Republic of the Philippines
Department of Environment and Natural Resources
BIODIVERSITY MANAGEMENT BUREAU
Ninoy Aquino Parks and Wildlife Center
Quezon Avenue, Diliman, Quezon City
Tel. Nos.: (632) 924-6031 to 35 Fax: (632) 924-0109, (632) 920-4417
Website: http://www.bmb.gov.ph E-mail: bmb@bmb.gov.ph

BMB Technical Bulletin
No. 2019-06

OCT 16 2019

SUBJECT: **INLAND WETLANDS AND TERRESTRIAL CAVES:** TECHNICAL GUIDE ON BIODIVERSITY ASSESSMENT AND MONITORING SYSTEM (BAMS)

Further to the issuance of BMB TB No. 2016-05, *Guidelines on the Biodiversity Assessment and Monitoring System for the Terrestrial Ecosystems*, as amended by BMB TB 2017-09 *Adopting the User Manual on BAMS for Terrestrial Ecosystems,* this Guidelines on BAMS for **inland wetlands and terrestrial caves** is being adopted to supplement the said Technical Bulletins which focus on the different **forest formations,** for the information and guidance of all concerned:

Section 1. Objectives. This Guidelines aims to provide the implementers of the Protected Area Management Office, Regional and Field Offices with the standardized tools for the assessment and monitoring of inland wetland and terrestrial cave ecosystems.

The Guidelines includes identifying trends on the status of the area and their use as well as the threats and stressors that cause their degradation in order to provide guidance for decision-makers in protected areas in implementing science-based management interventions.

Section 2. Scope. This Technical Bulletin shall apply to all inland wetland and terrestrial cave ecosystems in National Integrated Protected Areas System (NIPAS) Protected Areas (PAs), Key Biodiversity Areas (KBAs), Locally Managed Protected Areas and other areas requested for assessment and monitoring.

Section 3. Complementarity of the BAMS with other Assessment and Monitoring Tools/ Systems. Other assessment and monitoring tools/ systems which have been developed and issued applicable to inland wetlands and caves are as follows:

a) **Protected Area Suitability Assessment (PASA):** A tool for rapid assessment of biodiversity to determine the suitability of an area for establishment as protected area under specific categories of the NIPAS. The PASA shall include an inventory and observed condition of ecosystems such as forest, wetlands and caves, within the protected area.

b) **Biodiversity Monitoring System (BMS):** A tool designed to improve information available for decision-makers in protected areas through the regular collection of data on natural resources and their utilization. Sampling/Monitoring areas for BMS shall include representative/s of the wetlands and caves within the protected area,

and identify types of threats, critical areas, and threatened species and populations within each of these identified ecosystems.

c) **Lawin Forest and Biodiversity Protection System (Lawin):** A forest and biodiversity protection system that integrates forest biodiversity and threats monitoring, implementation of interventions to address threats and monitoring of the response of the forest ecosystem to these management interventions.

d) **DMC 2007-04, Procedure in Cave Classification:** prescribes the Manual on Cave Classification which details out the rationale, steps and factors considered for classifying a cave as well as the form for cave assessment.

e) **BMB TB 2018-06, Prescribing the Forms for Inventory and Profiling of Inland Wetlands:** prescribes the forms for the conduct of inland wetland inventory and profiling in order to ensure uniformity in generating information on inland wetland resources and ecosystem services.

This Guidelines on the BAMS for inland wetland and terrestrial cave ecosystems, is an improved modification of the BMB Technical Bulletin No. 2017-05. It provides guidance in the cave and inland wetland ecosystems inventory and boundary mapping, proper selection of monitoring sites and stations, and the establishment of permanent monitoring sites to be used for long term monitoring and management and in determining trends in species abundance and diversity, and the condition of the ecosystem, as well as the threats and stressors that causes the ecosystems' degradation.

Section 4. The BAMS for Inland Wetlands and Terrestrial Caves. This Technical Bulletin shall cover the assessment and monitoring of inland wetlands specifically, rivers, lakes, freshwater swamps and marshes including peatlands, and terrestrial caves specifically those for classification and classified caves*. Sampling protocol for detailed assessment and establishment of monitoring sites and parameters shall be included for each ecosystem, as well as its physical assessment and guidance on data analysis.

The key components of biodiversity to be assessed include state of variables such as species composition, species richness and abundances, while process variables such as growth and recruitment in fixed plots, in addition to the state variables, are the parameters being checked for monitoring purposes.

BAMS results in forest ecosystems is important in the data analysis and interpretation in order to come up with critical and integrated management interventions.

Annex 1 presents the whole process flow, while **Annex 2** details the process for the GIS-based inventory and boundary mapping of caves and wetlands. **Annexes 3** and **4** meanwhile detail the specific methods for assessment and monitoring of inland wetlands and terrestrial caves, respectively.

The reassessment of inland wetlands and terrestrial caves shall be conducted at least every three years. The frequency of monitoring shall depend on specific habitat types and management objectives, as well as the available required manpower and resources but the minimum is at least every three years. In cases of catastrophic events such as strong typhoons, landslides, flooding or drought, assessment activity shall be done immediately after. Regular quarterly monitoring of the degradation and source of threats to these ecosystems shall also be done during the conduct of BMS/LAWIN.

At least two permanent monitoring sites representative of each type of wetland/cave within the PA shall be selected from among the assessed inland wetland/cave per bio-geographical region based on the richness of biodiversity, resource use and presence of threats. For each wetland type/cave, a reference or control site which has the richest biodiversity, and another comparable site where the greatest threats occur, shall be selected at the minimum.

Section 5. Team Formation and Composition. The BAMS Team created by the Regional Executive Director under the BMB TB 2016-05, *Guidelines on Biodiversity Assessment and Monitoring System for Terrestrial Ecosystems*, shall also conduct the BAMS for inland wetlands and terrestrial caves. It shall be headed by the PASu and the CDD Chief within the NIPAS sites and non-NIPAS sites, respectively. It may tap the assistance of the academe, LGUs, other government agencies, and/ or civil society in the conduct of the activities. DENR personnel who have received training in wetland/cave assessment/profiling shall also be members of the assessment team.

