Tema Penelitian : Pengelolaan dan Pemanfaatan Hutan Berbasis Ecoregion untuk Keberlanjutan Penghidupan
Bidang Fokus : Agrokompleks

LAPORAN AKHIR
PENELITIAN DASAR
PELAKSANAAN TAHUN 2021

JUDUL PENELITIAN

Studi Potensi Pengembangan Ekowisata Gua Kelelawar di Kawasan Geopark Maros Pangkep

TIM PENGUSUL

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FAKULTAS KEHUTANAN
UNIVERSITAS HASANUDDIN

2021

HALAMAN PENGESAHAN
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Lama Penelitian Keseluruhan	: 2 tahun
Usulan Penelitian Tahun Ke-	: 1
Biaya Penelitian	: Rp. 125.540.000

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LAPORAN AKHIR PENELITIAN MULTI TAHUN

ID Proposal: 23401ceb-c2e7-4c1e-8a78-c6df19d7413b
Laporan Akhir Penelitian: tahun ke-1 dari 2 tahun

1. IDENTITAS PENELITIAN

A. JUDUL PENELITIAN

Studi Potensi Pengembangan Ekowisata Gua Kelelawar di Kawasan Geopark Maros Pangkep

B. BIDANG, TEMA, TOPIK, DAN RUMPUN BIDANG ILMU

Bidang Fokus RIRN / Bidang Unggulan Perguruan Tinggi	Tema	Topik (jika ada)	Rumpun Bidang Ilmu
Sosial Humaniora, Seni Budaya, Pendidikan Penelitian Lapangan Dalam Negeri (Menengah)	Pembangunan dan penguatan sosial budaya	Tatakelola dan pemerintahan	Konservasi Sumberdaya Hutan

C. KATEGORI, SKEMA, SBK, TARGET TKT DAN LAMA PENELITIAN

Kategori (Kompetitif Nasional/ Desentralisasi/ Penugasan)	Skema Penelitian	Strata (Dasar/ Terapan/ Pengembangan)	SBK (Dasar, Terapan, Pengembangan)	Target Akhir TKT	Lama Penelitian (Tahun)
Penelitian Kompetitif Nasional	Penelitian Dasar	SBK Riset Dasar	SBK Riset Dasar	3	2

2. IDENTITAS PENGUSUL

Nama, Peran	Perguruan Tinggi/ Institusi	Program Studi/ Bagian	Bidang Tugas	ID Sinta	H-Index
RISMA ILLA MAULANY Ketua Pengusul	Universitas Hasanuddin	Kehutanan		6020121	2
NASRI S.Hut, M.Hut Anggota Pengusul 1	Universitas Hasanuddin	Kehutanan	Pengambilan data lapangan dan pengolahan	6003243	1
A. SIADY HAMZAH S.Hut, M.Si Anggota Pengusul 2	Universitas Hasanuddin	Kehutanan	Identifikasi spesies dan pengambilan data lapangan	6668789	0

3. MITRA KERJASAMA PENELITIAN (JIKA ADA)

Pelaksanaan penelitian dapat melibatkan mitra kerjasama, yaitu mitra kerjasama dalam melaksanakan penelitian, mitra sebagai calon pengguna hasil penelitian, atau mitra investor

Mitra	Nama Mitra

4. LUARAN DAN TARGET CAPAIAN

Luaran Wajib

Tahun Luaran	Jenis Luaran	Status target capaian (*accepted, published, terdaftar atau granted, atau status lainnya*)	Keterangan (*url dan nama jurnal, penerbit, url paten, keterangan sejenis lainnya*)
1	Artikel di Jurnal Internasional Terindeks di Pengindeks Bereputasi	Accepted	Acta chiropterologica

Luaran Tambahan

Tahun Luaran	Jenis Luaran	Status target capaian (*accepted, published, terdaftar atau granted, atau status lainnya*)	Keterangan (*url dan nama jurnal, penerbit, url paten, keterangan sejenis lainnya*)
1	Artikel pada Conference/Seminar Internasional di Pengindeks Bereputasi	Terbit dalam Prosiding	International Conference on Wildlife Ecology Biodiversity Conservastion and Management (ICWEBCM)

5. ANGGARAN

Rencana anggaran biaya penelitian mengacu pada PMK yang berlaku dengan besaran minimum dan maksimum sebagaimana diatur pada buku Panduan Penelitian dan Pengabdian kepada Masyarakat Edisi 12.

Total RAB 2 Tahun Rp. 319,552,000

Tahun 1 Total Rp. 156,041,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
Bahan	ATK	Buku catatan	buah	10	12,000	120,000
Bahan	ATK	Pensil 2B	buah	12	3,000	36,000
Bahan	ATK	Pulpen	buah	12	2,500	30,000
Bahan	ATK	Papan Standar	buah	4	28,000	112,000
Bahan	ATK	Tinta Print (Hitam & Warna	paket	1	350,000	350,000
Bahan	ATK	Kertas A4 70 gram	rim	4	38,000	152,000
Bahan	ATK	Kertas Flipt Chart	roll	4	50,000	200,000
Bahan	ATK	Spidol permanent marker	buah	8	7,000	56,000
Bahan	ATK	Pencetakan dan penjilidan laporan	paket	1	1,500,000	1,500,000
Bahan	Bahan Penelitian (Habis Pakai)	Alkohol 70 %	liter	20	45,000	900,000
Bahan	Bahan Penelitian (Habis Pakai)	Jaring Kelelawar	buah	15	150,000	2,250,000
Bahan	Bahan Penelitian	Meteran roll 50	buah	2	50,000	100,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
	(Habis Pakai)	meter				
Bahan	Bahan Penelitian (Habis Pakai)	Toples Kaca 2000 ml	buah	40	45,000	1,800,000
Bahan	Bahan Penelitian (Habis Pakai)	Sepatu Lapangan	buah	7	750,000	5,250,000
Bahan	Bahan Penelitian (Habis Pakai)	Baju Overall Safety	buah	7	200,000	1,400,000
Bahan	Bahan Penelitian (Habis Pakai)	Helm Savety	buah	7	130,000	910,000
Bahan	Bahan Penelitian (Habis Pakai)	Sarung tangan safety	buah	4	250,000	1,000,000
Bahan	Bahan Penelitian (Habis Pakai)	Headlamp	buah	7	130,000	910,000
Pengumpulan Data	HR Pembantu Peneliti	Jasa Pembantu Lapangan (2 orang perlokasi x 30 hari)	lokasi	4	4,800,000	19,200,000
Pengumpulan Data	HR Sekretariat/Administrasi Peneliti	Jasa Administrasi Peneliti	bulan	9	300,000	2,700,000
Pengumpulan Data	Transport	Transportasi Makassar - 4 Lokasi Kajian	paket	4	3,000,000	12,000,000
Pengumpulan Data	Transport	Asuransi Tim	orang	7	150,000	1,050,000
Pengumpulan Data	Penginapan	Sewa Rumah/penginapan (30 hari)	lokasi	4	3,000,000	12,000,000
Pengumpulan Data	Biaya konsumsi	Konsumsi Lapangan (tim)	lokasi	4	5,400,000	21,600,000
Pengumpulan Data	Biaya konsumsi	Konsumsi Rapat (tim) (9 kali x 7 orang)	paket	9	315,000	2,835,000
Sewa Peralatan	Peralatan penelitian	Sewa GPS (90 hari)	paket	1	4,500,000	4,500,000
Sewa Peralatan	Peralatan penelitian	Sewa kamera DSLR + lensa (90 hari)	paket	1	13,500,000	13,500,000
Sewa Peralatan	Peralatan penelitian	Sewa Tripod Kamera (90 hari)	paket	1	1,800,000	1,800,000
Sewa Peralatan	Peralatan penelitian	Sewa Range Finder (90 hari)	paket	1	10,800,000	10,800,000
Sewa Peralatan	Peralatan penelitian	Sewa Binokuler (90 hari)	paket	1	8,100,000	8,100,000
Sewa Peralatan	Peralatan penelitian	Sewa Sound level meter (90 hari)	paket	1	900,000	900,000
Sewa Peralatan	Peralatan penelitian	Sewa Light meter (30 hari)	paket	1	900,000	900,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
Sewa Peralatan	Peralatan penelitian	Sewa Higro meter (30 hari)	paket	1	4,500,000	4,500,000
Sewa Peralatan	Peralatan penelitian	Sewa pH meter (30 hari)	paket	1	2,250,000	2,250,000
Sewa Peralatan	Peralatan penelitian	Sewa Digital Caliper (30 hari)	paket	1	900,000	900,000
Sewa Peralatan	Peralatan penelitian	Sewa Infrared Thermometer (30 hari)	paket	1	1,350,000	1,350,000
Analisis Data	HR Pengolah Data	Pengolahan dan Analisis Data	paket	1	1,540,000	1,540,000
Analisis Data	HR Pengolah Data	Analisis dan Pemetaan Gua	paket	1	1,540,000	1,540,000
Analisis Data	Biaya analisis sampel	Biaya Identifikasi Spesimen Kelelawar	spesimen	20	150,000	3,000,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Biaya seminar internasional	Biaya Seminar Internasional	orang	1	9,000,000	9,000,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Publikasi artikel di Jurnal Internasional	Proofread Publikasi /Artikel Jurnal / Internasional terndeks Scopus	paket	1	3,000,000	3,000,000

Tahun 2 Total Rp. 163,511,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
Bahan	ATK	Buku catatan	buah	10	12,000	120,000
Bahan	ATK	Pensil 2B	buah	12	3,000	36,000
Bahan	ATK	Pulpen	buah	12	2,500	30,000
Bahan	ATK	Papan Standar	buah	4	28,000	112,000
Bahan	ATK	Tinta Print (Hitam & Warna)	paket	1	350,000	350,000
Bahan	ATK	Kertas A4 70 gram	rim	4	38,000	152,000
Bahan	ATK	Kertas Flipt Chart	roll	4	50,000	200,000
Bahan	ATK	Spidol permanent marker	buah	8	7,000	56,000
Bahan	ATK	Pencetakan dan penjilidan laporan	paket	1	3,500,000	3,500,000
Bahan	Bahan Penelitian (Habis Pakai)	Jaring Kelelawar	buah	8	150,000	1,200,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
Bahan	Bahan Penelitian (Habis Pakai)	Sarung tangan safety	buah	4	250,000	1,000,000
Bahan	Bahan Penelitian (Habis Pakai)	Alat Pengambil Darah	buah	50	20,000	1,000,000
Bahan	Bahan Penelitian (Habis Pakai)	DNA Kit	paket	1	7,000,000	7,000,000
Bahan	Bahan Penelitian (Habis Pakai)	Primer Genetik	paket	1	9,000,000	9,000,000
Pengumpulan Data	FGD persiapan penelitian	Sewa Ruangan Pertemuan FGD	paket	4	600,000	2,400,000
Pengumpulan Data	HR Pembantu Peneliti	Jasa Enumerator (28 hari x 2 orang)	jam	448	25,000	11,200,000
Pengumpulan Data	HR Pembantu Peneliti	Jasa Pengambilan Sampel Darah Kelelawar (15 hari)	jam	180	25,000	4,500,000
Pengumpulan Data	HR Sekretariat/Administrasi Peneliti	Jasa Administrasi Peneliti	bulan	9	300,000	2,700,000
Pengumpulan Data	HR Petugas Survei	Jasa Pembantu Lapangan (2 orang perlokasi x 30 hari)	lokasi	4	4,800,000	19,200,000
Pengumpulan Data	Transport	Transportasi Makassar - 4 Lokasi Kajian	lokasi	4	2,040,000	8,160,000
Pengumpulan Data	Transport	Transport peserta FGD	paket	4	1,500,000	6,000,000
Pengumpulan Data	Transport	Asuransi Tim	orang	10	450,000	4,500,000
Pengumpulan Data	Penginapan	Penginapan (14 hari)	paket	4	1,400,000	5,600,000
Pengumpulan Data	Biaya konsumsi	Konsumsi Lapangan (tim)	lokasi	4	2,520,000	10,080,000
Pengumpulan Data	Biaya konsumsi	Konsumsi FGD	lokasi	4	1,350,000	5,400,000
Pengumpulan Data	Biaya konsumsi	Konsumsi Rapat (tim) (9 kali x 7 orang)	paket	9	315,000	2,835,000
Sewa Peralatan	Peralatan penelitian	Sewa kamera DSLR + lensa (14 hari)	paket	1	2,100,000	2,100,000
Analisis Data	HR Pengolah Data	Pengolahan dan Analisis Data	orang	2	1,540,000	3,080,000

Jenis Pembelanjaan	Komponen	Item	Satuan	Vol.	Biaya Satuan	Total
Analisis Data	Biaya analisis sampel	Paket Analisis (tip, bufferr, loading dye, gel red, dll)	sampel	50	650,000	32,500,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Biaya seminar internasional	Pendaftaran Seminar	paket	1	6,000,000	6,000,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Publikasi artikel di Jurnal Internasional	Proofread Publikasi /Artikel Jurnal / Internasional terndeks Scopus	paket	1	6,000,000	6,000,000
Pelaporan, Luaran Wajib, dan Luaran Tambahan	Biaya penyusunan buku termasuk book chapter	Buku Ajar ISBN	paket	1	7,500,000	7,500,000

6. HASIL PENELITIAN

A. RINGKASAN: Tuliskan secara ringkas latar belakang penelitian, tujuan dan tahapan metode penelitian, luaran yang ditargetkan, serta uraian TKT penelitian.

Kawasan Karst Maros-Pangkep dengan luasan 46.200 ha merupakan salah satu bentang alam yang unik dan khas, yang memiliki peranan penting secara geologi, arkeologi, ekologi, social-ekonomi dan historis bagi masyarakat Sulawesi Selatan maupun bagi dunia. Penunjukkan kawasan tersebut sebagai geopark di tahun 2019 dapat diartikan sebagai peluang sekaligus ancaman dalam pengelolaan sumberdaya alam. Tingginya kerusakan habitat akibat penambangan, polutan yang dihasilkan dari kegiatan tambang, intensitas aktifitas manusia di sekitar kawasan, serta alih fungsi lahan yang saat ini sedang terjadi menjadi tantangan tersendiri dalam pengelolaan kawasan ini. Di sisi lain peningkatan kebutuhan ekonomi masyarakat yang telah ada di dalam kawasan juga membutuhkan perhatian. Keberadaan gua-gua di kawasan karst dapat menjadi potensi untuk mengembangkan kegiatan ekowisata. Pengembangan ekowisata gua dapat menjadi suatu solusi dalam pemanfaatan dan pelestarian sumberdaya alam non-konsumtif untuk mencapai pembangunan berkelanjutan termasuk di Kawasan Karst Maros-Pangkep dengan melibatkan masyarakat dalam pengelolaannya. Namun, minimnya data dan informasi yang ada terkait potensi ekowisata gua dapat menjadi kendala dalam mengembangkan kegiatan ini.

Penelitian ini bertujuan untuk mengetahui potensi bio-fisik gua kelelawar di Gua Togenra, Londrong, Mimpi, dan Batu yang terletak di Kawasan Geopark Maros-Pangkep. Secara khusus, penelitian ini mengangkat gua dan kelelawar gua sebagai obyek daya tarik pengembangan ekowisata penggalian informasi terkait karakteristik fisik gua, keaneakaragaman dan populasi jenis kelelawar gua, mikro-habitat koloni kelelawar, serta termasuk keanekaragaman genetic kelelawar pada habitat yang berbeda dan persepsi masyarakat terhadap pengembangan ekowisata di Kawasan Geopark Maros-Pangkep. Wisata kelelawar dapat menjadi titik awal dalam mengedukasi masyarakat mengenai stigma buruk dan misinformasi terkait kelelawar (khususnya di era pandemic COVID-19 ini. Ke depannya, penelitian dasar ini diharapkan dapat berkontribusi dalam pengembangan strategi dan arah kebijakan pengelolaan kawasan.

Penelitian ini dibagi menjadi dua tahap dengan durasi 2 tahun. Di tahap I dilakukan untuk mengetahui kondisi bio-fisik gua, keaneragaman jenis kelelawar dan populasinya serta karakteristik mikro-habitat masing-masing jenis. Survey gua dilakukan untuk mengetahui deskripsi fisik gua secara menyeluruh baik panjang, lebar, luas, jumlah chamber, ornament gua, serta kondisi fisik gua lainnya) melalui pengukuran langsung. Untuk mengetahui keanekaragaman jenis kelelawar dan populasinya, digunakan trapping dengan pemasangan jaring kelelawar (mish net) sementara untuk penghitungan populasi digunakan kombinasi metode capture-mark-release-recapture dan photographic count. Karakteristik mikro-habitat dari masing-masing jenis dilakukan dengan pengukuran langsung terhadap variable lingkungan seperti suhu, kelembaban, kebisingan, intensitas cahaya, serta jarak dari sumber air. Untuk tahap II, penelitian berfokus pada pengambilan data terkait variasi genetic kelelawar antar gua dan persepsi masyarakat terhadap kelelawar, konservasinya, dan pengembangan ekowisata gua. Pengambilan sampel darah akan dilakukan untuk mengetahui variasi genetik sementara metode wawancara dan FGD akan diaplikasikan untuk mengetahui persepsi masyarakat.

Luaran utama dari penelitian ini adalah 1 artikel pada jurnal terindeks scopus (Asian Journal of Conservation Biology) dan sebagai tambahan adalah 1 artikel pada prosiding

terindeks scopus serta 1 buku ajar ber-ISBN. Tingkat Kesiapan Teknologi (TKT) yang akan dihasilkan dari penelitian dasar ini adalah TKT 2-3 (rancangan dan metodologi tersusun komplit).

Hasil penelitian yang telah diperoleh pada penelitian tahun pertama ini meliputi data (i) karakteristik habitat, (ii) keanekaragaman, populasi dan morphometrik kelelawar, dan (iii) karakteristik dan letak sarang. Pengambilan data untuk ketiga parameter tersebut telah dilakukan pada keempat gua yang terdapat di kawasan geopark Maros-Pangkep, yaitu di Gua Togendra di Kabupaten Barru, Gua Leang Londrong di Kabupaten Pangkep, Gua Batu dan Gua Mimpi di Kabupaten Maros.

B. KATA KUNCI: Tuliskan maksimal 5 kata kunci.

karst; gua; kelelawar gua; ekowisata

Pengisian poin C sampai dengan poin H mengikuti template berikut dan tidak dibatasi jumlah kata atau halaman namun disarankan seringkas mungkin. Dilarang menghapus/memodifikasi template ataupun menghapus penjelasan di setiap poin.

C. HASIL PELAKSANAAN PENELITIAN: Tuliskan secara ringkas hasil pelaksanaan penelitian yang telah dicapai sesuai tahun pelaksanaan penelitian. Penyajian dapat berupa data, hasil analisis, dan capaian luaran (wajib dan atau tambahan). Seluruh hasil atau capaian yang dilaporkan harus berkaitan dengan tahapan pelaksanaan penelitian sebagaimana direncanakan pada proposal. Penyajian data dapat berupa gambar, tabel, grafik, dan sejenisnya, serta analisis didukung dengan sumber pustaka primer yang relevan dan terkini.

Pengisian poin C sampai dengan poin H mengikuti template berikut dan tidak dibatasi jumlah kata atau halaman namun disarankan seringkas mungkin. Dilarang menghapus/memodifikasi template ataupun menghapus penjelasan di setiap poin.

