.8-23.5) | 8.86 ± 0.53 (8.4-9.7) | 52.82 ± 3.45 (47.1-56.0) | 59.30 ± 5.39 (53.1-67.0) | 6.98 ± 0.90 (6.0-8.1) |
| Murina        | S. flavus                | Male (1) | 33.9 | 5.0 | 11.0 | 4.0 | 16.9 | 7.0 | 27.0 | 49.0 | 7.7 |
|               |                          | Female (1) | 32.80 | 5.50 | 9.90 | 4.30 | 15.0 | 5.90 | 26.80 | 38.80 | 9.10 |
Table 5 - Continuation

| Family          | Species                  | Sex (n) | Forearm (mm) | Weight (g) | Ear length (mm) | Tragus (mm) | Tragula (mm) | Ear-Brachial (mm) | Tragus-Brachial (mm) | Hindfoot (mm) | Tail (mm) | Head-body length (mm) | Thumb (mm) |
|-----------------|--------------------------|---------|--------------|------------|-----------------|-------------|-------------|-------------------|----------------------|----------------|-----------|-----------------------|-------------|
| Cynopterus c.f. | luzoniensis              | Male (30) | 59.96 ± 2.50 | 28.66 ± 3.56 | 14.05 ± 1.76   | 0 ± 0       | 22.94 ± 1.85 | 10.77 ± 1.49       | 7.82 ± 2.12          | 80.78 ± 7.23 | 13.81 ± 2.33 |
|                 |                          | Female (30) | 60.45 ± 2.16 | 28.48 ± 3.28 | 14.60 ± 1.89   | 0 ± 0       | 23.03 ± 1.28 | 11.21 ± 2.05       | 8.24 ± 2.74          | 80.71 ± 7.12 | 13.81 ± 2.58 |
| Eonycteris      | spelaea                  | Male (3)  | 74.07 ± 1.01 | 61.25 ± 13.08 | 16.83 ± 0.29   | 0 ± 0       | 35.17 ± 0.50 | 15.77 ± 0.91       | 14.57 ± 4.56          | 106.07 ± 9.06 | 14.67 ± 1.75 |
| Rousettus       | amplexicaudatus          | Male (6)  | 80.53 ± 2.47 | 73.92 ± 9.31  | 19.02 ± 1.79   | 0 ± 0       | 38.52 ± 3.16 | 20.43 ± 2.71       | 19.12 ± 1.75          | N/A           | 100.67±6.04 |
|                 |                          | Female (4) | 72.28 ± 5.73 | 48.13±12.83   | 17.25 ± 1.50   | 0 ± 0       | 30.53 ± 4.10 | 14.08 ± 1.49       | 17.0 ± 2.31           | 89.85 ± 6.56 | 17.25 ± 2.87 |
| Macroglossus    | minimus                  | Male (8)  | 39.98 ± 1.22 | 16.38 ± 1.13  | 12.16 ± 1.96   | 0 ± 0       | 16.03 ± 2.19 | 9.36 ± 1.03        | 0 ± 0                | 61.11 ± 7.09 | 9.40 ± 1.22  |
|                 |                          | Female (13)| 39.95 ± 1.07 | 15.81 ± 3.62  | 12.61 ± 2.11   | 0 ± 0       | 16.64 ± 0.87 | 9.52 ± 1.54        | 0 ± 0                | 62.0 ± 6.41  | 10.55 ± 2.35 |
| Dobsonia        | crenulata†               | Male (2)  | 120.9±1.27   | 242.5±10.6    | 23.25 ± 2.47   | 0 ± 0       | 58.75 ± 1.77 | 27.65 ± 3.32       | 25.2 ± 0.28           | 146.0±8.49   | 30.0 ± 0    |