Section 6. Provision of Technical Assistance. The Regional and Field Offices as well as the BMB, upon request, may provide technical assistance in the assessment and monitoring of inland wetlands and terrestrial caves outside Protected Areas.

Section 7. Reporting. The results of the assessment and monitoring, with analysis and recommendations, shall be reported by the PASu or BAMS Coordinator to the respective Management Board(s), or the CDD Chief to equivalent management body. The complete report including recommendations, shall be submitted to the DENR Secretary through channels, with a copy furnished to the BMB.

Raw data shall be organized into a database and shall be retained with the Office of the PASu and CDD Chief, for NIPAS and non-NIPAS areas respectively. The processed and other pertinent data shall be inputted to the BMB database.

Section 8. Review and Evaluation. The methods and sampling design will continue to be modified and improved, hence, the implementation of measures, standardized methods, and tools provided herein shall be subjected to regular review and evaluation, and may be updated as necessary by the BMB in separate issuances/notices, taking into account the most appropriate standards, efficient and cost effective technologies that maybe developed later on, and recognized by relevant institutions.

Section 9. Fund Allocation. The DENR Regional and Field Offices, including the Protected Area Management Office, shall allocate necessary funding for the implementation of BAMS for inland wetland and cave ecosystems.

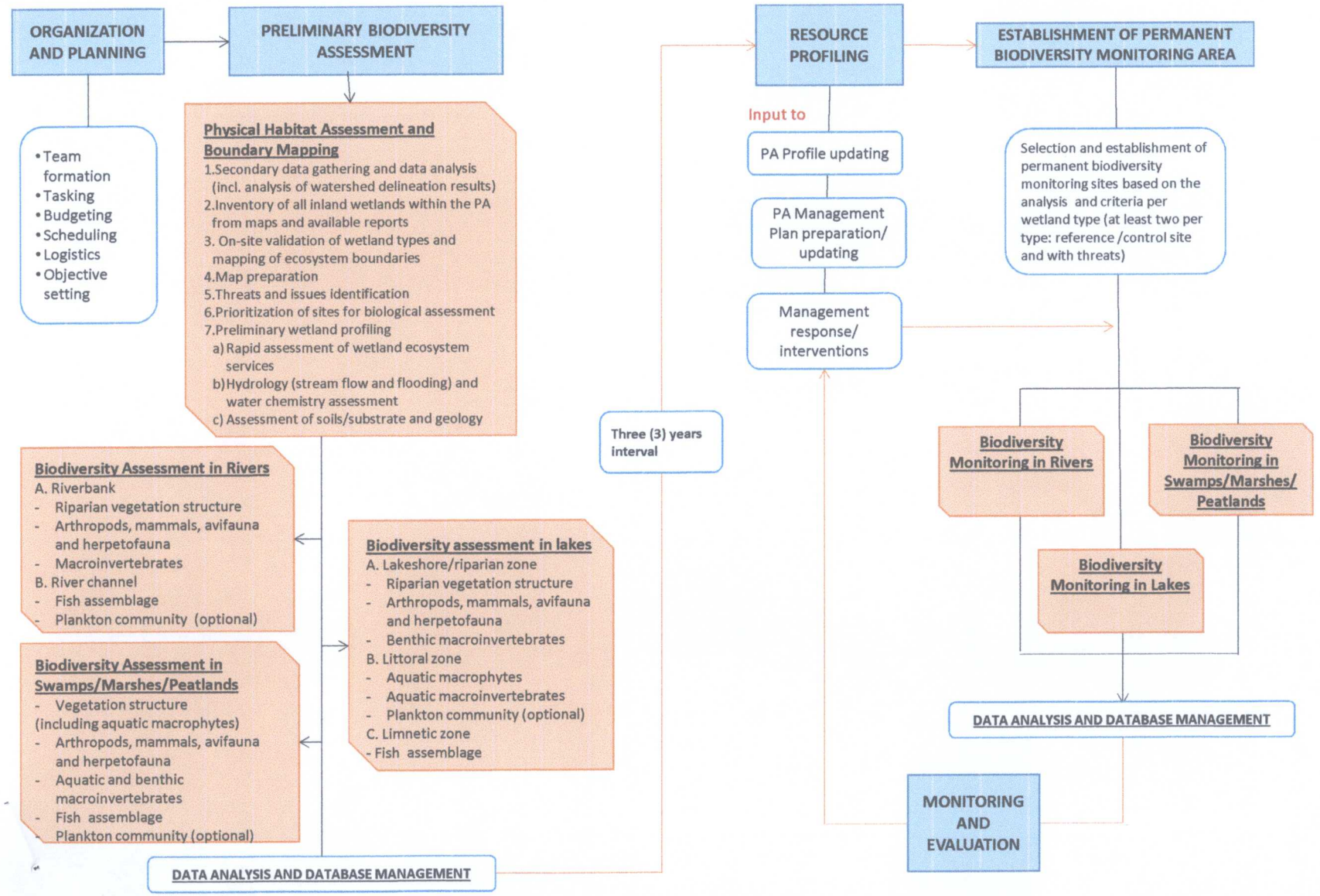
Section 10. Effectivity. This Technical Bulletin shall take effect immediately and shall be circulated for the information and guidance of all concerned.

RICARDO C. CALDERON, *CESO III*
Assistant Secretary for Staff Bureaus, and
BMB Director, in concurrent capacity