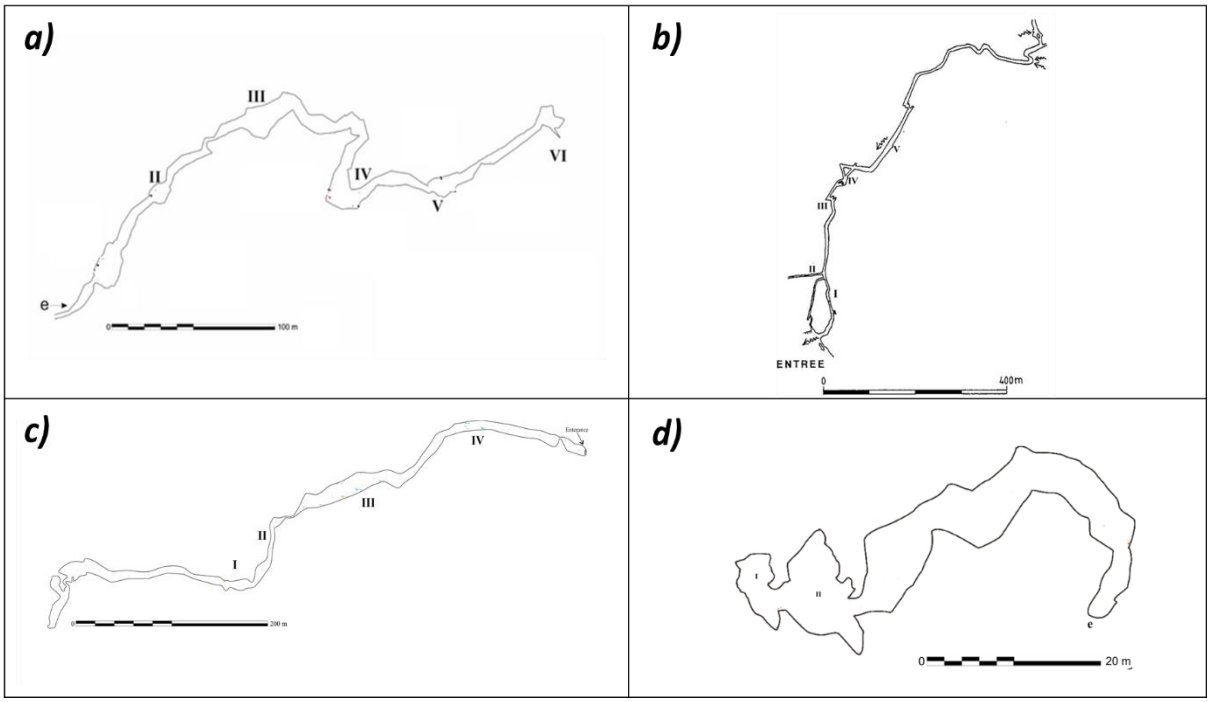
C. **HASIL PELAKSANAAN PENELITIAN:** Tuliskan secara ringkas hasil pelaksanaan penelitian yang telah dicapai sesuai tahun pelaksanaan penelitian. Penyajian dapat berupa data, hasil analisis, dan capaian luaran (wajib dan atau tambahan). Seluruh hasil atau capaian yang dilaporkan harus berkaitan dengan tahapan pelaksanaan penelitian sebagaimana direncanakan pada proposal. Penyajian data dapat berupa gambar, tabel, grafik, dan sejenisnya, serta analisis didukung dengan sumber pustaka primer yang relevan dan terkini.

C.1 Hasil Penelitian

Data yang dikumpulkan pada penelitian tahun pertama ini meliputi data (i) karakteristik habitat, (ii) keanekaragaman, populasi dan morphometrik kelelawar, dan (iii) karakteristik dan letak sarang. Pengambilan data untuk ketiga parameter tersebut telah dilakukan pada keempat gua yang terdapat di kawasan geopark Maros-Pangkep, yaitu di Gua Togendra di Kabupaten Barru, Gua Leang Londrong di Kabupaten Pangkep, Gua Batu dan Gua Mimpi di Kabupaten Maros.

C.1.1 Karakteristik Habitat

Pengukuran kondisi fisik dan mikroklimat gua dilakukan untuk mengetahui karakteristik habitat kelelawar di kawasan geopark Maros-Pangkep. Parameter fisik yang diukur adalah panjang, lebar, tinggi lorong gua, jenis dan sebaran ornamen-ornamen gua. Pengamatan fisik gua akan diukur mulai dari mulut gua hingga ditemukan tempat terakhir koloni kelelawar. Kondisi fisik dan letak sarang kelelawar dari masing-masing gua diperlihatkan pada gambar berikut ini.



Gambar 1. Peta karakteristik habitat gua: a) Gua Togendra, b) Gua Leang Londrong, c) Gua Mimpi, dan d) Gua Batu

Kelelawar adalah salah satu organisme yang hidup dan memanfaatkan gua sebagai habitatnya [1] dengan peranan penting menjaga kestabilan ekosistem di dalam dan di luar. Keempat gua kelelawar yang menjadi site penelitian memiliki karakteristik habitat yang termasuk kedalam kawasan kelompok batuan karbonat (gua karst) dengan profil gua yang beragam dengan perpaduan bentuk gua horizontal dan vertikal. Panjang gua secara horizontal (jarak datar) untuk keempat gua ini secara berurutan dari yang memiliki ukuran terpanjang sampai yang terpendek adalah Gua Leang Londrong (panjang total ±5.400 m, untuk pengamatan kelelawar ±520 m), Gua Mimpi (±800 m), Gua Togendra (±400 m), dan Gua Batu (±??? m). Untuk kondisi gua, Gua Togendra adalah gua kering, Gua Mimpi dan Gua Batu merupakan gua sedikit berair, dan Gua Leang Londrong merupakan gua yang berair (*riparian cave*), yang dialiri air sungai bawah tanah. Kelelawar hidup pada berbagai tipe habitat, kelelawar pemakan buah (Megachiroptera) cenderung memilih hidup pada pohon-pohon besar. Sedangkan kelelawar yang pada umumnya memakan serangga (Microchiroptera) lebih memilih bertengger pada lubang batang pohon, celah batang bambu dan gua [2].

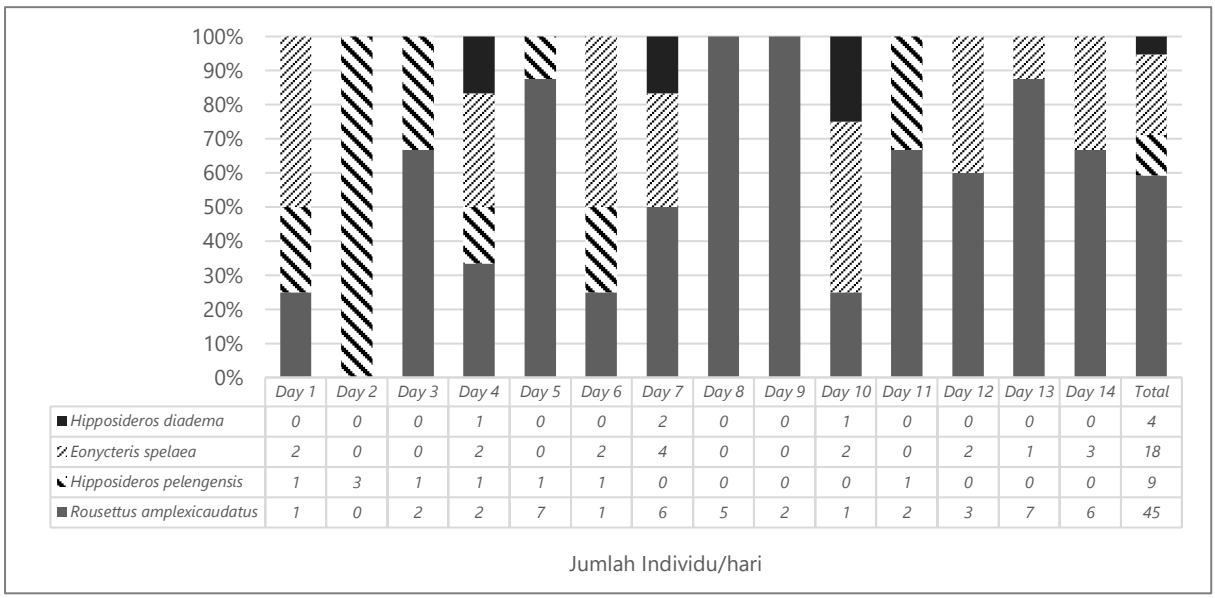
Salah satu habitat yang sering ditinggali kelelawar adalah gua karst [3]. Kondisi sarang kelelawar pada ruang gua karst pada lokasi penelitian dapat dilihat pada Gambar 2. Ekosistem gua khususnya gua karst yang ditinggali kelelawar merupakan gua yang gelap dan lembab dan digunakan sebagai tempat bersarang dan berlindung pada siang hari [4]. Kelelawar akan memilih gua yang sesuai sebagai tempat berlindung dan berkembangbiak dimana suhu udara, kelembaban udara, intensitas cahaya dan kecepatan angin menjadi faktor yang sangat menentukan keberlangsungan hidup populasi kelelawar di dalam gua [5].

Gambar 2. Kondisi sarang pada ruang gua karst: a). kelelawar yang berkoloni dan bergabung dengan koloni spesies lain b) kelelawar yang bertengger satu persatu spesies yang lain

C.1.2 Keanekaragaman, Populasi dan Morphometrik Kelelawar

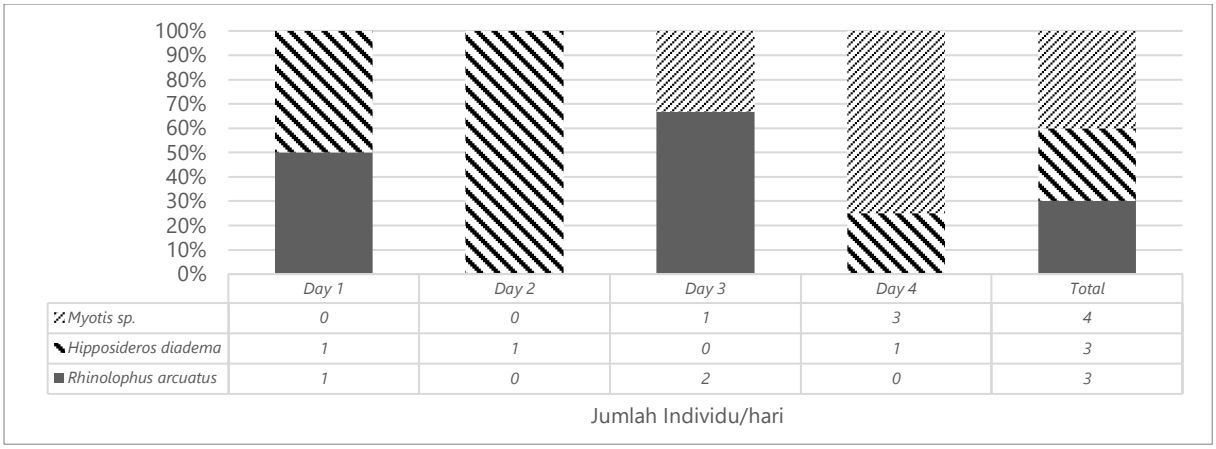
a. Keanekaragaman dan Populasi

Untuk melihat keanekaragam kelelawar di masing-masing lokasi penelitian, maka pengambilan sampel kelelawar dilakukan dengan penangkapan menggunakan mist net atau jaring kabut. Adapun hasil penangkapan kelelawar menggunakan mis net diperlihatkan pada grafik penjumpaan atau penangkapan kelelawar pada masing-masing gua.



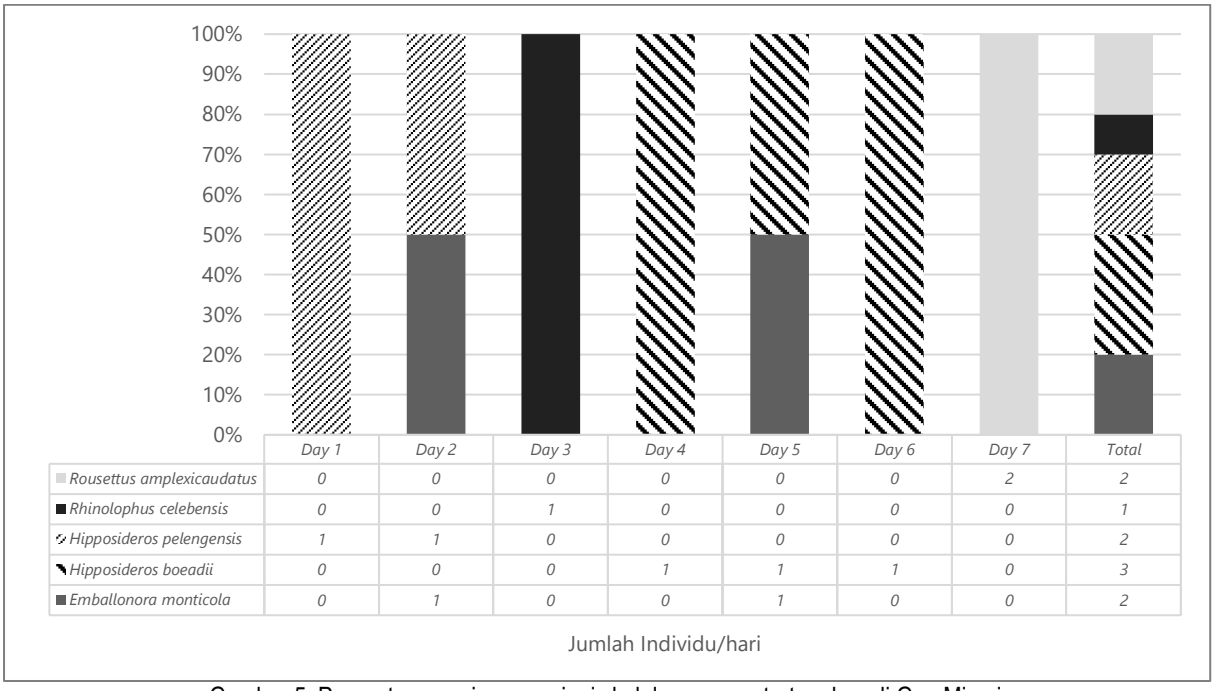
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Total
Hipposideros diadema	0	0	0	1	0	0	2	0	0	1	0	0	0	0	4
Eonycteris spelaea	2	0	0	2	0	2	4	0	0	2	0	2	1	3	18
Hipposideros pelengensis	1	3	1	1	1	1	0	0	0	0	1	0	0	0	9
Rousettus amplexicaudatus	1	0	2	2	7	1	6	5	2	1	2	3	7	6	45

Gambar 3. Persentase penjumpaan jenis kelelawar yang tertangkap di Gua Togendra



	Day 1	Day 2	Day 3	Day 4	Total
Myotis sp.	0	0	1	3	4
Hipposideros diadema	1	1	0	1	3
Rhinolophus arcuatus	1	0	2	0	3

Gambar 4. Persentase penjumpaan jenis kelelawar yang tertangkap di Gua Leang Londrong



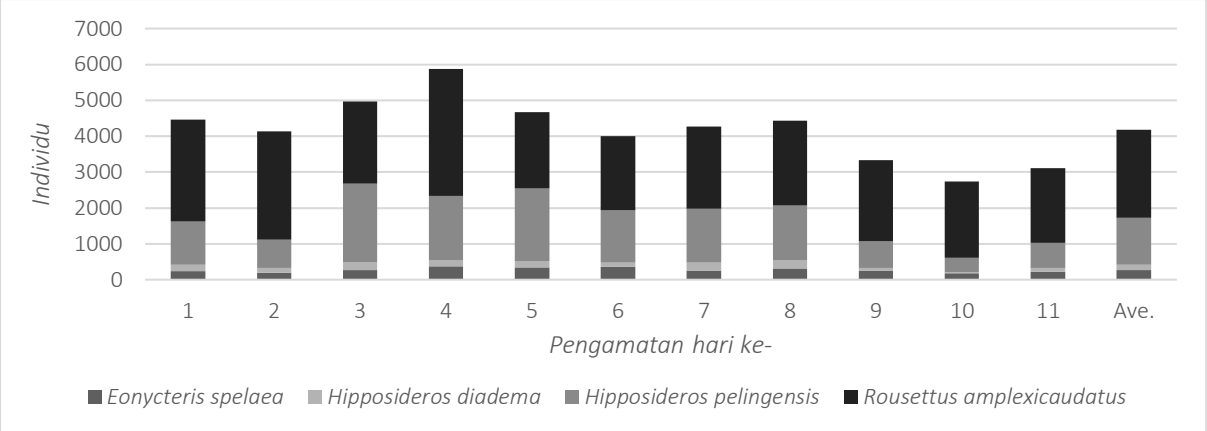
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Total
Rousettus amplexicaudatus	0	0	0	0	0	0	2	2
Rhinolophus celebensis	0	0	1	0	0	0	0	1
Hipposideros pelengensis	1	1	0	0	0	0	0	2
Hipposideros boeadii	0	0	0	1	1	1	0	3
Emballonora monticola	0	1	0	0	1	0	0	2

Gambar 5. Persentase penjumpaan jenis kelelawar yang tertangkap di Gua Mimpi

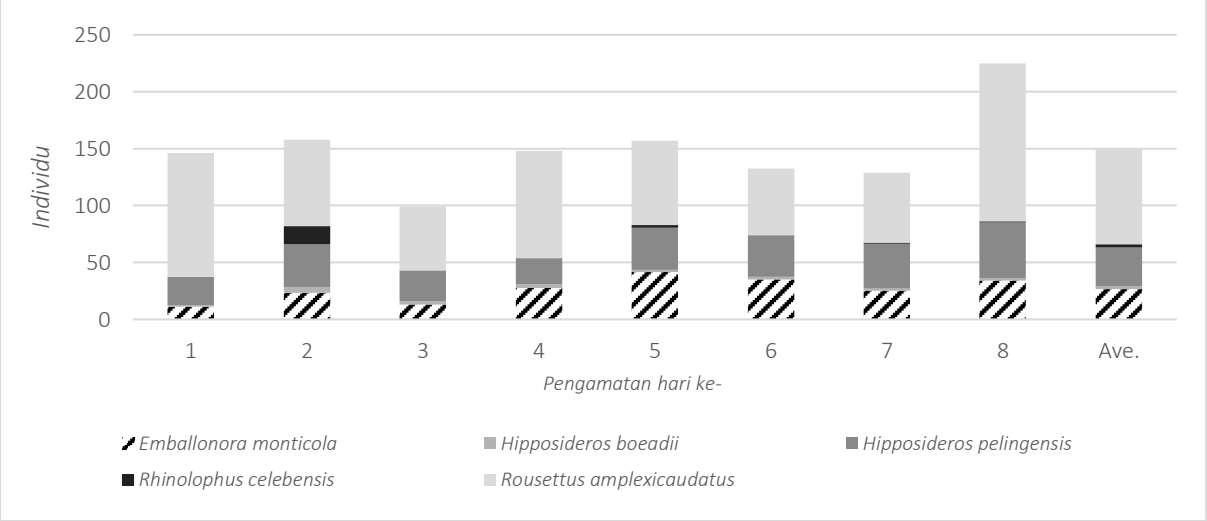
Selama dilakukan pemasangan jaring mis net, yang berhasil tertangkap 9 (sembilan) jenis kelelawar yaitu *Emballonora monticola, Eonycteris spelaea, Hipposideros boeadii, Hipposideros diadema, Hipposideros pelingensis, Myotis sp., Rhinolophus arcuatus, Rhinolophus celebensis, dan Rousettus amplexicaudatus*. Jumlah total kelelawar yang berhasil tertangkap adalah 76 individu individu di Gua Togendra, dan masing-masing 10 individu di Gua Leang Londrong dan Gua Mimpi. Sementara untuk di Gua Batu, penangkapan menggunakan misnet tidak dilakukan, dikarenakan kondisi guanya sangat memungkinkan untuk menghitung populasi kelelawar di dalam gua yang spesies kelelawarnya hanya terdiri dari satu individu. Total individu kelelawar yang tertangkap untuk keseluruhan site penelitian sebanyak 96 individu.