| Nyctimene       | cephalotes†              | Male (4)  | 68.03 ± 2.58 | 46.25 ± 2.50  | 14.5 ± 1.73    | 0 ± 0       | 26.63 ± 0.51 | 13.65 ± 1.48       | 18.75 ± 2.06          | 98.35 ± 3.16 | 16.25 ± 2.01 |
|                 |                          | Female (1) | 67.9         | 46.0          | 14.8           | 0 ± 0       | 28.1         | 13.4             | 21.4                 | 95.0         | 17.4       |
| Rhinolophus     | celebens                  | Male (28) | 39.74 ± 1.55 | 5.80 ± 0.62   | 14.78 ± 1.89   | 0 ± 0       | 16.92 ± 1.44 | 5.67 ± 1.20        | 18.39 ± 3.31          | 43.40 ± 3.70 | 3.11 ± 0.72  |
|                 |                          | Female (9) | 40.81 ± 0.98 | 6.67 ± 2.88   | 15.34 ± 1.77   | 0 ± 0       | 17.16 ± 1.10 | 6.23 ± 0.83        | 19.18 ± 2.76          | 44.37 ± 3.66 | 3.04 ± 0.68  |
| Rhinolophus     | tatrac                    | Male (98) | 51.02 ± 1.17 | 11.48 ± 1.89  | 18.65 ± 2.50   | 0 ± 0       | 24.38 ± 1.28 | 8.70 ± 1.27        | 18.50 ± 3.01          | 53.83 ± 5.46 | 3.92 ± 0.72  |
|                 |                          | Female (109)| 50.28 ± 1.30| 11.66 ± 2.63  | 17.84 ± 2.42   | 0 ± 0       | 23.71 ± 1.23 | 8.78 ± 1.00        | 17.78 ± 2.96          | 52.82 ± 4.69 | 4.01 ± 0.68  |
| Rhinolophus     | philippinensis            |           |              |              |                |                |                |                  |                     |              |            |
|                 | (Large morph)             | Male (1)  | 57.4         | 12.0         | 33.0          | 0 ± 0       | 23.8         | 9.4            | 29.0               | 68.0         | 6.1        |
|                 |                          | Male (3)  | 50.43 ± 0.67 | 8.83 ± 1.04  | 26.33 ± 0.58   | 0 ± 0       | 20.57 ± 2.06 | 7.97 ± 0.32       | 20.50 ± 0.71          | 56.40±12.55 | 5.47 ± 3.67  |
|                 |                          | Female (5) | 50.88 ± 1.13 | 9.50 ± 1.50  | 25.80 ± 1.48   | 0 ± 0       | 21.91 ± 1.59 | 8.06 ± 0.91       | 27.0 ± 4.18           | 57.36±12.91 | 4.44 ± 2.73  |
|                 |                          | Female (2) | 46.65 ± 0.21 | 7.0 ± 0.0    | 23.75 ± 0.35   | 0 ± 0       | 19.0 ± 1.41 | 6.95 ± 0.07       | 24.50 ± 2.12          | 46.35 ± 3.75 | 2.75 ± 0.35  |
Table 6 - Summary of bats captured on Buton Island, South East Sulawesi, representing new additions to our species inventory. Taxonomy follows Wilson & Mittermeier (2019). Species photos are provided in Donnelly et al. (2020). Additional wing morphometric values of adult individuals shown as mean ± standard deviation. N/A indicates no measurements collected. ‡ Species endemic to the Wallacean biodiversity hotspot as defined by Myers (2003).