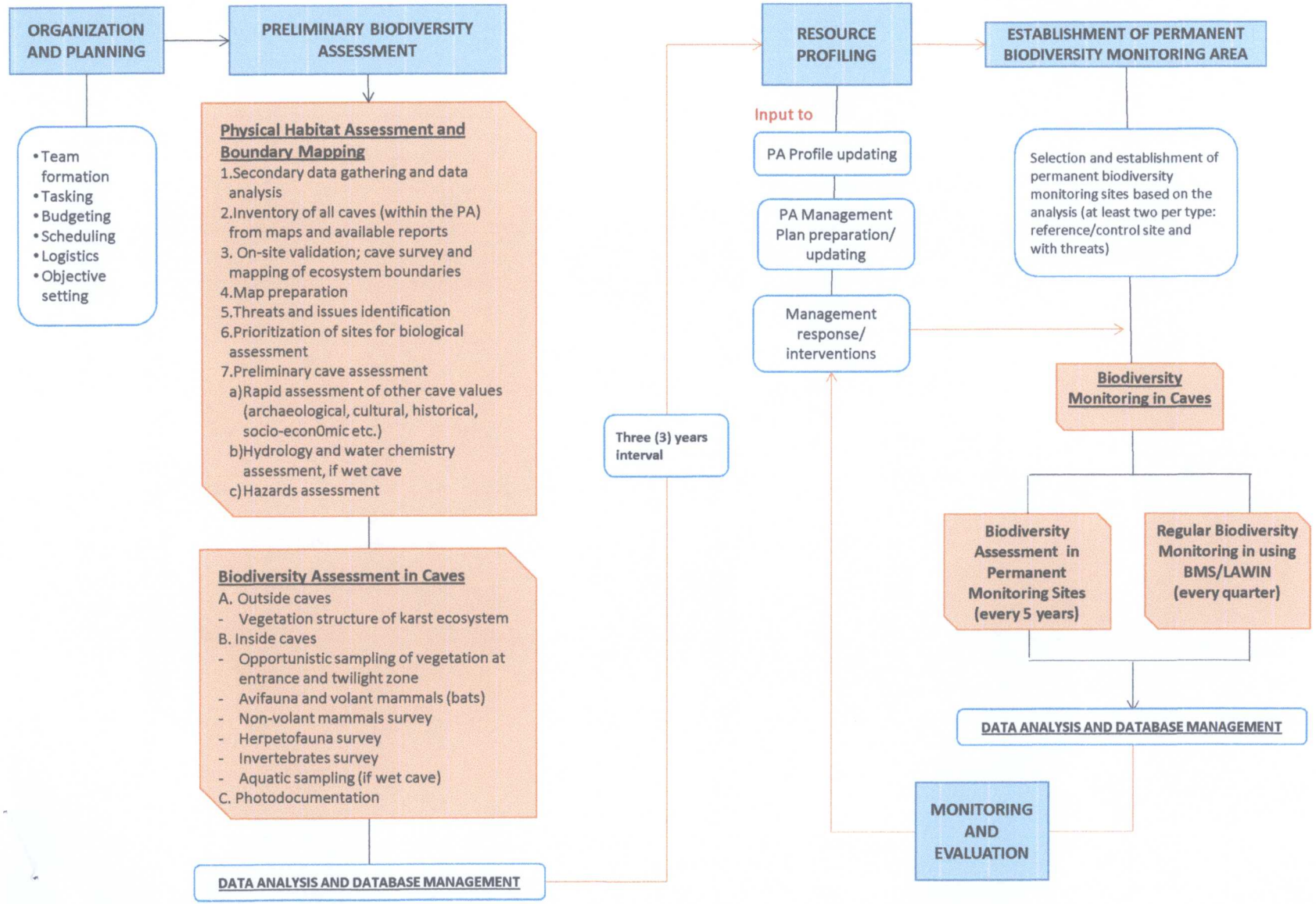
Republic of the Philippines
Department of Environment and Natural Resources
BIODIVERSITY MANAGEMENT BUREAU

BMB201903042

Annex 1. A. Biodiversity Assessment and Monitoring Process Flow for Inland Wetland Ecosystems



Annex 1. B. Biodiversity Assessment and Monitoring Process Flow for Terrestrial Cave Ecosystems



ANNEX 4. CAVE BIODIVERSITY ASSESSMENT AND MONITORING SYSTEM

I. Introduction

Caves are natural heritage brought about by the culmination of the various natural processes such as dissolution, wave action and other geological phenomena. In the Philippines, it was defined by Republic Act No. 9072 "*National Cave and Cave Resources Management and Protection Act*" as a "naturally occurring void, cavity, recess or system of interconnected passages beneath the surface of the earth or within a cliff or ledge and which is large enough to permit an individual to enter, whether or not the entrance, located either in private or public land, is naturally formed or man-made".

In terms of biological resources, the endemism in caves is remarkably high with at least 23 species that have been recorded in the Philippines (PAWB and GEC, 2013). Organisms inhabiting caves can be classified into three (3): troglo/stygoxene, troglo/stygophile, and troglo/stygobite (troglo – used for terrestrial species while stygo is used for aquatic species within caves). Of these three (3), the troglo/stygobite is considered as these are exclusively found in caves due to their adaptation to subterranean conditions (BMB, 2017).

Caves have played an important role in the environment and human civilization. They have served as refuge for both humans and animals since the ancient times. For instance, the Tau't Bato tribe lives in large caves in the southern part of Palawan during heavy rains (http://www.jacobimages.com/2012/05/palawan-taut-bato-singnapan-valley). Furthermore, caves have been used for various purposes such as ecotourism, community water source, research site for different fields of science, etc.

Threats exist inside and outside caves that can affect the resources and benefits they provide. An example of such threat is land use conversion for agricultural and ecotourism purposes, resulting in loss of vegetation and change in cave's microclimate. Another threat is the excessive collection of biological derivatives such as guano and bird's nest which harms the entirety of the cave inhabitants due to the loss of energy/food source, and damages geological features due to the methods of collection.

Using the Biodiversity Assessment and Monitoring System (BAMS), the existence of cave species within the Philippines can be determined. The information collected through the BAMS can be used to formulate management strategies and interventions to conserve and protect the flora, fauna and ecosystem services that cavesprovide, as well as mitigate hazards and threats.