Secara umum berdasarkan hasil penangkapan melalui mist net, jenis kelelawar yang dominan adalah *Rousettus amplexicaudatus* di Gua Togendra dengan persentase tangkap sebesar 60 % (Gambar 3), *Myotis sp.* di Gua Leang Londrong dengan persentase tangkap sebesar 40% (Gambar 4), *Hipposideros pelingensis* di Gua Mimpi dengan persentase tangkap sebesar 30% (Gambar 5), serta *Emballonora monticola* merupakan satu-satunya jenis kelelawar yang menghuni Gua Batu.

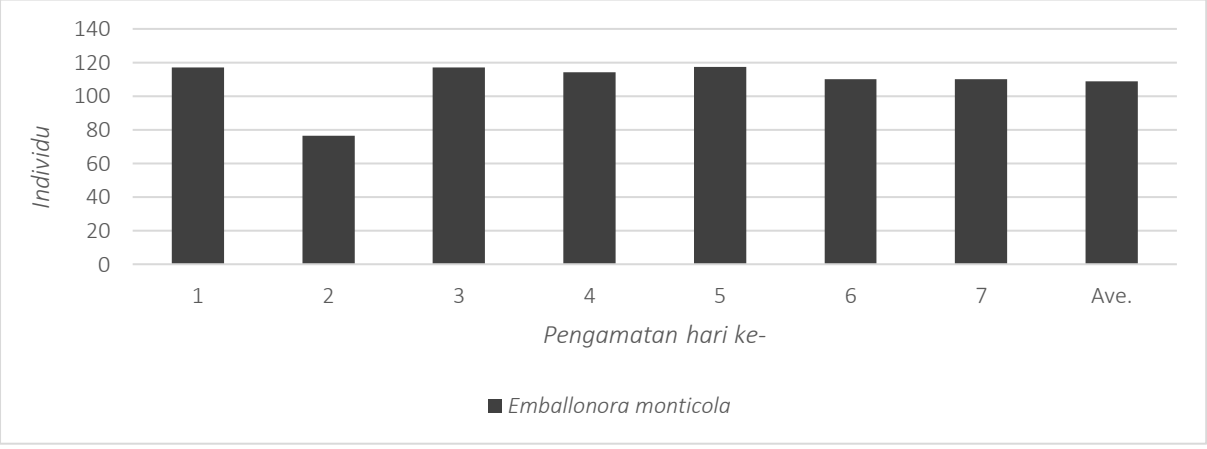
Selanjutnya, untuk mendapatkan gambaran mengenai populasi kelelawar pada masing-masing site penelitian, khususnya kelimpahan jenis dan populasi kelelawar maka selain melakukan penangkapan menggunakan mis net juga dilakukan kegiatan penghitungan secara visual (foto) atau *photographic count* terhadap individu kelelawar di lokasi bertengger (di dalam gua). Pengambilan foto dilakukan saat siang hari di dalam gua. Jumlah kelelawar di dalam gambar tersebut kemudian dihitung sebanyak 3 kali per gambarnya untuk mendapatkan gambaran terkait jumlah rata-rata kelelawar setiap harinya. Pengambilan gambar dilakukan setiap hari. Populasi kelelawar pada masing-masing gua diperlihatkan pada gambar berikut ini.



Gambar 7. Populasi kelelawar berdasarkan metode *photographic count* di Gua Togendra



Gambar 8. Populasi kelelawar berdasarkan metode *photographic count* di Gua Mimpi



Gambar 9. Populasi kelelawar berdasarkan metode *photographic count* di Gua Batu

Berdasarkan hasil pengukuran populasi dengan metode *photographic count* maka diketahui bahwa jumlah populasi rata-rata harian kelelawar yang terdapat di Gua Togendra sebanyak 4.179 individu yang terdiri dari spesies *Eonycteris spelaea* (272 individu), *Hipposideros diadema* (150 individu), *Hipposideros pelingensis* (1.303 individu), dan *Rousettus amplexicaudatus* (2.453 individu). Populasi rata-rata harian kelelawar yang terdapat di Gua Mimpi sebanyak 149 individu yang terdiri dari spesies *Emballonora monticola* (26 individu), *Hipposideros boeadii* (3 individu), *Hipposideros pelingensis* (34 individu), *Rhinolophus celebensis* (2 individu), dan *Rousettus amplexicaudatus* (84 individu). Untuk Gua Batu, populasi rata-rata harian kelelawarnya sebanyak 109 individu yang hanya terdiri dari satu spesies yaitu *Emballonora monticola*. Sementara untuk Gua Leang Londrong, penghitungan populasi menggunakan metode *photographic count* tidak dapat dilakukan dikarenakan oleh faktor kondisi gua yang berair (terdapat sungai keluar dari dalam gua). Namun, persentase populasi dapat dilihat dari

penangkapan kelelawar menggunakan mis net, dimana diperoleh bahwa populasi kelelawar yang terdapat di Gua Leang Londrong sekitar 40 % adalah spesies *Hipposideros diadema*, dan masing-masing 30 % adalah spesies *Myotis sp*. dan *Rhinolophus arcuatus*.

b. Morfometrik kelelawar

Pengukuran dilakukan pada bagian tubuhnya yang dimulai dari panjang kepala dan badan (HB), panjang ekor (T), panjang kaki belakang (HF), panjang telinga (E), panjang lengan bawah sayap (FA), panjang tulang betis (Tib), dan berat badan (Wt). Hasil pengukuran morfometrik kelelawar perjenis pada masing-masing gua diperlihatkan pada tabel berikut ini.

Tabel 1. Morfometrik Kelelawar di Gua Togenra, Kabupaten Barru (HB=head body; T=tail; E=ear length; FA=forearm; Tib= tibia length; HF=hind foot; Wt=weight)

No	Spesies		Jumlah Individu Tertangkap	Rata-rata ukuran tubuh (mm)						
				HB	T	E	FA	Tib	HF	Wt
1	*Eonycteris spelaea*	Jantan	17	95.4	14.5	11.8	73.7	33.2	15.6	103.5
		Betina	1	81.0	15.5	12.3	71.1	30.0	16.1	110.0
2	*Hipposideros diadema*	Jantan	4	98.1	52.8	24.1	92.4	31.7	16.2	73.8
		Betina	0	-	-	-	-	-	-	-
3	*Hipposideros pelingensis*	Jantan	7	100.9	48.7	22.1	96.9	34.8	14.0	107.9
		Betina	2	97.5	46.0	19.7	97.5	32.7	11.6	92.5
4	*Rousettus amplexicaudatus*	Jantan	21	82.8	14.3	11.6	75.6	33.0	15.4	91.4
		Betina	24	88.2	13.6	11.7	76.8	31.6	15.4	91.9

Tabel 2. Morfometrik Kelelawar di Gua Leang Londrong, Kabupaten Pangkep (HB=head body; T=tail; E=ear length; FA=forearm; Tib= tibia length; HF=hind foot; Wt=weight)

No	Spesies		Jumlah Individu Tertangkap	Rata-rata ukuran tubuh (mm)						
				HB	T	E	FA	Tib	HF	Wt
1	*Hipposideros diadema*	Jantan	1	100.25	54.08	23.49	100.66	35.22	16.30	80.00
		Betina	2	203.91	97.68	51.03	183.14	67.94	24.69	135.00
2	*Myotis sp.*	Jantan	1	36.40	16.03	10.43	36.55	14.15	8.20	25.00
		Betina	3	47.12	28.09	8.35	39.34	15.07	10.03	31.67
3	*Rhinolophus arcuatus*	Jantan	2	51.07	14.47	10.83	46.01	15.95	7.85	42.50
		Betina	1	33.63	21.14	17.10	44.18	19.99	8.81	50.00

Tabel 3. Morfometrik Kelelawar di Gua Mimpi, Kabupaten Maros (HB=head body; T=tail; E=ear length; FA=forearm; Tib= tibia length; HF=hind foot; Wt=weight)

No	Spesies		Jumlah Individu Tertangkap	Rata-rata ukuran tubuh (mm)						
				HB	T	E	FA	Tib	HF	Wt
1	*Emballonora monticola*	Jantan	1	44.25	27.42	11.08	44.36	24.50	5.74	25.00
		Betina	1	43.73	9.83	9.54	43.16	16.07	5.76	48.00
2	*Hipposideros boeadii*	Jantan	1	48.55	24.60	11.61	41.20	18.41	3.28	25.00
		Betina	2	48.70	25.30	9.99	39.18	15.12	4.75	30.00
3	*Hipposideros pelingensis*	Jantan	2	113.20	46.32	28.61	95.08	36.97	14.70	77.50
		Betina	0	-	-	-	-	-	-	-
4	*Rhinolophus celebensis*	Jantan	1	47.16	18.85	13.95	38.3	18.22	5.45	55
		Betina	0	-	-	-	-	-	-	-
5	*Rousettus amplexicaudatus*	Jantan	0	-	-	-	-	-	-	-
		Betina	2	97.85	24.39	12.245	70.965	36.46	19.14	92.5

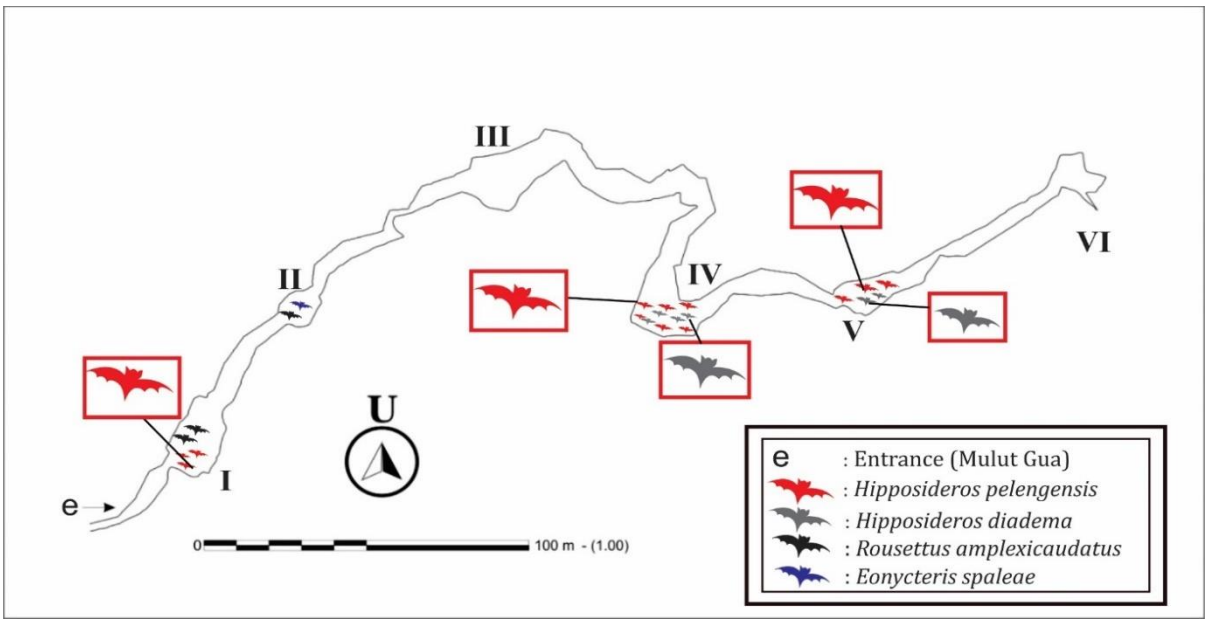
Tabel 4. Morfometrik Kelelawar di Gua Batu, Kabupaten Maros (HB=head body; T=tail; E=ear length; FA=forearm; Tib= tibia length; HF=hind foot; Wt=weight)

No	Spesies		Jumlah Individu Tertangkap	Rata-rata ukuran tubuh (mm)						
				HB	T	E	FA	Tib	HF	Wt
1	*Emballonora monticola*	Jantan	1	41.82	12.46	6.49	42.56	14.21	3.49	35.00
		Betina	1	46.62	26.03	11.01	45.51	18.24	5.90	35.00

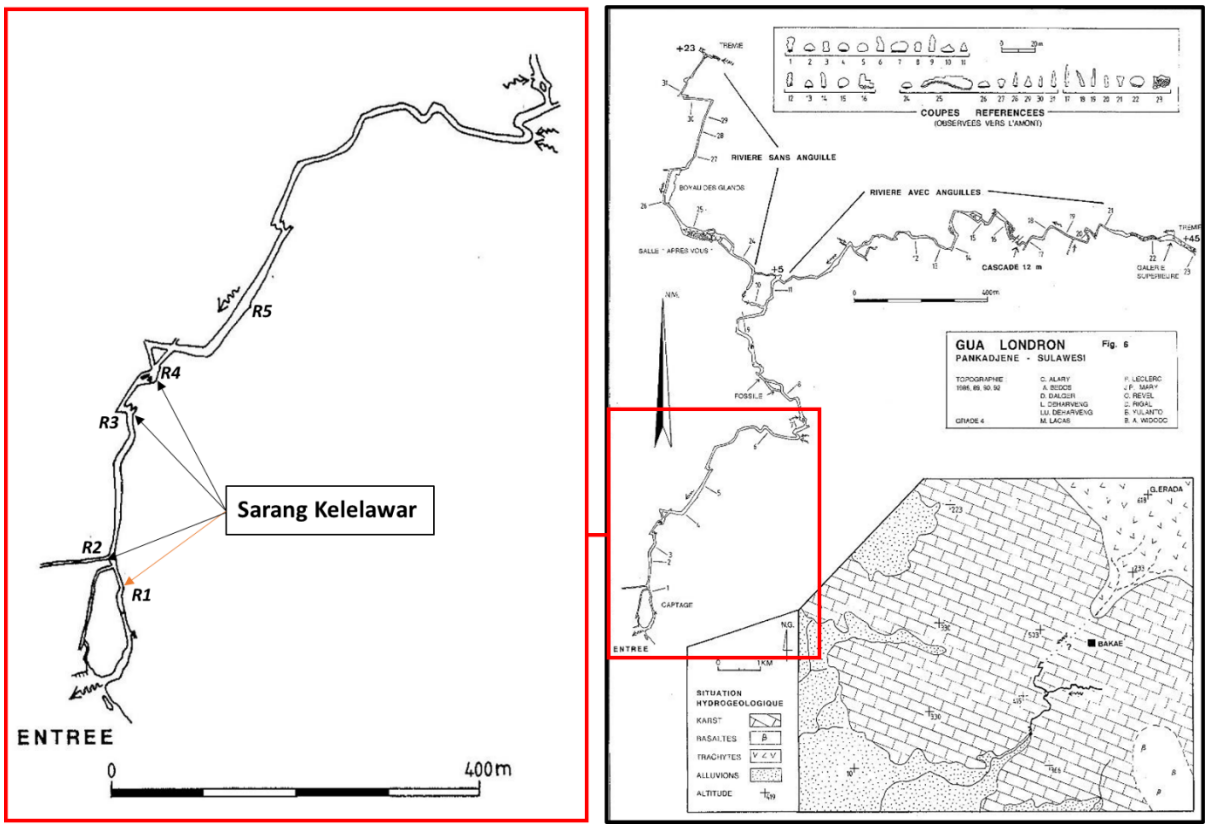
Berdasarkan pada pengukuran morfometrik kelelawar memperlihatkan bahwa dari kesembilan spesies kelelawar yang ditemukan, spesies kelelawar *Hipposideros diadema* merupakan spesies yang memiliki ukuran tubung yang paling besar dibandingkan dengan spesies kelelawar lainnya. Sementara spesies kelelawar yang memiliki ukuran tubuh paling terkecil adalah *Emballonora monticola*.

C.1.3 Karakteristik dan Letak Sarang

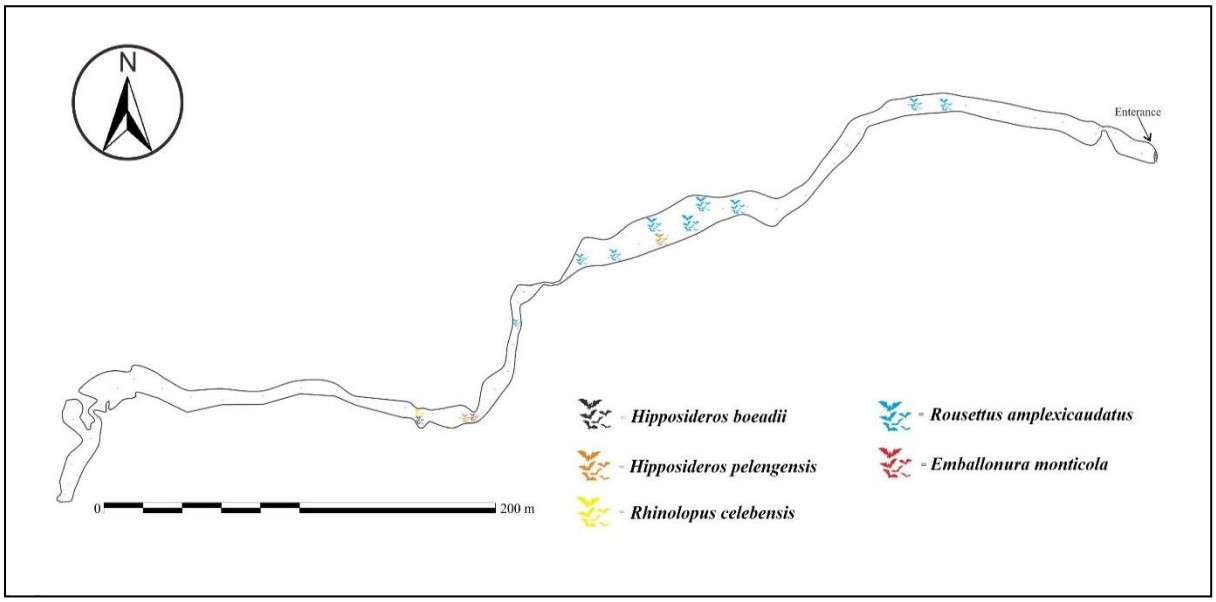
Karakteristik dan letak sarang kelelawar dilakukan di dalam gua dengan penandaan berdasarkan stasiun. Kondisi microhabitat (suhu, kelembaban, kebisingan, dan sebaran cahaya) diukur pada setiap koloni per jenis. Tinggi sarang dari dasar dan langit-langit gua, jarak sarang dari sumber air terdekat dari sarang kelelawar jenis lainnya juga diukur. Karakteristik dan letak sarang kelelawar pada masing-masing gua yang menjadi lokasi penlitian diperlihakan pada gambar berikut ini.