| Family | Species | Sex (n) | Metacarpal I (mm) | Metacarpal II (mm) | Metacarpal III (mm) | Metacarpal IV (mm) | Metacarpal V (mm) | 5th Digit (mm) | 3rd Digit (mm) | Phalanx 1 of 3rd Finger (mm) | Phalanx 1 of 4th Finger (mm) | Phalanx 2 of 4th Finger (mm) |
|--------|---------|---------|-------------------|-------------------|-------------------|-------------------|-------------------|----------------|----------------|-----------------------------|----------------------------|-----------------------------|
| Pteropodidae | Cynopterus c.f. luzoniensis | Male (27) | 36.94 ± 2.03 | 37.19 ± 2.28 | 34.58 ± 1.90 | 33.48 ± 2.34 | 32.08 ± 0.89 | 24.99 ± 1.92 | 71.09 ± 2.01 | N/A | N/A | N/A |
| | | Female (27) | 37.11 ± 2.23 | 37.21 ± 2.23 | 34.62 ± 2.04 | 33.62 ± 2.24 | 32.09 ± 0.94 | 25.06 ± 1.86 | 72.51 ± 2.14 | N/A | N/A | N/A |
| Rhinolophidae | Rhinolophus celebensis | Male (2) | 73.45 ± 4.88 | 69.05 ± 1.48 | 74.75 ± 1.06 | 32.8 ± 4.33 | 32.0 ± 0.40 | 28.08 ± 1.11 | 93.27 ± 4.52 | 93.58 ± 6.46 | 93.27 ± 4.52 | 93.58 ± 6.46 |
| | | Female (1) | 27.08 ± 4.17 | 29.39 ± 1.47 | 36.08 ± 1.97 | 26.5 ± 3.91 | 26.5 ± 3.91 | 26.5 ± 3.91 | 71.09 ± 2.01 | 71.09 ± 2.01 | 71.09 ± 2.01 | 71.09 ± 2.01 |
| | Rhinolophus tatar‡ | Male (76) | 36.52 ± 4.72 | 35.39 ± 1.95 | 34.24 ± 1.37 | 30.29 ± 3.81 | 30.29 ± 3.81 | 30.29 ± 3.81 | 58.53 ± 3.66 | 58.53 ± 3.66 | 58.53 ± 3.66 | 58.53 ± 3.66 |
| | | Female (53) | 36.08 ± 1.08 | 35.23 ± 1.36 | 34.38 ± 1.18 | 31.43 ± 1.37 | 31.43 ± 1.37 | 31.43 ± 1.37 | 57.49 ± 3.19 | 57.49 ± 3.19 | 57.49 ± 3.19 | 57.49 ± 3.19 |
| | Rhinolophus philippinensis (Intermediate morph) | Male (1) | 34.1 | 37.2 | 34.1 | 33.5 | 33.5 | 33.5 | 57.9 | 57.9 | 57.9 | 57.9 |
| | | Female (1) | 27.76 ± 1.92 | 29.46 ± 1.90 | 36.45 ± 2.85 | 34.89 ± 2.31 | 42.82 ± 2.83 | 63.91 ± 3.53 | 63.91 ± 3.53 | 63.91 ± 3.53 | 63.91 ± 3.53 | 63.91 ± 3.53 |
| | Emballonura monticolia | Male (1) | 24.41 ± 0.26 | 0.26 | 24.41 ± 0.26 | 24.41 ± 0.26 | 24.41 ± 0.26 | 24.41 ± 0.26 | 41.45 ± 0.50 | 41.45 ± 0.50 | 41.45 ± 0.50 | 41.45 ± 0.50 |
| | | Female (1) | 34.0 ± 2.26 | 34.85 ± 3.18 | 35.40 ± 1.13 | 34.30 ± 3.96 | 45.60 ± 2.12 | 70.80 ± 8.91 | 70.80 ± 8.91 | 70.80 ± 8.91 | 70.80 ± 8.91 | 70.80 ± 8.91 |
| | Miniopterus c.f. blepotis | Male (2) | 34.0, 34.6 | 34.0, 34.6 | 34.0, 34.6 | 34.0, 34.6 | 34.0, 34.6 | 34.0, 34.6 | 34.0, 34.6 | 34.0, 34.6 | 34.0, 34.6 | 34.0, 34.6 |
| | | Female (1) | 33.0, 36.6 | 33.0, 36.6 | 33.0, 36.6 | 33.0, 36.6 | 33.0, 36.6 | 33.0, 36.6 | 33.0, 36.6 | 33.0, 36.6 | 33.0, 36.6 | 33.0, 36.6 |

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cryptic Rhinolophus and Hipposideros complexes. Resolving taxonomic status in these groups relies on pairing methodological approaches, for example genetic and acoustic analyses, to determine the source of variation between and within species (Kingston & Rossiter 2004).

The Wallacea region remains, in general, poorly explored (Whitten et al. 2002), even in relation to adjacent parts of Southeast Asia such as Peninsular Malaysia. In addition, wildlife is increasingly sharing dwindling habitat with growing human populations in biodiversity hotspots (Williams 2013). Species in many taxa are still being described (O’Connell et al. 2019) and geographical distributions being extended for several taxa (Martin et al. 2018, Monkhouse et al. 2018). Despite their ecological importance, the diversity of bats and their respective geographic distributions are still poorly known, with many habitats and regions under-represented by limited surveys (Nunes et al. 2005, Patterson et al. 2017, Broto & Mortelliti 2019). Here, we further demonstrate the need to expand knowledge of the biodiversity within the Wallacea region, including Sulawesi.

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