II. Organization and Planning

a. Team composition

Pursuant to the Manual of Cave Classification provided under the DENR Memorandum Circular No. 2007-04 "*Procedure in cave classification*," a Cave Assessment Team shall be created by the Regional Executive Director in each CENRO to be composed of individuals with knowledge in the following disciplines: biology,

geology, socio-economics and other relevant field of expertise, e.g., archaeology, paleontology, hydrology, etc. In case a subject cave is located within the protected area, the Protected Area Superintendent shall be automatically part of the team. Other institutions may also participate in the conduct of caving activities.

b. Secondary Data Gathering

Sources of secondary data for cave biological assessment include:

- Cave Assessment reports
- Topographic map, geomorphic map
- Local Government Unit Plans and program
- Research results from the academe,
- Reports from locals
- Data from local and foreign exploration teams
- BAMS report on forest ecosystem
- SEAMS site report
- Management Plan

c. Preliminary Survey and Mapping

i. Inventory of cave

The inventory of caves at the local level is being populated initially by the closest DENR Office (CENRO/PENRO/RO). The Inventory can be based on reports from concerned individuals/groups, interviews with local residents and previous studies on the area. Any information and updates on the inventory should be submitted to the DENR Regional Office and the Biodiversity Management Bureau for consolidation into a regional and national inventory, respectively. The expected information to be included in the inventory are the following:

1. Name/s of the cave
2. Location (Sitio/Barangay/Municipality/City/Province)
3. Remarks (existing use of the cave, land use, etc.)

ii. Reconnaissance survey and identification of threats

This activity will be used to verify the location of the cave and gather other information such as:

1. Geographical coordinates
2. Threats present in the cave's adjacent lands
3. Terrain in the area including water bodies
4. Land use of adjacent lands
5. Current use of the cave

A location map can be produced using the geographical coordinates of caves within the area.

A Focus Group Discussion (FGD) in coordination with stakeholders, e.g., LGU, local community, NGOs, POs, etc. can be done to determine the threats.

iii. Analysis of information

Information from the collection of secondary data and reconnaissance activity should be considered in the selection of caves to be prioritized for BAMS activities. Other details such as meteorological data should also be considered due to flooding in caves.

d. Prioritization of caves for BAMS

The following should be considered in the selection of caves to be subjected to detailed biological assessment and monitoring:

1. Cave is under considerable pressure from threats.
2. Cave is known to harbor rich biodiversity or ecologically-important species or populations (threatened, endemic or economically-important).
3. Cave is currently being used by the community for ecotourism and other purposes e.g. religious activities, water source, etc.

Caves previously assessed and classified, particularly Class I and Class II caves, should be prioritized. Moreover, a cave classified as Class I based on its biological significance should be prioritized.

III. Biological Assessment Process

a. Introduction

The Biodiversity Assessment Process features four parts: physical assessment, flora assessment, fauna assessment and data analysis. The parameters set in the Cave Assessment Form (Annex B) under the DENR Memorandum Circular No. 2007-04 "*Procedure in cave classification*" will be used to summarize the results of the assessment.

As part of the physical assessment of the cave, the following geological and hydrological information should be provided:

Geological assessment

1. Types of speleothem and speleogen present
2. Approximate number of geologic formations
3. Location using survey station
4. Remarks

Hydrological assessment

1. Hydrologic feature
2. Location using survey station
3. Presence of water flow (perennial or intermittent)
4. Water origin (natural or man-made)
5. Size/volume
6. pH
7. Temperature
8. Remarks

Water quality assessment should also be done if the cave is being used by the community as water source. It should follow existing guidelines and standards for water quality under DENR Administrative Order No. 2016-08 "*Water quality guidelines and general effluent standards for 2016.*"

Physical assessment should be done simultaneously with the survey and mapping of the cave. Suitable sampling sites for biological assessment should be identified through the mapping activity.

Gear:

1. Helmet
2. Foot wear
3. Lightweight shirt and pants
4. Elbow and knee pads (if necessary)
5. Head lamp with at least two (2) backup lights
6. Batteries
7. Dry bag
8. Water bottle
9. Food (preferably easy to eat without producing crumbs)
10. Large plastic bag (preventive measure for hypothermia)
11. Match/ Lighter (preventive measure for hypothermia)
12. Candle (preventive measure for hypothermia)
13. Re-sealable plastic bag

b. Boundary Mapping

Equipment::

- Compass for measuring horizontal angles
- Clinometer for measuring vertical angles and heights
- Tape measure or Range Finder for measuring distances
- Hard-cover notebook or datasheet - Tip: use waterproof paper and pen.
- Protractor, ruler for plotting/sketching
- Pencil
- Or a cave survey software (Therion (https://therion.speleo.sk/download.php), TopoDroid application)

- For GIS processing…

Procedures:

Cave survey and mapping

1. A mapping team should be comprised of at least three (3) members who will function as follows:

    a. Tape man
    b. Instrument reader
    c. Recorder/Sketcher

2. The following information should be collected:

Name of Protected Area:							
Name of Cave:				Location:			
Date of Survey:				Geographical Coordinates:			
Station	Distance (m)	Direction/ Azimuth (degrees)	Inclination/ Slope (+ or – degree or percent??)	Left	Right	Up	Down
0 – 1							
1 – 2							
2 – 3							
3 - 4							

3. The team members and their respective offices, designation and contact numbers should be listed in a separate sheet of paper.

4. The tape man should select permanent landmarks as stations and markthem using flagging tapes. Stations should be placed in a convenient location wherethe instrument reader would be able to read the devices with little to no difficulty.

5. Station 0 should be established beneath the drip line of the cave entrance.
6. The tape man should proceed to the next station with the other end of the tape while the other end will be held by the instrument reader. The distance should not exceed 20 meters.

7. The instrument reader should read the following measurements to the recorder using the appropriate devices below:

    a. Distance – Tape
    b. Inclination – Clinometer
    c. Direction – Compass

More advanced instruments such as range finder, tandem (combination of clinometer and compass), etc., can also be used in lieu of the abovementioned devices

8. Left, right, up and down distances relative to the established station should be measured.

9. All measurements should be noted by the recorder.

10. The recorder should draw a rough sketch of the cave map which would reflect notable cave resources and hazards as observed per station.

11. The tape should only proceed to the next station after all the parameters have been recorded.

12. In case a passage was not mapped due to various circumstances e.g. presence of hazards, poisonous fauna, etc., the said passage should be marked in the cave map.

13. Survey and mapping should proceed until the entire cave has been mapped or until it is plausible.

Special cases:

For vertical and water-filled passages, if ascend/descend and swimming are plausible, the distance traveled and estimated depth for water bodieshould be recorded. Otherwise, these features should only be noted and marked in the cave map.