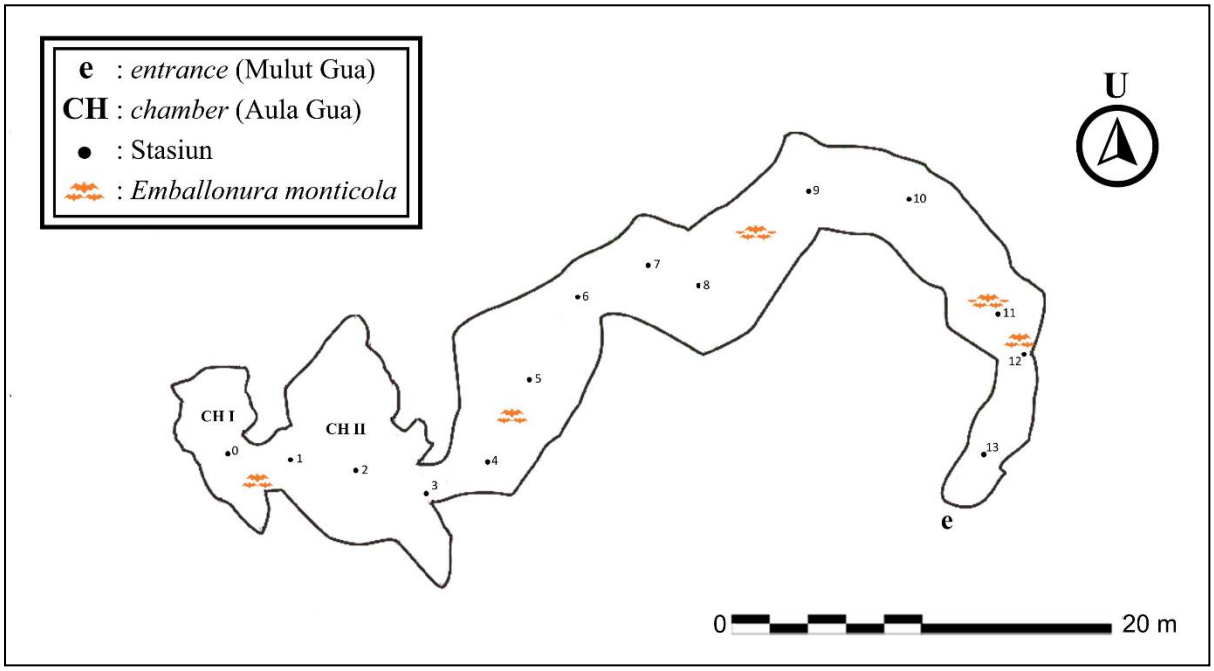
Gambar 10. Karakteristik dan letak sarang kelelawar di Gua Togenra



Gambar 11. Karakteristik dan letak sarang kelelawar di Gua Leang Londrong



Gambar 12. Karakteristik dan letak sarang kelelawar di Gua Mimpi



Gambar 13. Karakteristik dan letak sarang kelelawar di Gua Batu

Kondisi kawasan karst termasuk gua-gua yang ada di dalamnya, telah menciptakan habitat mikro yang unik sehingga tercipta niche ekologi spesifik yang membentuk organisme endemik [6,7]. Adapun kondisi microhabitat (suhu, kelembaban, kebisingan, dan sebaran cahaya) pada masing-masing gua dapat lihat pada gambar berikut ini.

Tabel 5. Kondisi microhabitat (suhu, kelembaban, kebisingan, dan sebaran cahaya) di Gua Togendra

Parameter Fisik Microclimates		**Stasiun Pengamatan/Chamber**					
		I	**II**	**III**	**IV**	**V**	**VI**
Suhu (°C)	Min	22.9	25.8	26.6	26.6	26.0	24.8
	Max	25.8	27.2	30.5	27.2	26.6	26.1
	Ave.	24.06	26.5	27	26.9	26.3	25.5
Kebisingan (dB)		28.3	48.1	18	17.7	15.8	15.9
Intensitas Cahaya (lx)		468	461	461	460	461	461
Kelembaban (%)		82.8	86.3	86.6	86.8	86.6	86.4

Tabel 6. Kondisi microhabitat (suhu, kelembaban, kebisingan, dan sebaran cahaya) di Gua Leang Londrong

Parameter Fisik Microclimates		Stasiun				
		I	II	III	IV	V
Suhu (°C)	Min	26.7	26.7	26.2	26.3	26.1
	Max	26.7	27.8	26.3	26.4	26.2
	Ave.	26.7	27.3	26.3	26.4	26.2
Kebisingan (dB)	Min	79.5	59.1	46.9	56	70.9
	Max	81.7	76.5	50.2	58.7	71.1
	Ave.	80.6	67.8	48.6	57.4	71
Intensitas Cahaya (lx)	Min	0	0	0	0	0
	Max	0	0	0	0	0
	Ave.	0	0	0	0	0
Kelembaban (%)		95.5	89.6	93.8	91.7	93.8

Tabel 7. Kondisi microhabitat (suhu, kelembaban, kebisingan, dan sebaran cahaya) di Gua Mimpi

Parameter Fisik Microclimates		Stasiun Pengamatan												
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Suhu (°C)	Min	21.7	21.7	20.8	21.1	21.2	21.1	21.3	20.9	20.9	21.0	21.1	21.2	21.2
	Max	24.3	24.3	23.1	23.9	23.8	24.1	23.6	23.4	23.7	22.6	23.2	23.2	23.2
	Ave.	22.7	22.7	22.2	22.4	22.3	22.2	22.0	22.1	22.0	21.8	22.2	22.3	22.1
Kebisingan (dB)	Min	43.0	43.0	43.1	43.1	43.4	42.2	42.6	42.6	42.6	42.7	42.4	42.7	42.4
	Max	52.4	52.4	50.3	50.3	65.4	54.4	60.3	52.9	52.9	49.7	51.9	47.5	51.2
	Ave.	46.0	46.0	45.3	45.3	47.4	45.6	46.2	45.1	45.1	44.6	45.2	44.4	44.8
Intensitas Cahaya (lx)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ave.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kelembaban (%)	Min	91.5	91.5	89.3	89.3	93.1	93.2	92.7	93.4	93.4	92.5	93.1	93.0	92.6
	Max	96.5	96.5	96.2	96.2	96.4	96.4	96.2	96.0	96.0	95.4	95.5	96.4	96.4
	Ave.	94.5	94.5	93.9	93.9	94.7	94.5	94.6	94.5	94.5	94.0	94.3	94.4	94.2

Tabel 8. Kondisi microhabitat (suhu, kelembaban, kebisingan, dan sebaran cahaya) di Gua Batu

Parameter Fisik Microclimates		**Stasiun Pengamatan**														
		P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**	**P13**	**P14**	**P15**
Suhu (oC)	Min	25.6	25.8	25.7	25.5	25.4	25.2	25.1	25.1	25.0	24.7	24.9	25.0	25.2	25.5	25.7
	Max	25.7	25.8	25.7	25.6	25.4	25.3	25.2	25.2	25.1	25.0	24.9	25.0	25.2	25.6	25.7
	Eve.	25.6	25.8	25.7	35.1	25.4	25.3	25.2	25.1	25.1	24.9	24.9	25.0	25.2	25.5	25.7
Kebisingan (dB)	Min	43.2	43.6	43.0	43.0	43.5	44.1	43.7	43.7	44.1	43.9	46.5	48.7	50.1	49.7	51.0
	Max	45.8	46.2	46.5	45.9	47.0	48.6	51.2	46.4	47.2	49.2	51.5	53.3	54.4	55.2	58.6
	Ave.	44.5	44.9	44.7	44.5	45.2	46.4	47.5	45.1	45.7	46.6	49.0	51.0	52.2	52.5	54.8
Intensitas Cahaya (lx)	Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	21.9	29.3	74.5	918.9
	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	26.1	39.5	84.5	1183.9
	Ave.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	24.0	34.4	79.5	1051.4
Kelembaban (%)		93.2	92.8	93.2	85.7	92.9	93.2	93.4	93.5	93.5	93.6	93.7	93.5	92.6	91.5	90.9

Proses pemasangan *mist net*

Penangkapan Kelelawar

Proses pengukuran kelelawar

Sarang kelelawar

Pengambilan sampel

Pengukuran mikrohabitat

Pemetaan Gua

Tim Peneliti

Gambar 13. Dokumetasi kegiatan penelitian tahap pertama

.

D. **STATUS LUARAN**: Tuliskan jenis, identitas dan status ketercapaian setiap luaran wajib dan luaran tambahan (jika ada) yang dijanjikan pada tahun pelaksanaan penelitian. Jenis luaran dapat berupa publikasi, perolehan kekayaan intelektual, hasil pengujian atau luaran lainnya yang telah dijanjikan pada proposal. Uraian status luaran harus didukung dengan bukti kemajuan ketercapaian luaran sesuai dengan luaran yang dijanjikan. Lengkapi isian jenis luaran yang dijanjikan serta mengunggah bukti dokumen ketercapaian luaran wajib dan luaran tambahan melalui Simlitabmas mengikuti format sebagaimana terlihat pada bagian isian luaran

Luaran utama dari penelitian ini adalah 1 artikel pada jurnal terindeks scopus (Asian Journal of Conservation Biology) dan sebagai tambahan adalah 1 artikel pada prosiding terindeks scopus serta 1 buku ajar ber-ISBN. Ketercapaian luaran utama penelitian untuk tahun pertama ini telah mencapai 90 % dari seluruh tahapan (hingga terbit), yaitu sudah pada tahap under review pada Jurnal Scopus Q3 di Asian Journal of Conservation Biology. Sementara untuk luaran tambahan yang berupa 1 artikel pada prosiding terindeks scopus sementara dalam proses submit ke sistem IOP Earth and Environmental Science untuk dipublish. Artikel prosiding tersebut telah dipresentasikan pada seminar internasional "The 2nd Biennial Conference of Tropical Biodiversity 2021" pada tanggal 04 Agustus 2021, Makassar – Indonesia. Terdapat dua artikel prosiding yang di presentasikan yang masing-masing berjudul (i) Discovering Potentiality of Togenra Cave and its Bat Species as an Ecotourism Spot in Barru, South Sulawesi, dan (ii) Diversity of Cave-dwelling Bats in Leang Londrong Bantimurung-Bulusaraung National Park. Untuk buku ajar ber-ISBN semantara dalam proses pengumpulan bahan tulisan dan sejauh ini telah tersusun draft buku ajar sekitar 40%.

E**. PERAN MITRA:** Tuliskan realisasi kerjasama dan kontribusi Mitra baik *in-kind* maupun *in-cash* (jika ada). Bukti pendukung realisasi kerjasama dan realisasi kontribusi mitra dilaporkan sesuai dengan kondisi yang sebenarnya. Bukti dokumen realisasi kerjasama dengan Mitra diunggah melalui Simlitabmas mengikuti format sebagaimana terlihat pada bagian isian mitra

Penelitian ini tidak bekerjasama dengan mitra.

F. **KENDALA PELAKSANAAN PENELITIAN**: Tuliskan kesulitan atau hambatan yang dihadapi selama melakukan penelitian dan mencapai luaran yang dijanjikan, termasuk penjelasan jika pelaksanaan penelitian dan luaran penelitian tidak sesuai dengan yang direncanakan atau dijanjikan.

Secara umum kendala yang dihadapi selama melakukan penelitian tahap pertama ini yaitu terhambatnya pelaksanaan kegiatan disebabkan karena pandemi covid 19, dimana pada beberapa lokasi site penelitian merupakan lokasi wisata sehingga pada waktu-waktu tertentu lokasi wisata yang merupakan bagian dari lokasi penelitian juga ikut ditutup. Selain itu, terdapat satu lokasi penelitian (Gua Leang Londrong) yang guanya merupakan gua yang berair (*riparian cave*). Kondisi gua yang seperti ini menjadikan peneliti kesulitan dalam mengumpulkan data utamanya dalam hal pengumpulan data di dalam gua, dimana pada waktu-waktu tertentu bisa saja terjadi banjir di dalam gua.

G**. RENCANA TINDAK LANJUT PENELITIAN:** Tuliskan dan uraikan rencana tindaklanjut penelitian selanjutnya dengan melihat hasil penelitian yang telah diperoleh. Jika ada target yang belum diselesaikan pada akhir tahun pelaksanaan penelitian, pada bagian ini dapat dituliskan rencana penyelesaian target yang belum tercapai tersebut.

Rencana tahap selanjutnya untuk penelitian tahap pertama ini yaitu akan difokuskan pada proses review pada jurnal bereputasi terindeks scopus (Asian Journal of Conservation Biology), follow up proses penerbitan artikel prosiding yang telah tersubmit dan tereview di IOP Earth and Environmental Science, dan pengumpulan bahan naskah buku ajar ber-ISBN. Selain dari pada itu, rencana tahapan selanjutnya juga sudah akan mempersiapkan kegiatan penelitian tahap kedua untuk tahun 2022 yang kegiatannya akan difokuskan pada pengambilan data persepsi masyarakat terhadap kelelawar dalam upaya konservasi dan rencana pengembangan ekowisata di Kawasan Geopark Maros-Pangkep.

H. DAFTAR PUSTAKA: Penyusunan Daftar Pustaka berdasarkan sistem nomor sesuai dengan urutan pengutipan. Hanya pustaka yang disitasi pada laporan akhir yang dicantumkan dalam Daftar Pustaka.

1. Whitten T, Soeriaatmadja R.E., dan Suraya A.A. (1999). Ekologi Jawa dan Bali. Seri Ekologi Indonesia. Jilid II. Kartikasari SN, editor. Alih bahasa: SN Kartikasari, TB Utami & A Widiantoro. Yogyakarta: Jurusan Teknik Geologi, Fakultas Teknologi Mineral UPN Veteran Yogyakarta
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Local Community Perspectives: Discovering the Potentiality of Togenra Cave and its Bat Species as an Ecotourism Spot in Barru, South Sulawesi

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Dear the Editor of Asian Journal of Conservation Biology,

As one of important karst caves located Tonasa Karst Formation, Togenra Cave is located in Barru Regency (South Sulawesi-Indonesia. The cave serves as an important habitat for several cave bat species, and is known to host a high diversity of bats from the area. With its unique features, the cave has been designated as a tourism target by the Barru Regency. In order to provide economic alternatives to local communities, and sustainably develop ecotourism in the area, we explored community's knowledge, attitudes and behaviours towards the cave and its bats. In this study, we therefore interviewed people from the local communities, to 1) examine their knowledge and attitude toward the Togenra Cave, bats and conservation; and 2) assess the potentiality of Togenra Cave and its bat species as an ecotourism spot.

We believe that this report will be of great interest to managers and researchers world-wide in the development of wildlife-based ecotourism sector. We found that this topic is relevant with the scope of *the Asian Journal of Conservation Biology* as one of the most reputable journal related with aspects of biodiversity and conservation.

All authors in the manuscript have agreed to the content of submitted manuscript and the manuscript or parts of it have not been published elsewhere or are currently not under reviewed elsewhere. Thank you very much for your consideration on the submitted manuscript.

Sincerely,

Risma Illa Maulany
(Corresponding author)

Local Community Perspectives: Discovering the Potentiality of Togenra Cave and its Bat Species as an Ecotourism Spot in Barru, South Sulawesi

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Abstract

The Togenra Cave in Barru Regency (South Sulawesi) is one cave located in the Tonasa Karst Formation known for its unique features and functions, not only for humans but also for the environment. Currently, the local government of Barru does not regulate access to the cave, and locals are free to access the cave for calcium and guano mining. These unregulated activities can threaten the ecosystem of the Togenra Cave. Therefore, there is an urgent need to develop a non-consumptive use of the cave, through ecotourism activities that can provide long-term benefits to the local communities near Togenra. This study aimed 1) to examine knowledge and attitude of people in these communities toward the Togenra Cave, bats and conservation; and 2) to examine the potentiality of Togenra Cave and its bat species as an ecotourism spot. The study was conducted between August and November 2020. We distributed a set of questionnaires to 31 respondents from the local communities, including their community leaders. The data obtained from the questionnaires were analysed descriptively. To examine the potentiality of both Togenra Cave and bats as ecotourism objects, we used combined analyses of SWOT (Strengths, Weaknesses, Opportunities, Threats) and AHP (Analysis of Hierarchy Process). Our results showed that participants' knowledge about the Togenra Cave, bats and conservation were considered low with few participants had a negative perception of bats. Furthermore, our analyses showed a strengths-weaknesses score of 1.39, and an opportunities-threats score of 1.68, suggesting that there are more opportunities to develop ecotourism in the Togenra Cave.

Keywords: knowledge and perspectives of community, bat existence and conservation, potentiality of cave-bats ecotourism

Introduction

Karst and caves are known for their unique features upholding historical, cultural, but also economic and ecological values (Sherwood & Simek 2001; Cigna & Forti 2013; Pipan & Culver 2013; Forti 2015). The specific ecosystems of both karsts and caves are highly vulnerable, especially to anthropogenic pressure (van Beynen & van Beynen 2011). Across the globe, the main causes of karst disturbance include quarrying, pollution, groundwater extraction, construction and agricultural activities (Baker & Genty 1998; Arfib et al. 2000; Calo & Parise 2006; Parise & Pascali 2013). In the province of South Sulawesi, Tonasa Formation is the largest karst complex, spanning across 5 different regencies (Jeneponto, Maros, Pangkep, Bone, and Barru) and being stretched for 100 km in length (Amran & Hamzah 2016). The area

has positively contributed not only to the local economic and livelihood, but also towards national income through water resource provision and cement mining (Duli et al 2019). As for other karst areas, however, anthropogenic activities like cement mining, pollution and land conversion for agricultural or human settlement purposes have become the main stressors threatening the existence of the area.

Ecotourism may promote conservation and is often considered an important conservation tool (Meletis & Campbell 2007). Ecotourism not only provides leisure activities, but it also educates tourists by requiring them to travel responsibly, and it contributes to building community capacity and generating socio-economic benefits to local communities, while pursuing conservation goals (Ceballos-Lascuráin 1996). Despite some concern about the effectiveness of ecotourism for conservation (Gössling 1999; Das & Chatterjee 2005; Krüger 2005), ecotourism is still considered a valid option, especially when economic factors still control the use of natural resources. In recent years, both cave and cave bat tourism have been developed in many countries (Pennisi et al., 2004; Kim et al. 2008; Bagstad and Wiederholt, 2013; Okonkwo et al. 2017; Constantin et al. 2021; Tanalgo & Hughes 2021). This has opened new opportunities for the non-consumptive use of caves and bats, which have great potential to stimulate and improve local economy, increase environmental awareness and education, and contribute to conservation (Rindam 2014; Okonkwo et al. 2017; Tanalgo & Hughes 2021).

The Togenra cave is one of several important karst caves located in the Barru Regency, and it is also a part of the Tonasa Karst Formation. The cave serves as an important habitat for several cave bat species, and is known to host a high diversity of bats from the area (Suhardjono et al. 2012; Asrijaya 2021). Thanks to these unique features, the cave has been designated as a tourism target by the Barru Regency (Government of Barru Regency, 2012). Currently, however, there is no specific regulation by the local government of Barru related to the cave access and use. This has opened opportunities for some locals to freely access the cave for calcium and guano mining, therefore threatening the ecosystem of the Togenra Cave.

In order to provide economic alternatives to local communities, and sustainably develop ecotourism in the area, we explored community's knowledge, attitudes and behaviours towards the cave and its bats (Singh et al. 2007). Indeed, a comprehensive understanding of human attitudes and behaviour may importantly contribute to the successful conservation of animal species and their habitats (Pennisi et al. 2004; Clements et al. 2018; Maulany et al. 2021). In this study, we therefore interviewed people from the local communities, to 1) examine their knowledge and attitude toward the Togenra Cave, bats and conservation; and 2) assess the potentiality of Togenra Cave and its bat species as an ecotourism spot.

Methods

Study Site

The Togenra Cave is one cave inhabited by bats, belonging to the karst formation of Tonasa, in the area of Maros-Pangkep Geopark, in South Sulawesi (Indonesia). Administratively, the Togenra Cave is situated in the Latimpa sub village of Madello Village, Balusu District, Barru Regency, and it lays between 04º19'51.71941" S and 119º38'19.39078" E (Figure 1). From the capital of South Sulawesi Province, Makassar, the distance to the research location is 97.9 km or about 2 hours and 30 minutes. At the onset of our study, there were two known entrances to the cave: the main entrance located 300 m from the provincial main road, and a secondary entrance on the other side, facing the hills and being more difficult to access. The shape of the cave is a combination between horizontal and vertical cave, with seasonal water flows inside. The length of the cave is 455 m, from the main entrance to the last

point where the bats could be found (Asrijaya, 2021). The research began in August 2020 and ended in February 2021.

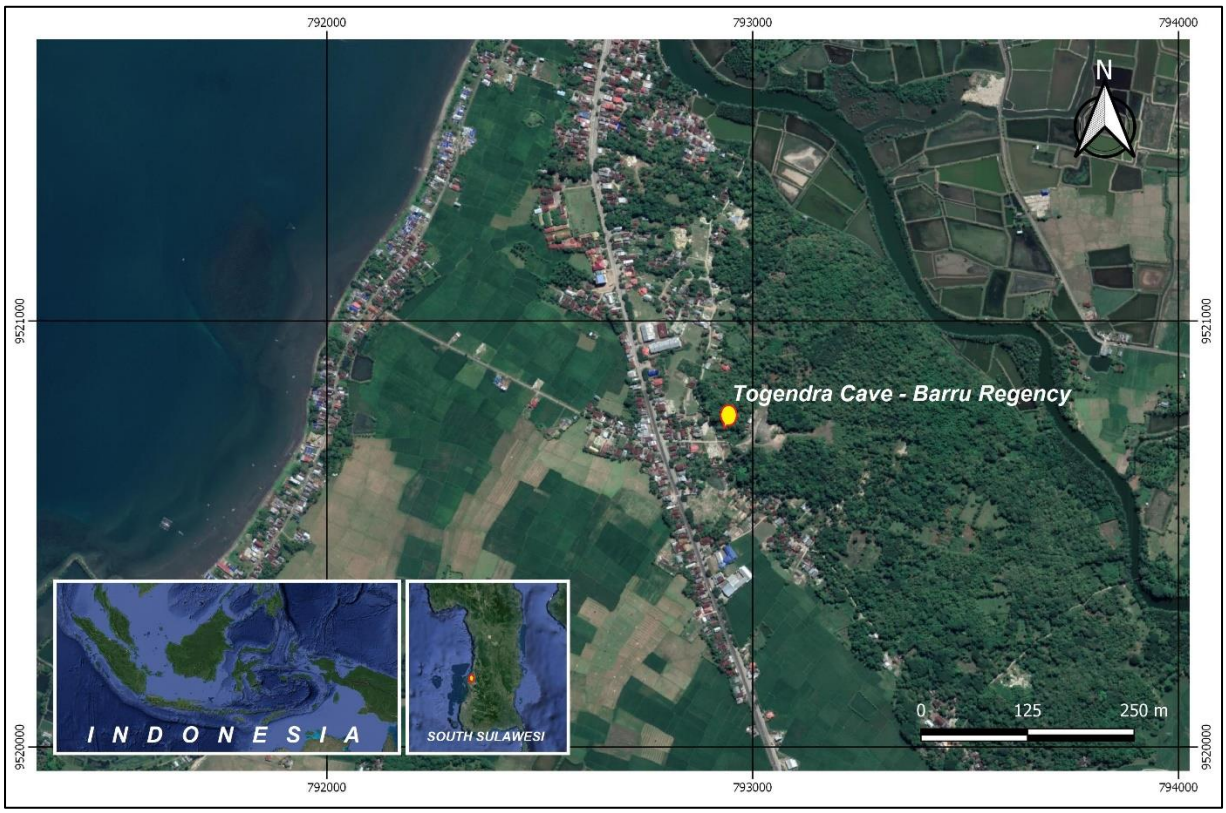


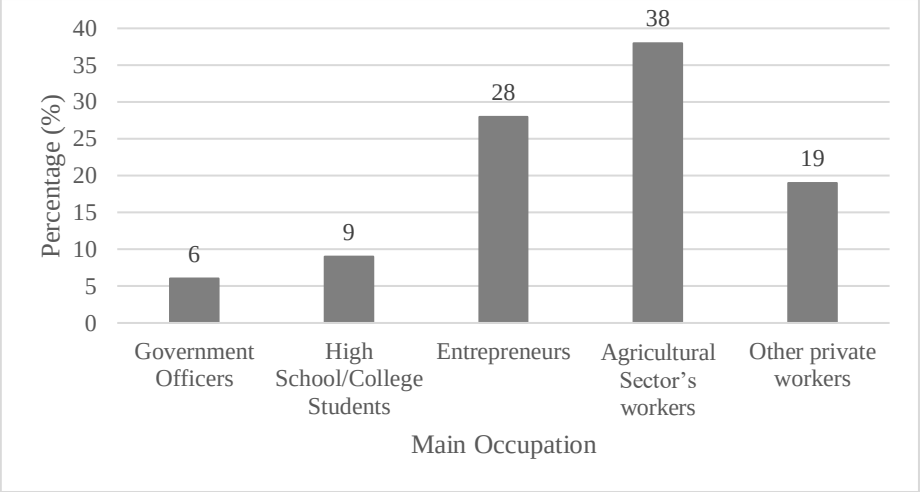
Figure 1. Map of our Study Site in the Togenra Cave, Barru Regency, Sulawesi.

Data Collection and Analysis

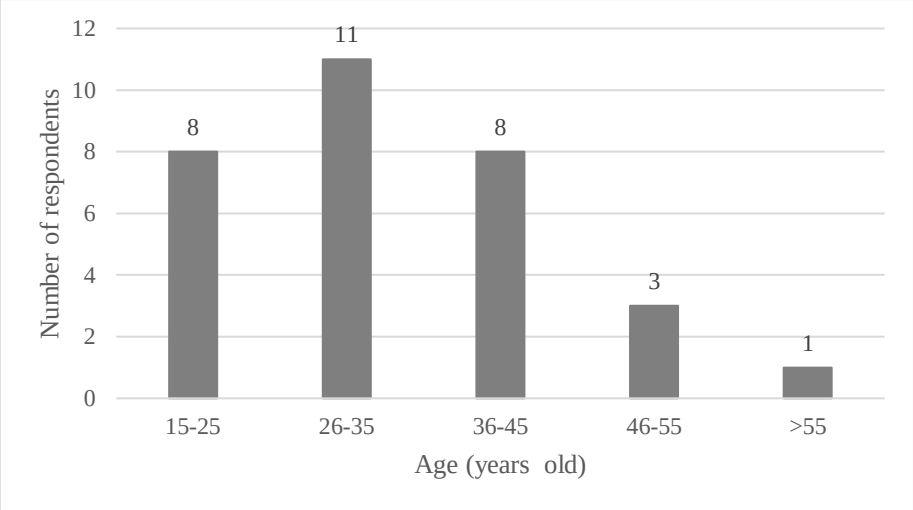
To better understand local people's knowledge and attitude toward the cave and its cave-dwelling bats, and to assess their potential as an ecotourism spot, we developed a questionnaire that was distributed to members of the local communities, These could be either local people living 0.5 km from Togenra Cave and/or conducting activities inside or nearby the cave, or village community leaders. In particular, we assessed 1) participants' knowledge and attitudes toward the Togenra Cave, bats and conservation, and 2) potentiality of Togenra cave and its bats as ecotourism spot. Descriptive analyses were generated to summarise the findings. Finally, we drew the potential threats and prioritizing strategies for future ecotourism development by using SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis and Analysis of Hierarchy Process (AHP).

Results

We collected demographic information on 31 respondents from the local communities. Most respondents (38%) worked in the agricultural sector, as farmers, animal breeders, gardeners or fishermen, whereas 28% were entrepreneurs and 19% worked in the private sectors (Figure 2a). Only 9% of the respondents were high school/college students, 87% of the respondents were in their reproductive age, and 13% more than 46 years old (Figure 2b).



(a)

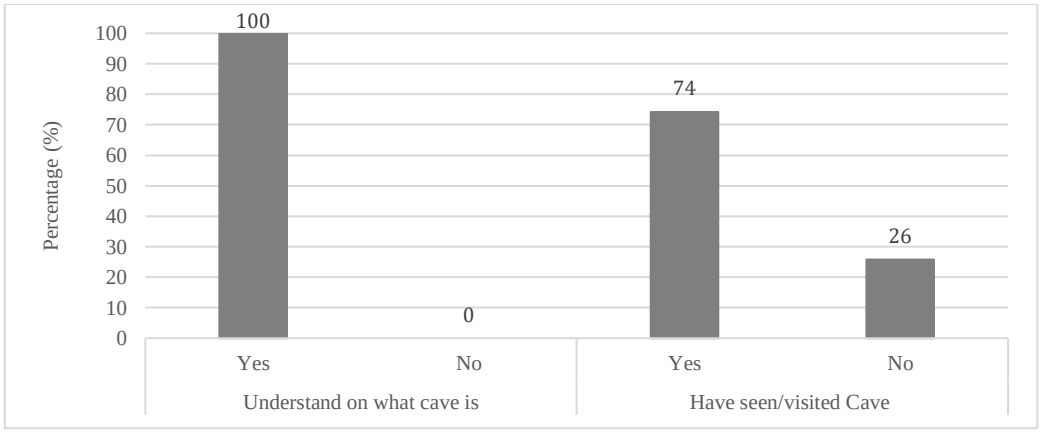


(b)

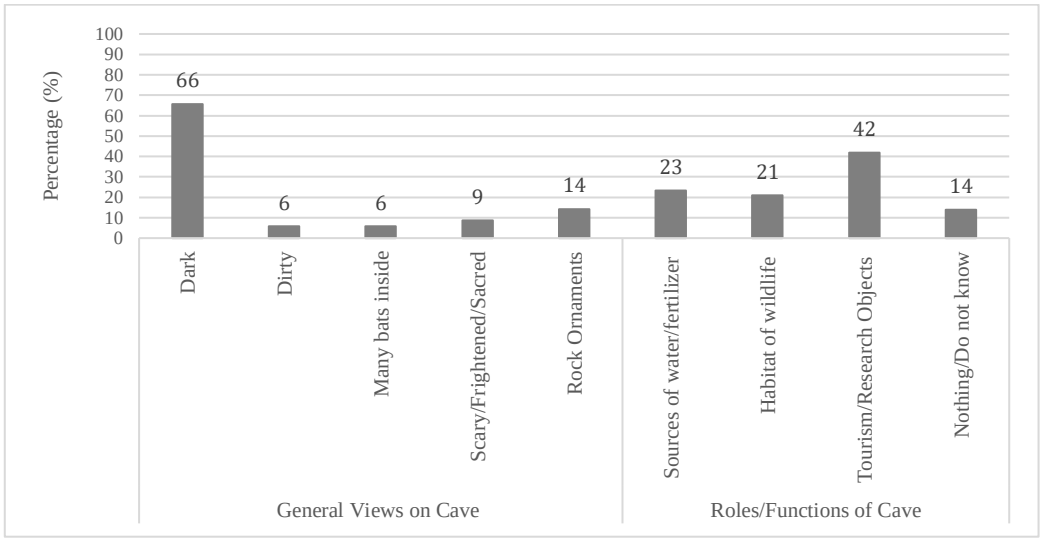
Figure 2. Profile of the respondents living in the Togenra Cave area, including their (a) occupation and (b) age

Respondents' Knowledge about the Togenra Cave and Activities inside the Cave

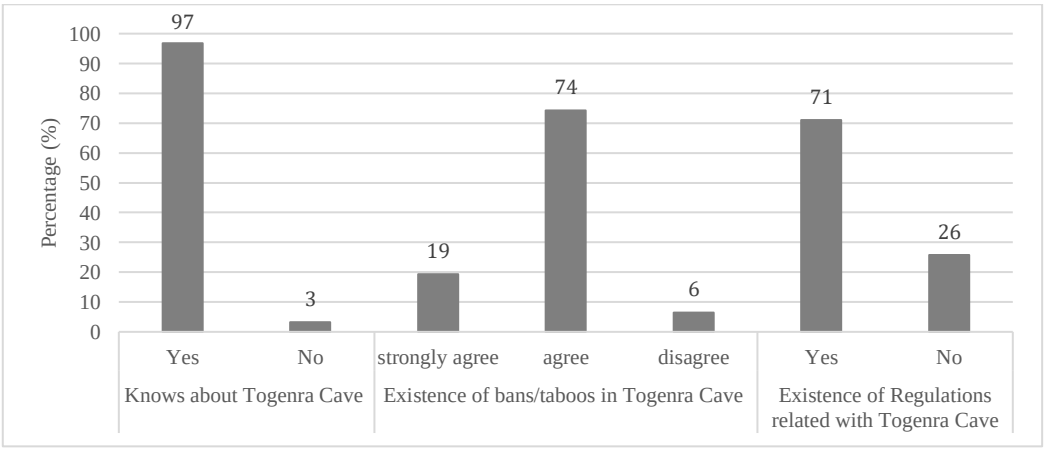
All the the respondents as in Figure 3a had already known about the cave, although only 74% had ever visited or seen it (Figure 3a). Overall, several respondents reported negative attitudes toward the cave, claiming that the place was dark (66%), dirty (6%), or scary (9%; Figure 3b). Regarding the function of the cave, many respondents mentioned that the cave could serve as a tourist/research object (42%), as a source of fertilizers/guanos (23%), and as a habitat for wildlife (21%). However, 14% of the respondents provided no answer about the functions of the cave (Figure 3b).


Percentage (%)
100
90
80
70
60
50
40
30
20
10
0
100
0
74
26
Yes
No
Yes
No
Understand on what cave is
Have seen/visited Cave

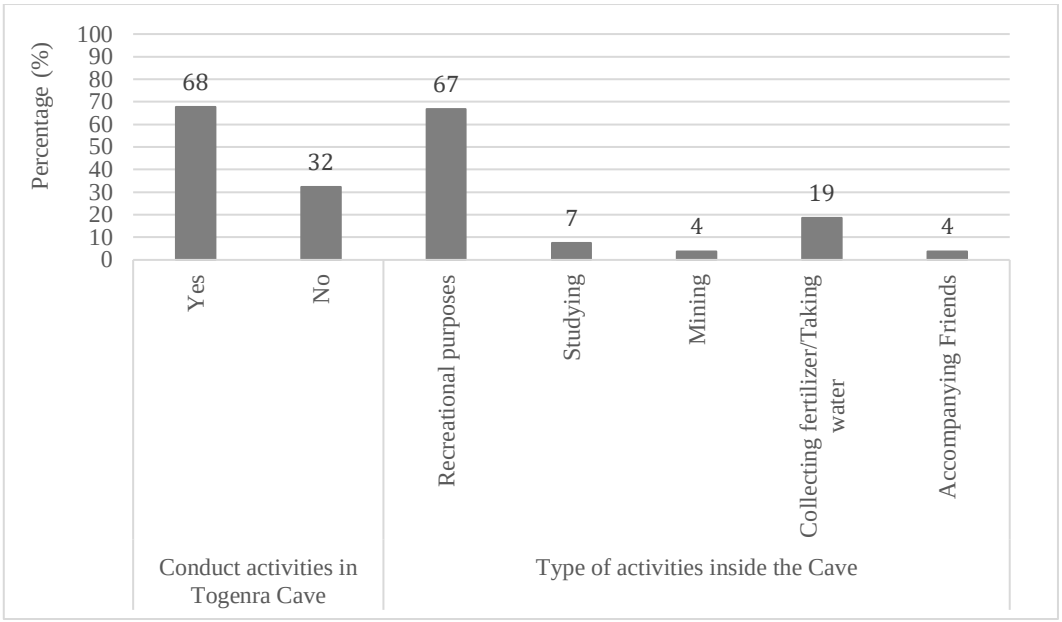
(a)


Percentage (%)
100
90
80
70
60
50
40
30
20
10
0
66
6
6
9
14
23
21
42
14
Dark
Dirty
Many bats inside
Scary/Frightened/Sacred
Rock Ornaments
Sources of water/fertilizer
Habitat of wildlife
Tourism/Research Objects
Nothing/Do not know
General Views on Cave
Roles/Functions of Cave

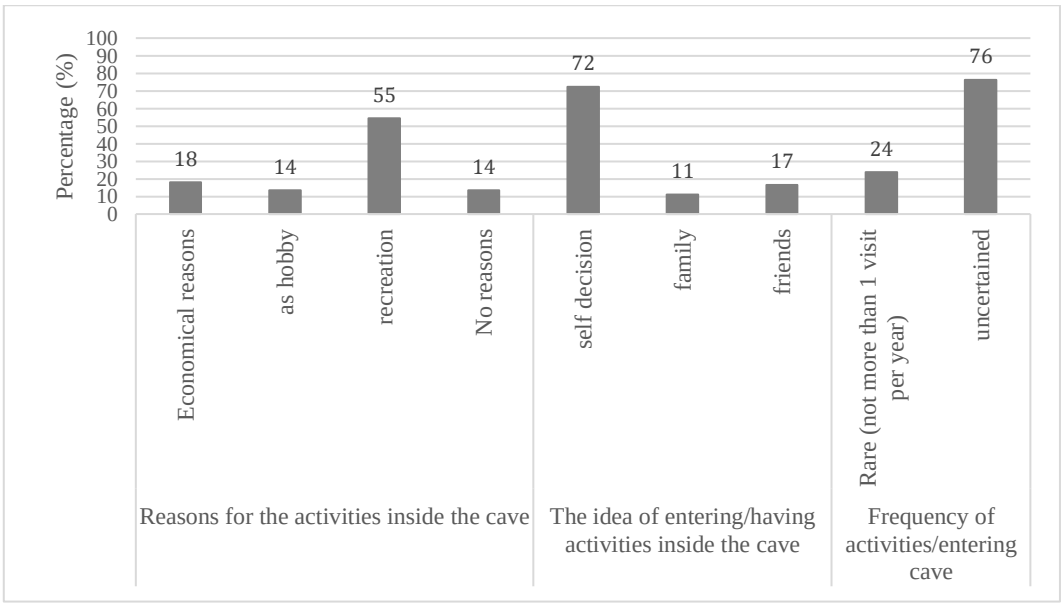
(b)


Percentage (%)
100
90
80
70
60
50
40
30
20
10
0
97
3
19
74
6
71
26
Yes
No
strongly agree
agree
disagree
Yes
No
Knows about Togenra Cave
Existence of bans/taboos in Togenra Cave
Existence of Regulations related with Togenra Cave

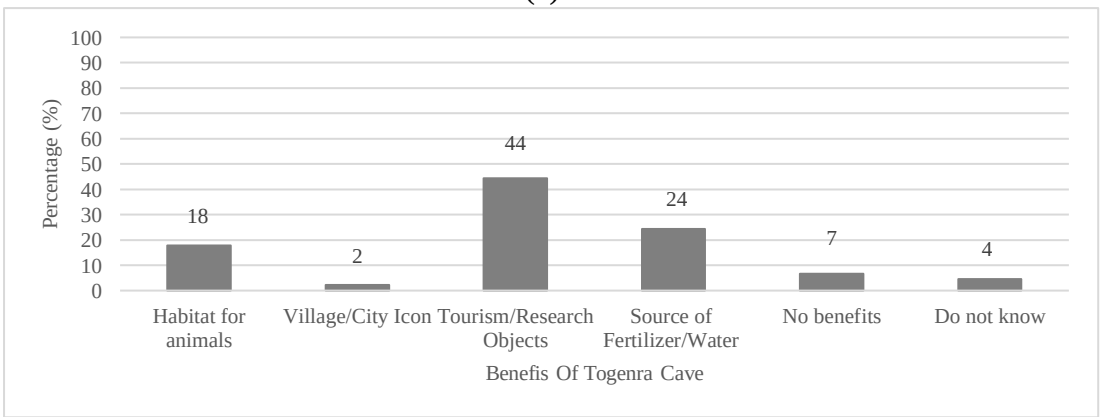
(c)