Data processing and map lay-outing

1. Data collected during the actual survey and mapping should be organized in tabular form.

2. True values for vertical change and horizontal distance should be computed using these formulas:

    a. Vertical change (Height)

    Sin(X) x Distance between stations

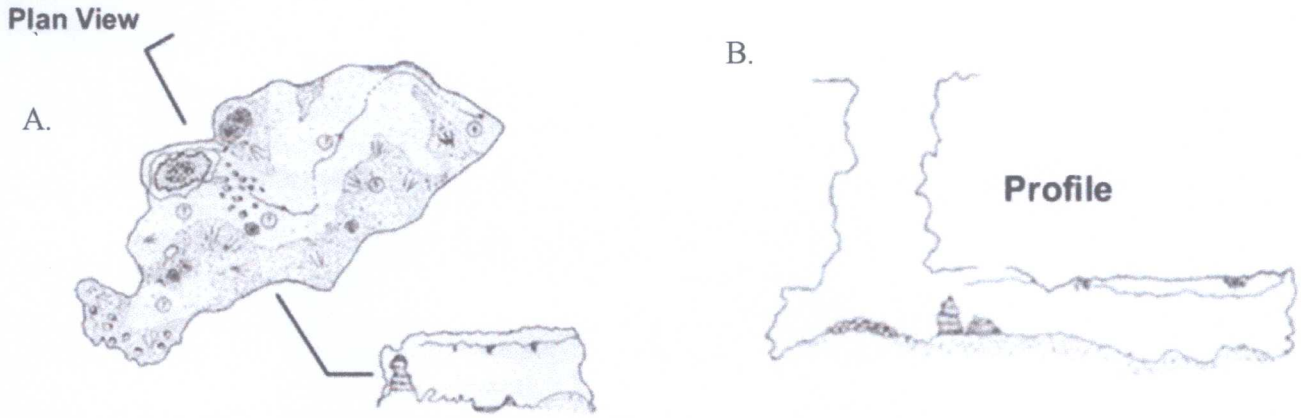
    b. Horizontal distance

    Cos(X) x Distance between stations

    Where X is the Direction of the survey line

3. Two maps—plan- and profile-view (see Figure 1)—should be drawn using the computed and collected values. Plan view illustrates the map horizontally, while profile view displays the map vertically.

Figure 1. Plan view (A) and profile view maps (B)



Dr. Laurence Meissner's. Map 2 [digital image]. Retrieved from https://www.concordia.edu/academics/school-of-natural-and-applied-sciences/friesenhahn-cave/cave-maps.html

4. North arrow and appropriate legends for stations, cave resources and hazards should be indicated.

GIS processing of cave map….

c. Flora and Fauna Biodiversity Assessment Methods outside caves

Attaining the data and information on the biodiversity of flora and fauna outside caves would require the adoption of different methods and assessment of the site. Methods for the assessment will follow the guidelines prescribed in the Manual on Biodiversity Assessment and Monitoring Systems: How-to Guidelines.

In case the immediate vicinity of a cave has been included in the BAMS activity for the forest ecosystem, the flora and fauna data collected can be used. Otherwise, data gathering on flora, using the methods on the abovementioned Manual, should be done and analyzed.

d. Flora Biodiversity Assessment Method in caves

For the flora in the entrance and twilight zone, opportunistic sampling will be utilized. Opportunistic sampling is described as making sampling decisions during the process of collecting data (http://www.qualres.org/HomeOppo-3815.html). This may include hand picking method and species observation.

Instruments: ???

Opportunistic Sampling (cave entrance to twilight zone)

Procedure:

1. Existing flora (vascular plants, mosses and ferns and their allies) should be recorded starting from Station 0 (cave entrance).
    a. The flora and their respective location relative to the established stations should be noted following the survey line up to the twilight zone or until there are flora found/ observed.
2. Form _ should be accomplished.

e. Fauna Biodiversity Assessment Method in caves

Several methods can be used for fauna assessment. As a general method, opportunistic sampling should be used. Other methods such as mist netting, harp, baited pit-fall and cage trappings can also be used for in-depth species identification of specific taxa.

Opportunistic Sampling (for terrestrial and aquatic species within the cave)

1. Record the fauna observed for each of the survey stations established during cave mapping.
2. The following information should be collected relative to each cave survey station:

    a. Species of fauna observed
    b. Number of individuals observed per species
    c. Location of species observed relative to the survey stations especially keystone, threatened troglo/stygobitic (terrestrial and aquatic organisms with adaptations to the cave environment) species
    d. Presence and frequency of roosting sites of bats
    e. Presence and frequency of nesting sites of swiftlets

Mist Netting (for volant mammals)

Sampling design

Considerations in the selection of sampling sites in using mist

1. Height and width of the cave ceiling can accommodate a mist net and the assessment team
2. Cave floor can support the two poles
3. Mist net can be stretched

Mist netting on cave openings is discouraged to prevent the obstruction of the bat's movement in and outside the cave. It is also not advisable to be done in

roosting sites considering the presence of pups within the bat colony. (https://www.bats.org.uk/about-bats/where-do-bats-live/bat-roosts/maternity-roosts)

Equipment

1. Mist net (30 x 7 feet) (see Figure 2)
2. Poles (2)
3. Rope
4. Shovel (see Figure 2)
5. Cloth bag
6. Caliper (see Figure 2)
7. Pesola (see Figure 2)

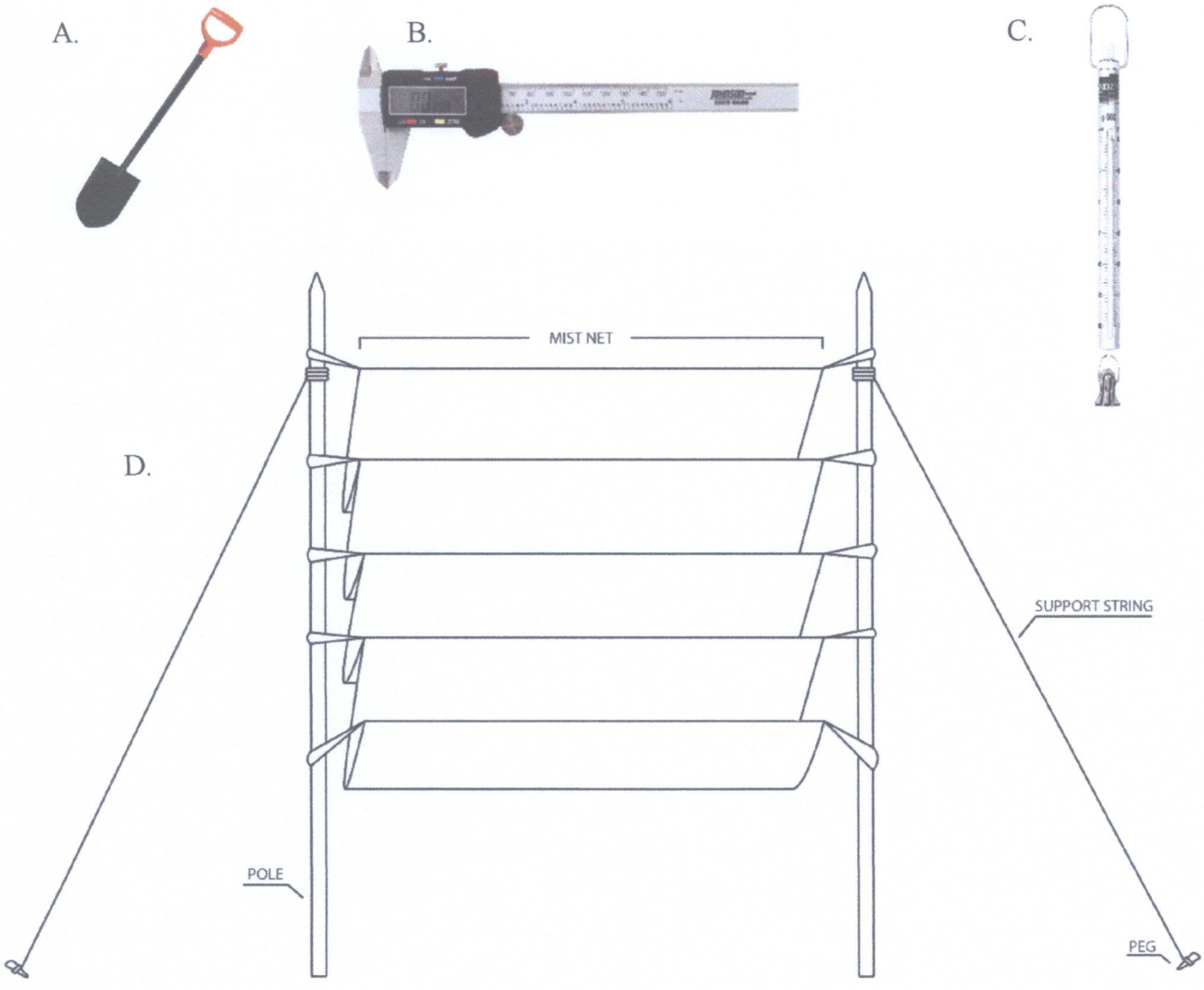


Figure 2. Equipment used for digging holes where the poles will be placed (A), for measuring morphological characters (B), for weighing (C) and set-up of mist net (D).

Procedure

1. Assemble the mist netting setup near the sampling site
2. Place the two poles to open the mist net completely
3. Let the mist net open for at least three (3) hours preferably starting 5:00 P.M.
4. Presence of bats in the net should be checked every 30 minutes and be collected immediately. If bats are left in the net for prolonged period of time, the following may occur:
    - Injury to the bats and mortality
    - Damage to the net due to bats' chewing
    - Escape of bats
5. Extracted bats should be placed in a cloth bag.
6. Specimen should be handed over to other team members for measurements.
7. The following information should be recorded in Form _:
    - Species name
    - Sex
    - Age
    - Morphological measurements (mm) (See Figure 3)
        - Head-to-body length (HBL)
        - Tail length (TL)
        - Ear length (EL)
        - Forearm length (FL)
        - Hindfoot length (HL)
        - Body weight (Wt) in gram

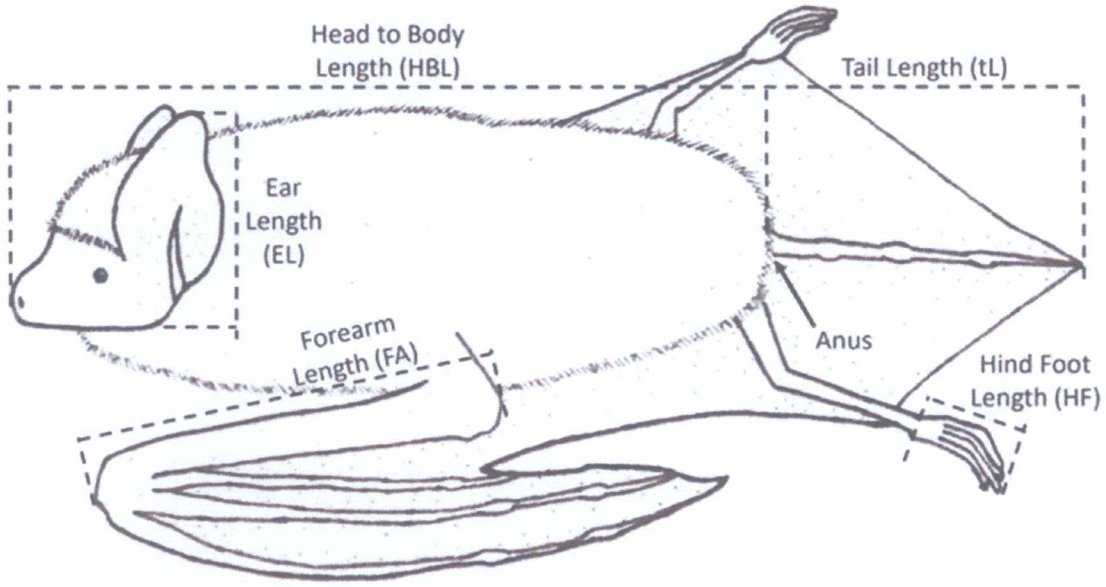


Figure 3. Morphological characteristics of volant mammals to be measured.