Percentage (%)
100
90
80
70
60
50
40
30
20
10
0
68
32
67
7
4
19
4
Yes
No
Recreational purposes
Studying
Mining
Collecting fertilizer/Taking water
Accompanying Friends
Conduct activities in Togenra Cave
Type of activities inside the Cave

(d)


Percentage (%)
100
90
80
70
60
50
40
30
20
10
0
18
14
55
14
72
11
17
24
76
Economical reasons
as hobby
recreation
No reasons
self decision
family
friends
Rare (not more than 1 visit per year)
uncertained
Reasons for the activities inside the cave
The idea of entering/having activities inside the cave
Frequency of activities/entering cave

(e)


Percentage (%)
100
90
80
70
60
50
40
30
20
10
0
18
2
44
24
7
4
Habitat for animals
Village/City Icon
Tourism/Research Objects
Source of Fertilizer/Water
No benefits
Do not know
Benefis Of Togenra Cave

(f)

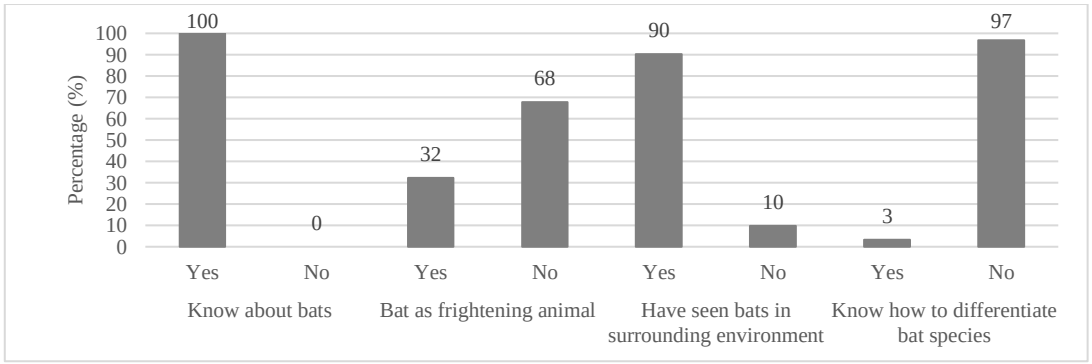
Figure 3. Local respondents' knowledge about the Togenra Cave in Barru, and in particular: their (a) general knowledge about caves/the cave; (b) understanding of the functions of the cave; (c) knowledge of rules in the Togenra Cave; (d) type of activities conducted in the cave; (e) frequency and reasons for these activities; and (f) benefits of the Togenra Cave for the locals

Almost 100% of the respondents were familiar with the cave. Most of them (68%) conducted activities inside the cave, mostly related with recreational purposes (55%). Indeed, most people (44%) acknowledged tourism and recreation as the main benefits offered by the cave. Only 18% of the respondents entered the cave to collect guanos or water for economic reasons, although the frequency of entering the cave was overall uncertain (76%). Most respondents (74%) were also aware of the existence of taboos and/or bans in the Togenra Cave (74%), and agreed on the need to establish regulations for the future management of the cave (71%).

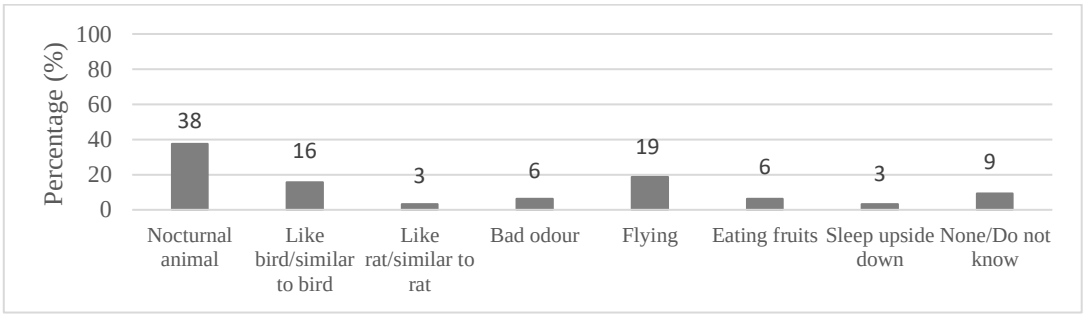
Knowledge and Attitudes toward Cave Bats, Interactions with Humans, and Conservation

Several questions aimed to assess respondents' knowledge and attitudes toward cave bats, their interactions with animals and bat conservation (Figure 3). Most respondents (38%) related "bats" with nocturnal animals. Although 68% respondents claimed that bats are not frightening, many used negative descriptions for the bats in the Togenra Cave (i.e. creepy eyes, bad odour, dog-shaped head), and showed insufficient knowledge about these species. The existence of bats in the Togenra Cave was relatively well known in the communities we studied (87%), although few respondents were informed about the number of bat species in the cave, and/or changes in the population size of bats.

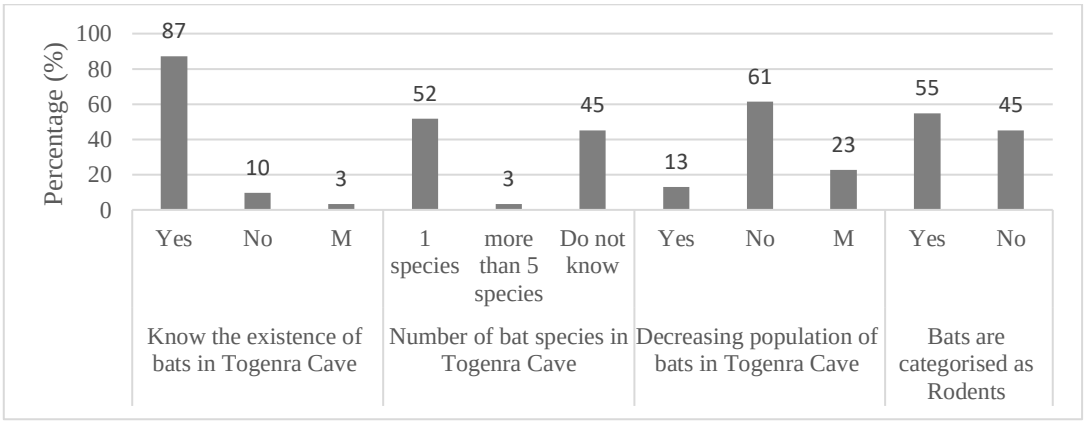
Most respondents (64%) reported having only had visual contact to the bats in the Togenra Cave, which is not surprising considering that most respondents entered the cave for recreational purposes (Figure 4). No respondents were reported having direct interactions with the bats (e.g. touching, throwing, catching. Moreover, when locals were encountered with the bats in the cave, most of them claimed to ignore the presence of the bats (Figure 4a). Not many respondents realized the benefits of bats (65%), and only 5% stated that the bats should be protected. Many respondents (42%) reported having experienced disturbance caused by bats, including bats entering their houses (41%), destroying plants or agricultural fields (36%), and making noise (14%). In relation with health issues arising from exposure to bats (including corona virus), the majority of respondents (74%) had no knowledge about these issues.



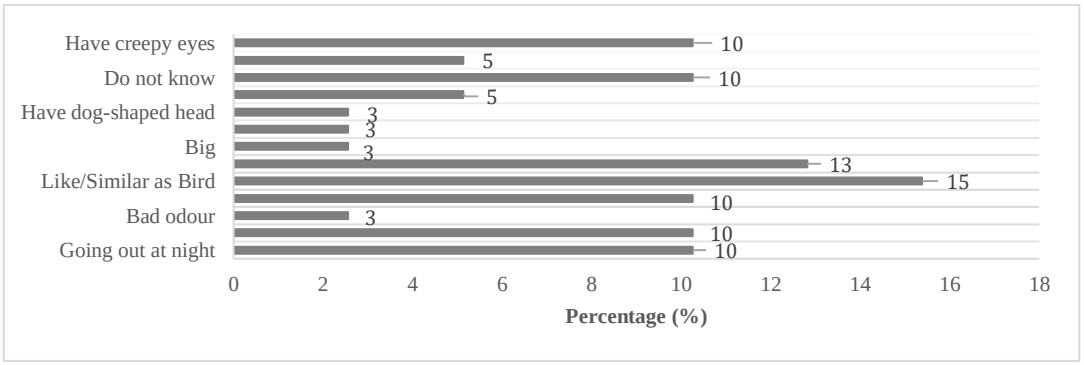
(a)



(b)

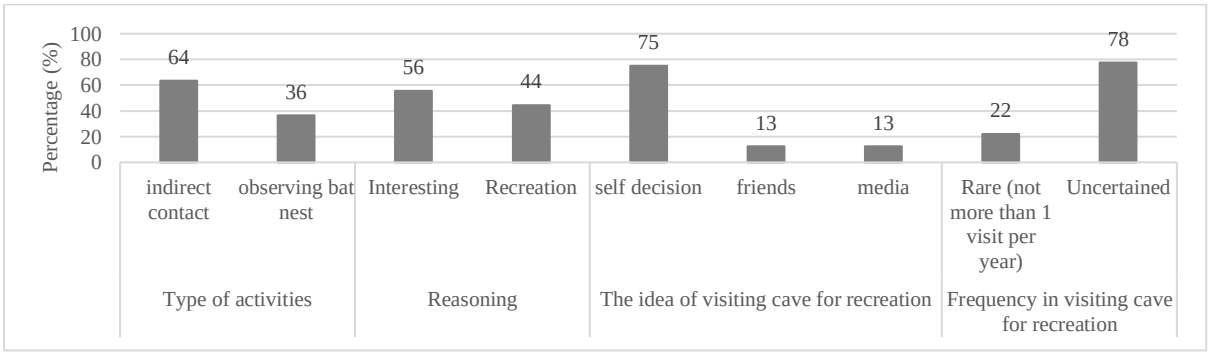


(c)

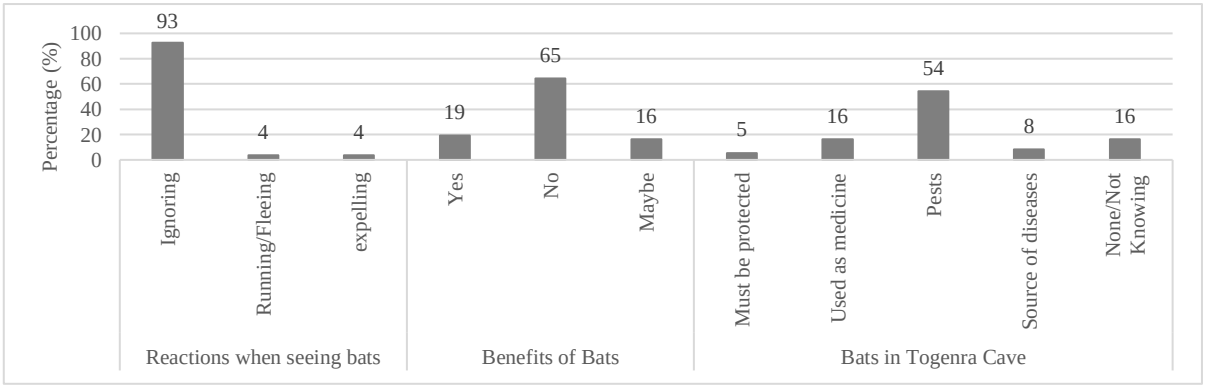


(d)

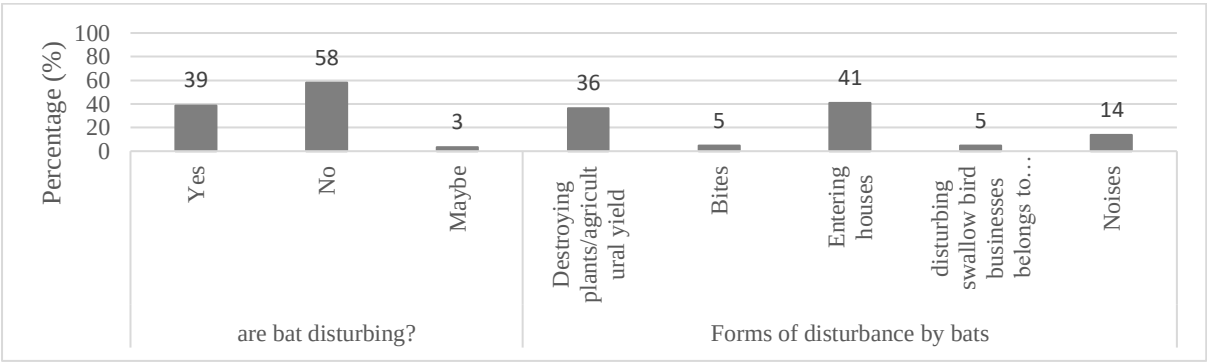
Figure 3. Responses by locals living close to the Togenra Cave, in Barru, assessing (a,b) their knowledge about bats and (c) about the presence of bats in the Togenra Cave; and (d) their description of bats in Togenra


Percentage (%)
100
80
60
40
20
0
64
36
56
44
75
13
13
22
78
indirect contact
observing bat nest
Interesting
Recreation
self decision
friends
media
Rare (not more than 1 visit per year)
Uncertained
Type of activities
Reasoning
The idea of visiting cave for recreation
Frequency in visiting cave for recreation

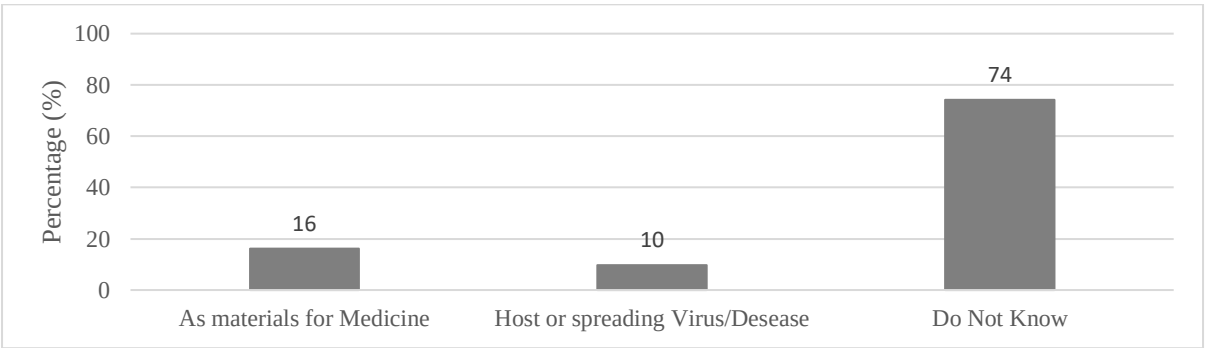
(a)


Percentage (%)
100
80
60
40
20
0
93
4
4
19
65
16
5
16
54
8
16
Ignoring
Running/Fleeing
expelling
Yes
No
Maybe
Must be protected
Used as medicine
Pests
Source of diseases
None/Not Knowing
Reactions when seeing bats
Benefits of Bats
Bats in Togenra Cave

(b)


Percentage (%)
100
80
60
40
20
0
39
58
3
36
5
41
5
14
Yes
No
Maybe
Destroying plants/agricultural yield
Bites
Entering houses
disturbing swallow bird businesses belongs to…
Noises
are bat disturbing?
Forms of disturbance by bats

(c)

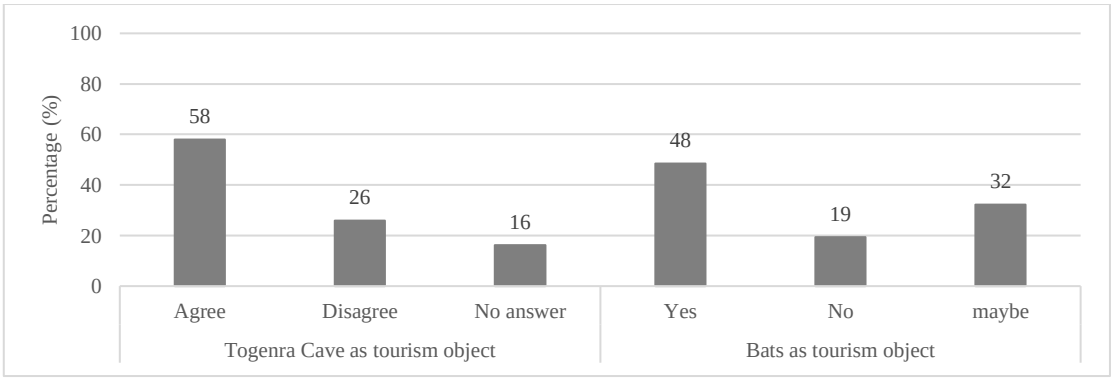

Percentage (%)
100
80
60
40
20
0
16
10
74
As materials for Medicine
Host or spreading Virus/Desease
Do Not Know

(d)

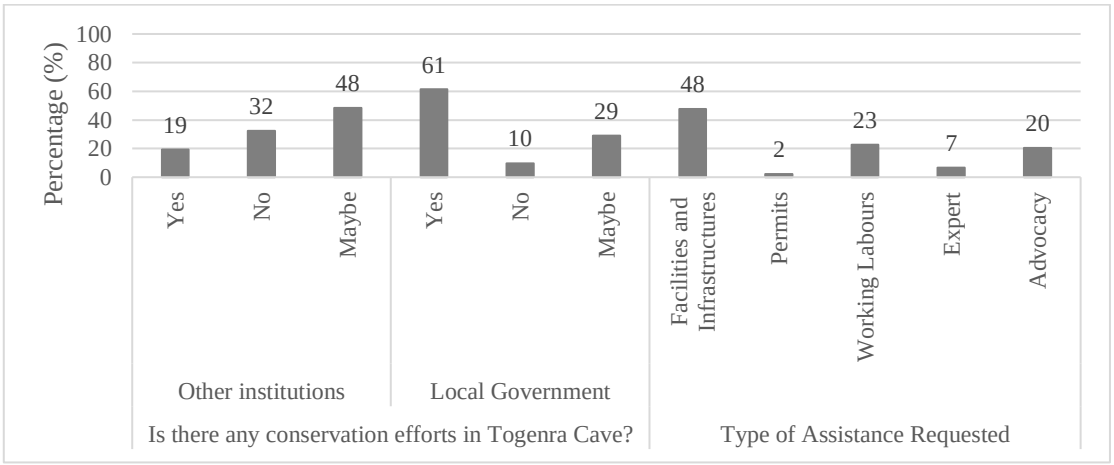
Figure 4. Responses by locals living close to the Togenra Cave, in Barru, assessing (a) their interactions with bats in the Togenra Cave; (b) their behaviour and attitudes towards bats; (c) the kinds of disturbance by bats experienced by respondents; and (d) health-related issues

Togenra Cave as an ecotourism object

Based on the interviews to the locals, 58% respondents agreed to appoint Togenra Cave as an ecotourism spot, although only 48% considered bats as a potential tourism object (Figure 5). Around 61% of the respondents considered that the local government should implement conservation efforts in the area, whereas 19% considered that other parties should take conservation measures. In relation with the assistance required to develop ecotourism in the Togenra Cave, 23% respondents mentioned the need for workforce, 20% for advocacy support, 7% for experts, and 2% for permit matters.