Illustration by DAP Fernandez (2017)

8. References such as taxonomic keys and photographic guides should be used for species identification.
9. All specimens should undergo photographic documentation.
10. If a bat cannot be identified, a specimen photograph should be sent to experts. Preserved specimen may also be sent but as last resort.
11. After species identification, the collected specimen should be released.

Mist Netting (for birds) same as for bats in terms considerations, equipment,

Sampling Design

Sampling sites must be selected by following these criteria:

1. Height of the cave ceiling
2. Whether the cave floor can support the two poles
3. Whether the mist net can be stretched
4. Possible exits during birds' roosting time

Equipment

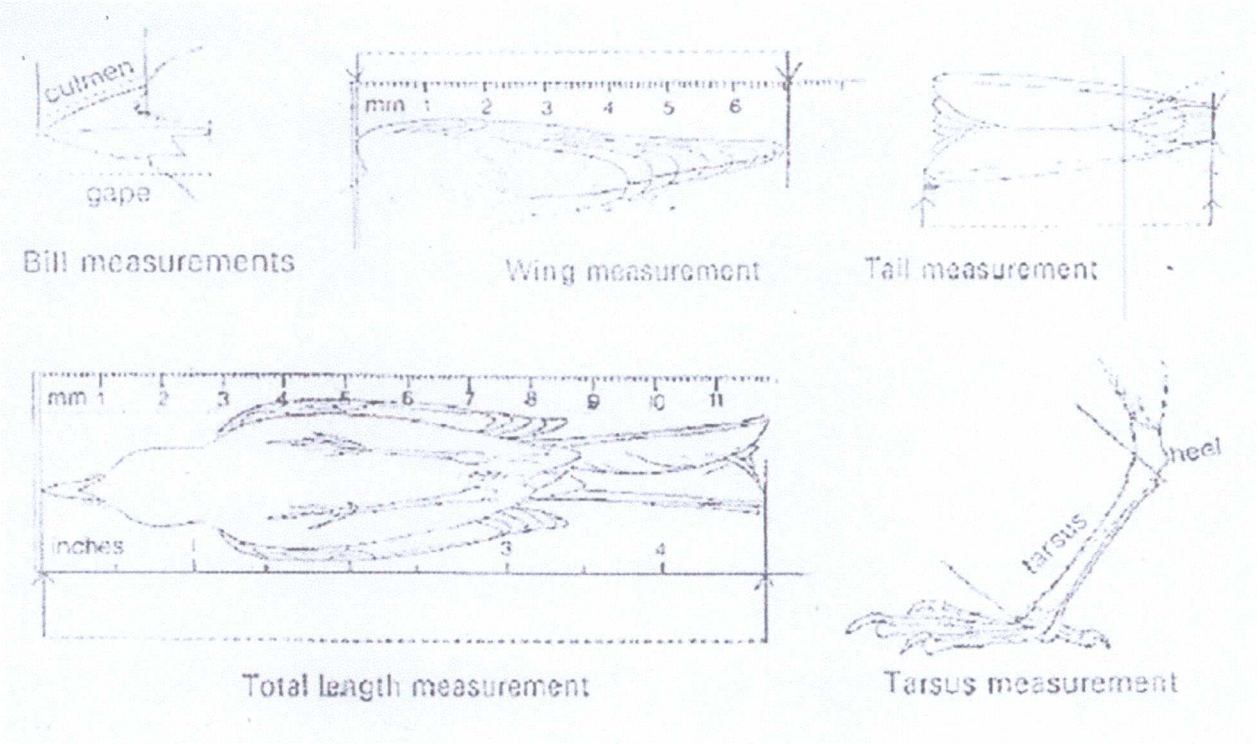
1. Mist net
2. Poles (2)
3. Shovel
4. Cloth bag
5. Caliper
6. Pesola

Procedure

Follow the same procedure as the mist netting of bats except with the following details:

- Time for mist netting - preferably in the afternoon (2:00 P.M.)
- Time for retrieval captured birds– every 20 minutes
- Morphological measurement to be measured (see Figure 4)
    - Total length (TL)
    - Tail-vent length (TV)
    - Wing cord (WC)
    - Bill or culmen length (B)
    - Gape width (G)
    - Tarsus length (T)
    - Body weight (Wt) in grams

Figure 4. Morphological characteristics of Avifauna to be measured.



- Accomplish Form _

Baited Pit-fall trapping (for invertebrates)

Sampling Design

1. Site for set-up should be selected using the following criteria:
    - Near water bodies e.g. pools, river, etc.
    - Presence of guano
    - Minimal air flow
2. At least three (3) pit fall traps (replicates) should be placed in at most five (5) sites that meet the abovementioned criteria.

Equipment

1. Reusable plastic cups
2. Vial
3. Shovel
4. Ziplock bags
5. Gault's solution (preservative)
6. Sodium chloride – 50 g

7. Chloral hydrate – 10 g
8. Potassium nitrate – 10 g
9. Water – 1000 ml
10. Glycerine – several drops

Procedure

1. In the sampling site, dig a hole and place the plastic cup with its rim level with the ground surface.
2. Pour 2 cm depth Gault's solution into the cup.
3. Place the 70 ml vial with bait (cat food, cheese, meat, etc.) in the center of the cup. A stone can be placed in the vial to prevent it from floating. (See Figure 5)
4. Flatten the ground surface in such a way that the plastic cup's rim is unnoticed.
5. Place a flat rock over the cup with its one side propped up which will serve as entrance of invertebrates.
6. The pit fall traps should be collected after one (1) day or sooner if more than five (5) or six (6) of one species have been collected.
7. Specimens should be removed using a forcep and placed in 75-80% ethanol for transport. The whole pit fall trap can also be removed while the specimens are intact. The specimens can be extracted out of the Gault's solution using a piece of mesh fabric as strainer.
8. All specimens should undergo photographic documentation.
9. If it cannot be identified, a specimen photograph should be sent to experts. Preserved specimen may also be sent but as last resort.
10. Form _ should be accomplished.