(a)



(b)

Figure 5. Local perspectives (a) on the use of the Togenra Cave and bats as potential tourism objects; and (b) on the need for conservation efforts and the types of assistance required to develop ecotourism

Potentiality Analysis of the Togenra Cave and its Bats as an Ecotourism Spot

To assess the potentiality of the Togenra Cave and its bats as an ecotourism spot, internal and external factors were identified into strengths, weaknesses, opportunities, and threats, by covering several aspects related to the Togenra Cave, bats and conservation. We

identified 12 strengths and 4 weaknesses in the internal factors, and 8 opportunities and 5 threats in external factors. To determine priority strategies for the development of ecotourism in the Togenra Cave, both internal and external factors were given values, rated and scored. We then analysed them using the Analysis Hierarchy Process (AHP). The total score gained for strengths and weaknesses (S-W) was 1.39, whereas for opportunities and threats (O-T) it was 1.68 (Table 1).

Table 1. Scoring Internal and External Factors for the Development of Ecotourism in the Togenra Cave

Internal Factors				
	Strengths	**Value (V)**	**Rating (R)**	**Score (VxR)**
S1	Knowledge about the cave	0.1	3	0.3
S2	Having ever visited a cave/caves	0.06	1	0.06
S3	Function of the cave as tourism object	0.1	4	0.4
S4	Knowledge about the existence of the Togenra cave	0.08	2	0.16
S5	Existence of bans/taboos/myths/regulations in the Togenra Cave	0.07	2	0.14
S6	Need for regulations/bans on the activities inside the Togenra Cave	0.08	3	0.21
S7	Having ever visited the Togenra Cave	0.04	1	0.04
S8	Tourism as one activity in the Togenra Cave	0.1	3	0.3
S9	Recreation as main reason for conducting activities in the Togenra Cave	0.1	3	0.3
S10	Entering/conducting activities in the cave was mostly a self-decision	0.08	1	0.08
S11	No disturbances caused by the existence of bats	0.09	3	0.27
S12	Having never heard about or having never been involved in hunting or consuming bats	0.1	4	0.4
Total Strengths				2.69
	Weaknesses			
W1	Cave as a dark place	0.2	1	0.2
W2	Insufficient knowledge about the functions of caves	0.1	2	0.6
W3	The Togenra Cave provides no benefits	0.4	2	0.8
W4	The word ‘bats’ is associated with night animals which considered negative by the locals	0.3	1	0.3
Total Weaknesses				1.3
	Total (S-W)			**1.39**
	External Factors			
	Opportunities			
O1	Cave and bats as tourism objects	0.14	4	0.56
O2	General interactions are mostly visual interactions.	0.12	3	0.36
O3	Interest as the main reason for interactions	0.12	4	0.48
O4	Recreational purposes as the main reason for interactions	0.12	3	0.36
O5	Willingness of the local community to develop the Togenra Cave as an ecotourism destination	0.14	4	0.56
O6	Involvement of other institutions in conserving bats and developing ecotourism in the Togenra Cave	0.12	3	0.36
O7	Involvement of the government in conserving bats and developing ecotourism in the Togenra Cave	0.12	3	0.36
O8	Facilities and infrastructures are required by the local community to develop ecotourism	0.12	4	0.48
Total Opportunities				3.52
	Threats			
T1	Negative description of the bats in the Togenra Cave	0.16	2	0.32
T2	Ignoring the presence of bats when encountering them	0.16	1	0.16
T3	Assuming that bats have no benefits	0.32	2	0.64
T4	Assuming that bats can host viruses/diseases, including the Covid-19 virus	0.16	2	0.32
T5	Beliefs on bat meat as medicine	0.2	2	0.4
Total Threats				1.84
	Total (O-T)			**1.68**

Finally, the score generated was translated into priority strategies in developing the Togenra Cave as an ecotourism spot, using internal and external factors' scoring. The final score laid in quadrant I, between internal strengths and external opportunities (growth strategy; Figure 6). These results suggest that there are both potential and opportunities to develop ecotourism in the Togenra Cave.

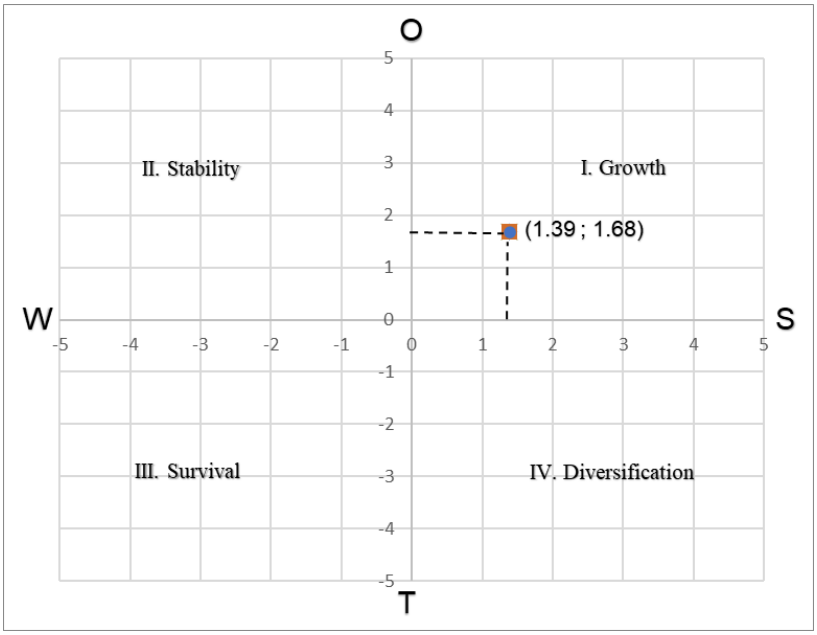


Figure 6. SWOT Matrix of ecotourism development in the Togenra Cave

Discussion

Based on the questionnaires distributed to local respondents living close to the Togenra Cave, Barru Regency, we found that local people were overall quite familiar with the Togenra Cave, with bats and its conservation, although they had little knowledge about these topics. Many respondents, for instance, considered the cave as a dark, dirty, creepy and/or scary place, having limited to no benefits or functions for humans and the environment. In addition, respondents had often negative attitudes toward bats, which were often considered as pests, and/or mistakenly identified as being rodents/similar to birds. Lack of detailed knowledge on caves and bats likely contributed to these negative attitudes and misconceptions towards caves and cave bats. These findings are in line with other studies in other areas of the world, according to which people living in agricultural areas have little awareness about the importance of bats for the environment, with negative consequences for their attitudes towards bats (Mahmood-ul-Hassan et al. 2011; Scheffers et al. 2012; Tanalgo et al. 2016).

Although the majority of respondents entered Togenra for tourism or recreational purposes, less intensive interactions occurred between the locals with both the Togenra Cave and the bats. Most respondents only had visual interactions with bats, although nearly a quarter of cave visitors aimed to collect guanos or water inside the Togenra Cave. This may potentially pose severe threats to the cave environment and the bats living inside the cave, especially if these activities remain unregulated. Moreover, respondents agreed on developing the Togenra Cave and the cave bats into an ecotourism object. This might open important opportunities for further steps in developing ecotourism in the area. As resulted from the analysis, the SWOT

score lied in zone I, suggesting more opportunities to turn the cave and the bats into an ecotourism object.

Based on the SWOT and AHP analyses, we formulate several strategies that might support the development of cave ecotourism in Togenra. By optimizing existing strengths and opportunities, the first strategy required is ***1) to improve community's knowledge and attitudes, and raise awareness on the values and benefits of cave, bats, conservation and ecotourism***. Failure to appreciate the benefits of caves and cave bats for the environment, accompanied by insufficient knowledge on these topics, likely contribute to the emergence of negative attitudes toward both the cave and the bats (Pennisi & Confer 2005; Trewhella et al. 2005; Mickleburgh et al. 2009; Kingston 2016; Garcia-Cegarra & Pacheco 2017). As in other countries, bats are mostly viewed as uncharismatic, frightening animals, and often considered as pests (Prokop et al. 2009; Tanalgo et al. 2016). Few people realize the valuable ecosystem services that bats provide to human communities (Mildenstein et al. 2016). Therefore, awareness needs to be built about the ecosystem services provided by caves and cave bats, to increase conservation willingness and support from the local communities (Madden 2004).

The local community close to Togenra knows about the existence of the cave and partially of the cave bats, but it has insufficient knowledge about these issues. Even though knowledge is not the only factor positively affecting community behavior in biodiversity conservation (Guagnano et al. 1995; Stern 2000), it often has a positive impact on conservation efforts (Keller et al. 1996; Hoffmaster et al. 2016). In some African islands, for instance, providing sufficient knowledge to schools and local communities has effectively increased people's concerns and involvement about bats and their conservation (Tanshi et al. 2013; Mildenstein et al. 2016). Educating the local community is therefore a first necessary step to improve people's understanding of the environmental importance of caves and bats, and thus their attitudes towards bats and their support for conservation efforts (Kingston 2016).

A second strategy to support the development of cave and bat ecotourism from the perspective of the local community is ***2) to encourage the active involvement of the local community and relevant stakeholders in the process of ecotourism development.*** Experience is crucial to improve public attitudes, as it can influence people's attitudes and behaviours towards the object (Smith et al 2011). The local people close to the Togenra Cave mostly had indirect contact with the bats, even when they were known to frequently visit the cave. Past and current experiences with bats might interfere with the ability of locals to change their attitude towards these animals. In his studies, Kellert described several factors that may shape human attitudes, including past experience and knowledge (Kellert 1979, 1980; Kellert and Berry 1980; Kellert and Westervelt 1981, 1983). Therefore, direct involvement may provide new experiences related to cave protection and bat conservation, including the development of ecotourism. These experiences may increase local knowledge and improve people's attitudes. Relevant stakeholders need also to be actively involved in developing ecotourism in the area, to reduce the negative impacts generated through the initiation of collaborative management (Hikmah et al. 2020).

In order to implement cave protection and bat conservation through ecotourism, another important strategy based on the SWOT and AHP analyses is ***3) to establish local management bodies and formulating local rules/regulations to protect the cave and regulate its use, especially for ecotourism purposes***. At present, based on the questionnaires distributed, the access and use of the Togenra Cave are not regulated, and this has made the cave become the target for activities like guano and water collection. Establishing a local management body is crucial in order to implement ecotourism. In particular, the body could initiate the development of ecotourism, including planning, identification of potential tourism objects, mapping, establishment of proper regulations, identification of local people's needs, required facilities and infrastructures, regular monitoring of the impacts generated by ecotourism

activities, and establishment of integrated marketing and networks (Wood, 2002). As regard to the cave utilization, protection and bat conservation, local regulations will need to be implemented by the management unit, to guarantee the preservation of nature and avoid environmental problems (Bokov et al. 2019).

Together with providing education and increase awareness in the local community, another strategy that needs to be employed is ***4) to improve community capacity in conservation and ecotourism aspects.*** Further support to the local community of Togenra is required in order to enhance people's capacities in the form of various relevant trainings. This will not only boost their knowledge, awareness and attitudes, but will also provide hands-on experience for the locals. For example, in the Philippines, local protected area rangers are involved in the training of bat identification and monitoring techniques (Mildenstein 2011; Mildenstein and Mills 2013).

Lastly, another important strategy to develop ecotourism along with the community's perspectives is ***5) to establish a stakeholders' forum***. The success of ecotourism development and implementation is highly dependent on good coordination and communication between stakeholders (Wood 2002). This forum can be formed by relevant stakeholders that might jointly acquire funds to establish basic infrastructures required for the development of ecotourism in the area. This platform could be also used to exchange information and expand networks between stakeholders, to develop social capital, increase coordination and effectively contribute to conservation programs (Kingston et al 2016). In turn, this will indirectly encourage the local community to positively change their mind sets towards caves, bats, conservation and ecotourism.

Conclusion

In conclusion, our study shows that the local community close to the Togenra Cave (Barru-South Sulawesi) has still limited knowledge and negative attitudes toward caves, bats and conservation. However, the local community also considered the cave and the bats as potential objects for the non-consumptive use of resources, through the development of ecotourism in the area. To increase people's knowledge and improve their attitudes, several strategies can be used, highlighting all the strengths, weaknesses, threats and opportunities linked to these processes. These strategies include educational projects, the active involvement of local communities, the establishment of local management initiatives and regulations, capacity enhancement, and the implementation of a stakeholders' forum.

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Diversity of cave-dwelling bats in Leang Londrong, Bantimurung-Bulusaraung National Park: An initial field note

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Abstract. Leang Londrong is one the caves in Maros-Pangkep Karst Formation utilized for nature tourism and has become a habitat for bats. Little is known on the bats inhabited the cave. Therefore, this study is aimed to investigate the diversity, abundance, morphometric of cave-dwelling bats in Leang Londrong, Bantimurung-Bulusaraung National Park as well as their distribution of roosting sites and micro-climate conditions between May-June 2021. The bats were trapped and collected by using two-layered mist nets erected in front of cave entrance. With captured-marked-recaptured (CMR) method, bat diversity, abundance, and morphometric, were examined. Direct measurements on roosting sites were employed to determine micro-climate conditions. There were 3 species of *Microchiropteran* bats found in the site namely *Rhinolophus arcuatus*, *Hipposideros diadema* and *Myotis sp*. Total number of all bats trapped in the net during the observation days was 10 individuals. The largest bat species found living in the cave was *Hipposideros diadema* (average body length of 101.1 mm; tail of 51.46 mm; ear 24.5 mm; forearm length of 96.12 mm; tibia length of 34.6 mm; hind foot of 14.32 mm; and 63.75 g of weight). Meanwhile, *Myotis* sp. was known to be the smallest. For micro-climate conditions, the five roosting sites inside the cave had the average temperature of 26.58°C (range: 26.2-27.3) with the humidity in average around 92.88% (range 89.6-93.8%), while the average light intensity was found to be 0 lx in each roost with the noise level recorded in average of 65.08 dB.

1. Introduction

Maros-Pangkep Karst (MPK) is known to be the second largest karst complex in the world after China [1]. Compared to other karst areas, the unique character of MPK karst area is shown by high tower karsts extended over the land [2]. The area is a part of Tonasa Formation with unique ecosystem and known to have 268 caves [3] valued for not only its economical but also for cultural and ecological aspects [4–6]. As many other karst areas, MPK has played important roles in storing and regulating clean drinking water and for other purposes not only to serve Maros and Pangkep Regencies but also Makassar City [7,8]. In water usage, Arsyad et al. [8] have also estimated economic valuation from MPK area where the area has positively contributed around 15 million m^3 surplus in water storage per year. In cultural aspects, MPK upholds highly valuables prehistoric evidences with a minimum age of 39,600 years according to uranium dating series which can be seen in 127 sites consisted of 78 caves with cave paintings and others documenting artifacts [6]. In term of ecological roles, karst ecosystem is known to host rich and unique species of flora, fauna, and ecosystem [9,10]. MPK has also become a

home for many endemic and protected species including bats which has not been widely explored [1,11–13].

Karst ecosystems are categorized as non-renewable resources that when it is degraded it cannot be fully recovered [14]. Both karst and caves ecosystems are very susceptible towards changes [15]. Anthropogenic threats are among the highest threats faced by the area in particular quarrying, pollution, groundwater extraction, construction and agricultural activities [16–19]. Cement mining, pollution, and land conversion have negatively impacted and become the major of threats towards the MKP ecosystem [6].

Maros-Pangkep karst complex is spread in three regencies of South Sulawesi Province, Maros, Pangkep, and Barru. The area of MKP in total covers ± 46,200 ha where half of the land is also a part of Bantimurung-Bulusaraung National Park (22,800 ha) [1]. Leang Londrong is one the caves situated in Pangkep Regency with the distance of around 49.6 km from the capital city of South Sulawesi Province, Makassar, or can be reached within 1 hour 15 minutes. *'Leang'* means cave in Bugisnese-Makassarese language. The site is under the management of Bantimurung-Bulusaraung National Park and is known as one of the seven wonders of nature tourism spots in the area. The cave is now utilized for nature tourism and has become a habitat for bats [3]. However, little is known on the bat species inhabited the cave. Therefore, this study is aimed to the diversity, abundance, morphometrics of cave-dwelling bats, distribution of roosting sites and their micro-climate conditions in Leang Londrong, Bantimurung-Bulusaraung National Park.

2. Material and methods

2.1. Study area

Leang Londrong is situated in Panaikang Village, Minasate'ne District, Pangkep Regency (South Sulawesi) at Maros-Pangkep Karst Formation. The main attractions are karstic cave and river. Geographically, this cave is located between 4° 51′ 43″ S and 119° 38′ 12″ E at the elevation between 1-50 m above sea level (Figure 1). Leang Londrong is a horizontal riverine karst cave with the length of 5.4 km. The cave and its surrounding environment have provided environmental services not only for tourism but also for water utillization. The river had served as the main water sources used not only for agricultural purposes but also for cement industry [6].

2.2. Data Collection and Analysis

The study consisted of 4 (four) phases of data collection: 1) cave exploration; 2) diversity of cave-dwelling bat species; 3) measurement of physical and environmental characteristics of roosting sites; and 4) distribution and abundance of cave-dwelling bats in Leang Londrong. All the data collected were analyzed descriptively by using Microsoft Excel. Any data related with visual mapping were drawn by using Corel Draw software.

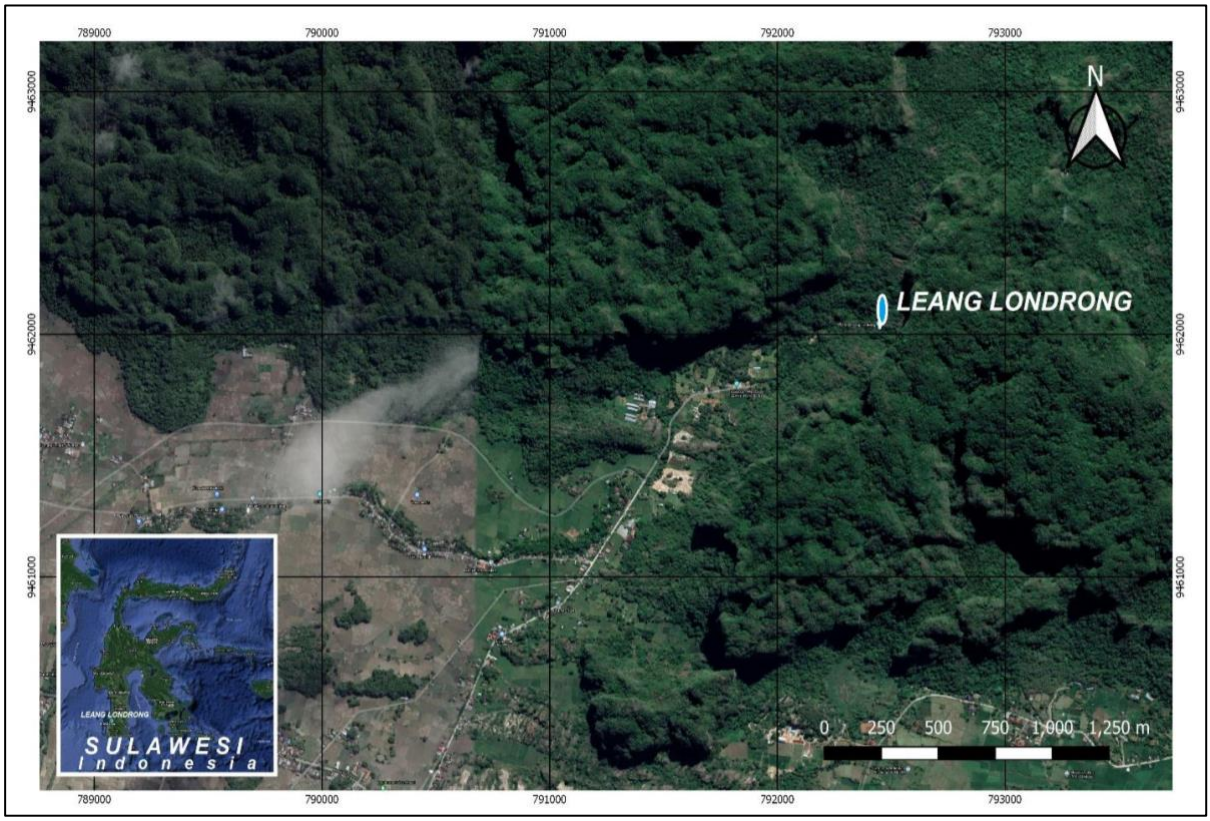

Figure 1. Map of Leang Londrong-Pangkep, Bantimurung-Bulusaraung National Park

2.3. Diversity, abundance, and morphometric of Cave-dwelling bats

In determining the species inhabited Leang Londrong, two layered mist nets were erected in front of the cave entrance. First net of 5x5 m was set 10 m from the cave entrance while the second with the size of 3x3 m net was placed inside with the distance around 25 from the first net. Trapping efforts were carried out for 3 hours starting from 5.00 pm until 8.00 pm in the evening. Any bats trapped in the mist nets will be marked and measured prior to the release. Some measurements towards head to body (HB), tail length (T), ear length (E), length of forearm wing, length of calf (Tib), hind foot (HF) were conducted by using digital calliper. The weight and sex of each individual trapped were also recorded. A pair of male and female of each species will be euthanized and collected for specimen purposes. In addition, for species identification, morphological features were documented through photographing. These photographs were then sent to the Indonesian Research Centre (LIPI) to confirm the species inhabited Leang Londrong for further identification. To estimate the abundance of each bat cave-dwelling species in Leang Londrong, a captured-marked-recaptured (CMR) method was applied. Any individuals trapped in the net were marked and recorded. Any marked individuals from previous capture were also noted.

2.4. Roosting distribution and Micro-climate Conditions

To determine the location of roosting site for each site, the length of the cave was divided into 50 m. The distances from the entrance to the location of bat roosts inside the cave were measured and marked by using laser distance meter Krisbow PRO 100m. Data on each station and roost site were later translated into a map to project the distribution of bat roost sites inside Leang Londrong. In examining micro-climate (temperature, humidity, noise, and light intensity) of roosting habitat inside the cave, manual measurements were utilized to mark each roosting spot inside the cave. Here, then some environmental aspects were monitored. Temperature and humidity of the roosting site inside the cave

was recorded by using a temperature dual laser gun (Krisbow IR 50 T) and Humidity Meter (Krisbow). A sound meter digital (Krisbow 35 TO130 D) was used to detect noise in each roosting site inside the cave. To observe light penetration into the roosting sites, a light meter Krisbow LED 400,000 Lux was used.

3. Result

Leang Londrong is categorized as karstic riverine cave where all the cave system is inundated by river water (Figure 2). To portray the conditions of Leang Londrong, the cave was explored briefly as it could only be accessed by using canoe/small boat. Due to the river conditions, difficulties in access including dark cave, involvement of high cost in renting canoe/small boat, the data collection could not be done simultaneously in particular to conduct repeated data collection for micro-climate conditions of roosting sites.

The cave could only be entered as far as 0.52 km or less than a quarter of the total length from the entrance. There were four roosting spots of cave-dwelling bats found along the cave. The distances of the roosting spots from the cave entrance were accordingly 150 m (R1), 192 m (R2), 180 m, (R3) 375 m and 520 m (R4) (Figure 3).

Figure 2. Conditions of the entrance and inside of Leang Londrong, Pangkep,Bantimurung-Bulusaraung National Park

Based on the mist net traps installed for 10 observation days, there were three species of *Microchiropteran* bats found in the site (Figure 4). The cave-dwelling bat species of Leang Londrong were *Rhinolophus arcuatus*, *Hipposideros diadema* and *Myotis sp.* At the beginning of mist net installation from day 1-4, there were no bats caught inside the traps. Only in day 5, some individuals were found. Total number of bats caught in the net was 10 individuals which was consisted of 3 individuals of *Rhinolopus arcuatus*, 3 individuals of *Hipposideros diadema*, and 4 individuals of *Myotis sp*. All marked individuals caught in the mist nets were not found in the other observation days and therefore, a *captured-marked-recaptured* (CMR) formula can not be deployed (Figure 5).

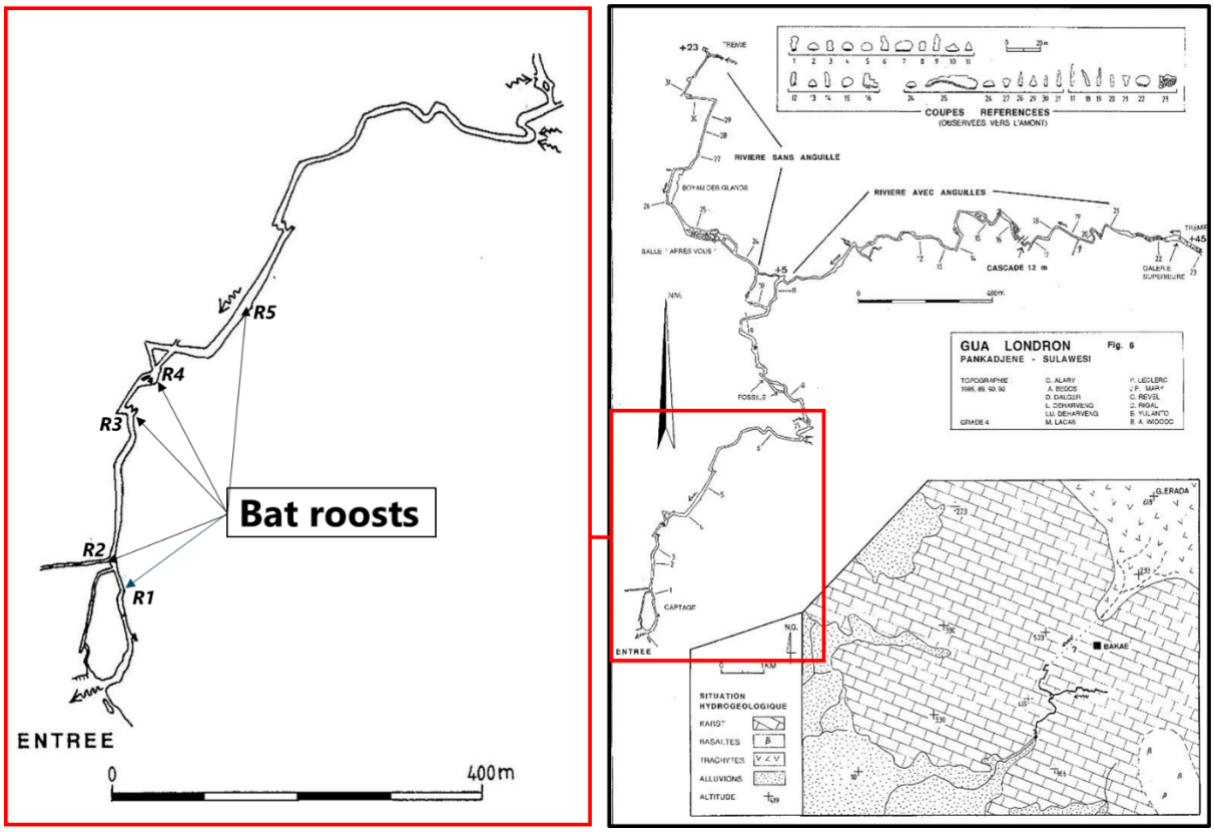

Figure 3. Roost distribution of cave dwelling bats from the entrance to 0.52 meter inside in Leang Londrong-Pangkep, Bantimurung-Bulusaraung National Park (Modified from Broquisse et al [20])

(a) (b) (c)

Figure 4. Diversity of Leang Londrong cave-dwelling bats (a) *Hipposideros diadema*; (b) *Rhinolophus arcuatus*; and (c) *Myotis sp*. in Bantimurung-Bulusaraung National Park

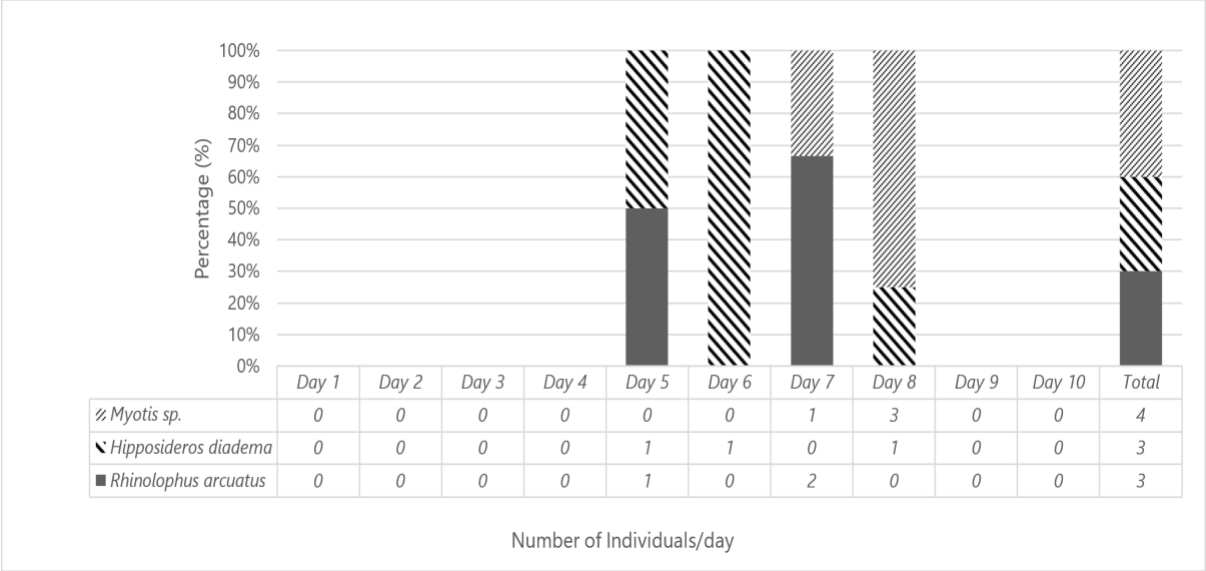

Figure 5. Percentage of cave dwelling species caught in Leang Londrong-Pangkep, Bantimurung-Bulusaraung National Park

From the morphological measurement, the largest species found was *Hipposideros diadema* with the average body length of 101.1 mm; tail of 51.46 mm; ear 24.5 mm; forearm length of 96.12 mm; tibia length of 34.6 mm; hind foot of 14.32 mm; and 63.75 g of weight. Meanwhile, the size of *Rhinolopus arcuatus* was moderate compared to the other two species with the average body length of 42.35 mm; tail of 17.80 mm; ear 13.97 mm; forearm length of 45.10 mm; tibia length of 17.97 mm; hind foot of 8.33 mm; and 9.75 g of weight. *Myotis sp.* was known to be the smallest. *Myotis sp.* had the average body length of 41.76 mm; tail of 22.06 mm; ear 9.39 mm; forearm length of 37.95 mm; tibia length of 14.61 mm; hind foot of 9.12 mm; and 4.15 g of weight (Table 1).

Table 1. Morphological measurement of cave dwelling bat species found in Leang Londrong-Pangkep, Bantimurung-Bulusaraung National Park (*BL= body length, T= tail, E: ear, FL= forearm length, Tib= tibia length, HF= hind foot and Wt= weight*)

No	Spesies	Sex	Number of Individuals Caught	Morphometric Measurements (mm)						
				HB	T	E	FA	Tib	HF	Wt
1	*Hipposideros diadema*	M	1	100.25	54.08	23.49	100.66	35.22	16.30	60.00
		F	2	101.96	48.84	25.52	91.57	33.97	12.35	67.50
2	*Myotis sp.*	M	1	36.40	16.03	10.43	36.55	14.15	8.20	4.00
		F	3	47.12	28.09	8.35	39.34	15.07	10.03	4.30
3	*Rhinolophus arcuatus*	M	2	51.07	14.47	10.83	46.01	15.95	7.85	10.50
		F	1	33.63	21.14	17.10	44.18	19.99	8.81	9.00

To examine micro-climate conditions of each roost site inside Leang Londrong, repetitive monitoring and data collection could not be carried out due to difficulties and risks in entering the cave. However, during the first exploration into the cave, it was found that the average temperature of all roost sites was 26.58°C (range: 26.2-27.3) with the humidity in average around 92.88% (range 89.6-93.8%). In term of light intensity, the cave was totally dark with 0 lx in each roost. The noise recorded in average was 65.08 dB (Table 2).

Table 2. Micro-climate conditions of each roost site in Leang Londrong-Pangkep, Bantimurung-Bulusaraung National Park (R=roost site)

Parameters of microclimate		Roost sites				
		R1	R2	R3	R4	R5
Temperature (°C)	Min	26.7	26.7	26.2	26.3	26.1
	Max	26.7	27.8	26.3	26.4	26.2
	Average	26.7	27.3	26.3	26.4	26.2
Noise (dB)	Min	79.5	59.1	46.9	56	70.9
	Max	81.7	76.5	50.2	58.7	71.1
	Average	80.6	67.8	48.6	57.4	71
Light intensity (lx)	Min	0	0	0	0	0
	Max	0	0	0	0	0
	Average	0	0	0	0	0
Humidity (%)	Average	95.5	89.6	93.8	91.7	93.8

4. Discussion

Leang Londrong is under the management of Bantimurung-Bulusaraung National Park in cooperation with the local government of Pangkep Regency. It has become one of nature tourism targets. With the area of 51.57 ha, the tourism activities of Leang Londrong begun to operate since 2006 [21]. It highlights the beauty of natural scenery in the context of karst ecosystem and also the flowing perennial river which constantly coming out from the cave throughout the year as the two main tourism objects. Leang Londrong can be categorized as *distrophic* cave with constant river [22]. This has made the access into the cave without canoe or small boat becoming impossible. During the study, it could only be entered to around 0.5 km where in total Leang Londrong had 5.9 km in length [21]. Conditions of Leang Londrong as the karstic riverine cave have impeded data collection process in this study and a long-term monitoring of the cave as well as its bats in the future.

During the first 4 days, none of the bats were caught and in total of 10 observation days there were only 10 individuals of three Microchiroptera species found *(Hipposideros diadema, Rhinolopus arcuatus, Myotis sp.)*. No *Megachiroptera* were seen nearby the entrance cave or trapped in the mist nets. *H. diadema, R. arcuatus* can be identified to species level, unfortunately one species. Number of species recorded during the study was slightly different with what have been noted by previous study in Leang Londrong. Suyanto & Wiantoro [23] have mentioned only two species inhabited the cave, *H. diadema* and *Miniopterus schreibersii*. No record of both *R. arcuatus* and *Myotis sp.* were found [23]. This might be related with the nature of the cave. Therefore, there are some possibilities that other species may also occupy this site.

The biggest challenge in studying Leang Londrong and its bats is the difficulty of accessing the cave which cannot be done without proper equipment, sufficient manpower and considerable expense. And therefore, direct measurement of the cave physical characters and direct catching of the bats on each roosting sites inside the cave to confirm species diversity cannot be done. Mist net trap effectiveness was also contributed to number of individuals caught. Using mist net trap to capture bats is considered beneficial as it can provide more comprehensive data on age, sex, reproductive state, including diversity and abundance of bat in the area [24]. In this study, even though the traps were set in two layers with a distance of 25 m apart, due to the nature of the cave, the traps cannot cover all areas of exit/entrance points used by the bats. Some gaps created between the traps and cave walls have made spaces for individuals to escape. Other possible entrance/exit holes inside the cave could exist and the bats used these alternative points to escape. In addition, with the capabilities of *Microchiroptera* as insectivores

and as most cave dwellers, with their virtuous three-dimensional memory could also enable them to hinder from the trap sites [25].

Hipposideros diadema or diadem leaf-nose bat is considered as *Least Concern* (LC) by IUCN though the population showed a decreasing trend [26]. This species mostly lives on caves. In South Sulawesi, *H. diadema* found in Leang Londrong was considered larger than those found in other sites. The majority of body length in others were below 100 mm with the weight between 50-73 g [23,27] while in Leang Londrong the average body length was above 100 mm with the weight above 60 g.

Meanwhile, based on IUCN, *Rhinolopus arcuatus* (Arcuate horseshoe bats) is also classified as *Least Concern* (LC) [28]. The population of the species is reported to be stable but concerns laid on declining habitat with decreasing habitat quality in some areas [28]. Here, *R. arcuatus* was first reported as one species inhabited Leang Londrong. In South Sulawesi, the species has been reported to inhabit Marapettang and Sawi Caves in Maros and Mara Kallang Cave, Pangkep [21,23]. Other has also reported on the existence of the species in Mangolo Nature Park and Rawa Aopa National Park, Southeast Sulawesi [29]. In term of body size, *R. arcuatus* could be considered moderate compared to other two species in Leang Londrong. However, compared to its neighbor populations in Mara Kallang (Pangkep), Marapettang and Sawi (Maros) as well as in the Southeastern part of Sulawesi, the size of *R. arcuatus* in Leang Londrong tended to be smaller in body size [21,23,29].

In the world, Genus *Myotis* have been recorded to have 343 species in total where only 12 species found in Indonesia and 5 species were noted to be existed in Sulawesi [30]. Those were *M. ater, M.adversus, M. formosus, M. horsfieldii,* and *M. muricola.* One of the species was found in Leang Londrong. Unfortunately, it cannot be identified to the species level. This can be due to limited photographs taken in some important morphological key features or errors occurred during the measurements.

The positions of roost site have been marked and mapped along 0.5 km from the entrance. But, to determine the location based on the species, it was difficult as the visibility inside the cave was very poor. Inside the cave, temperatures were quite constant inside the cave with relatively high humidity and starting from the entrance to 150 m (R1) to the last roost found (0.52 km-R5), the situation of the cave was very dark (0 lx). The noise levels were around 65 dB which were generated from the sound of the river flowing. This tranquil situation with damp conditions and stable temperatures are suitable for roosting sites [31,32]. Microclimate conditions chosen as roosting sites in particular sound intensity, distance from the cave entrance, temperature, humidity and light intensity are usually adjusted with the needs of their body conditions [33,34]. However, details are required to portray the conditions of the three species roosting inside the cave.

5. Conclusions

Leang Londrong is one of important caves for *Microchiropteran* bats even though in this study there were only three species recorded *Hipposideros diadema, Rhinolopus arcuatus, Myotis sp*. There are possibilities that this site might uphold more species. Details on species diversity, abundance, roosting site distribution, and also microclimate conditions could not be attained due to the nature of the cave. Therefore, further studies on the cave and its bats need to be carried out in the future with more proper equipment, trained staff, and sufficient budget to further elaborate the site. Complete and comprehensive data on cave and bat species can be later used to properly manage the area for future development of ecotourism activities in Leang Londrong as well as to support the conservation of bats and its habitat protection in Maros-Pangkep Karst area.

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