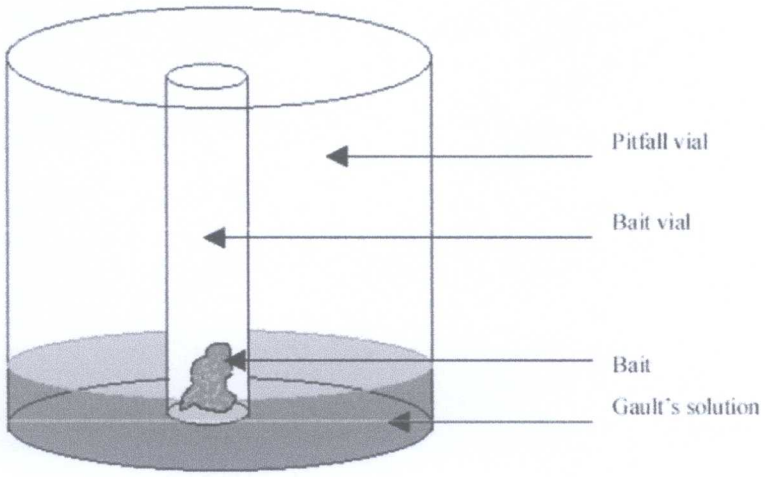


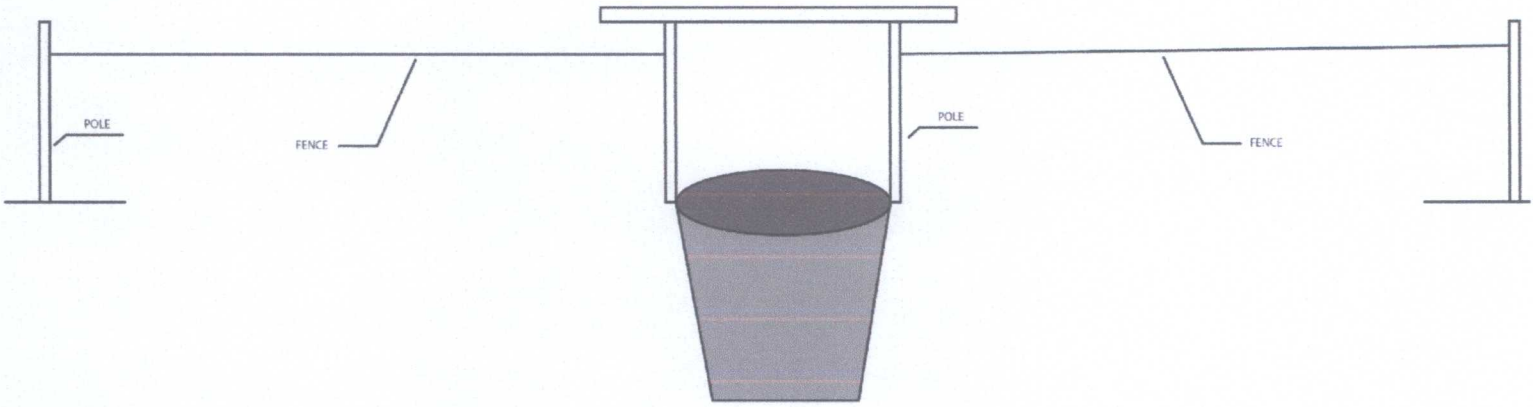
Figure 5. baited pit-fall trap

- **Pit-fall trapping (for herpetofauna) (see Figure 6)**

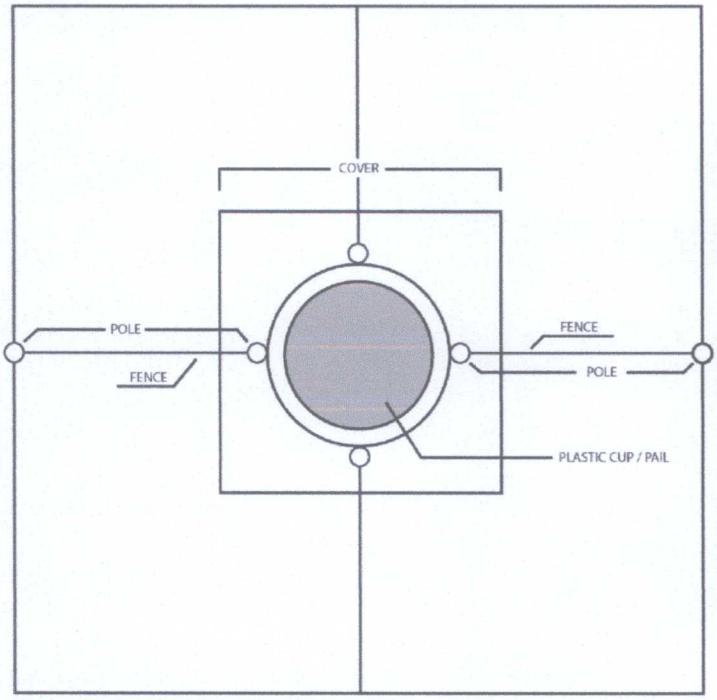
Equipment

1. Buckets
2. Cloth bags
3. Caliper
4. Pesola
5. Shovel

A.



B.



C.

Figure 6. Pit-fall traps with drift fences (A) and two of the common patterns of placement of drift fences (B and C).

Follow the same sampling design and procedure for invertebrates except for the following:

- Materials to be used
- Preservative and bait will not be used for this pitfall trap.
- Traps should be checked twice a day, once in the morning and once in the afternoon.
- Drift fences must be strategically placed to direct the organism to the pitfall trap to capture them more effectively.
- All traps will be retrieved after one (1) day.
- Captured herpetofauna should be placed inside a cloth bag. One specimen per cloth bag should be followed. (see Figure 7)

Figure 7. Toad captured in a pit-fall trap

- The following details must be recorded:
  a. Species identification
  b. Sex
  c. Morphometrics
     i. Amphibians (frogs, toads, caecilians) (see Figure 8.)
        1. Snout-vent length (SVL)
        2. Tail length (TL)
        3. Total length (ToL)
        4. Head length (HL)
        5. Head width (HW)
        6. Interorbital distance (IOD)
        7. Eye diameter (ED)
        8. Snout length (SL)
        9. Tail-vent length (TVL)
        10. Forelimb length (FLL)
        11. Hindlimb length (HLL)
        12. Weight (Wt) in grams

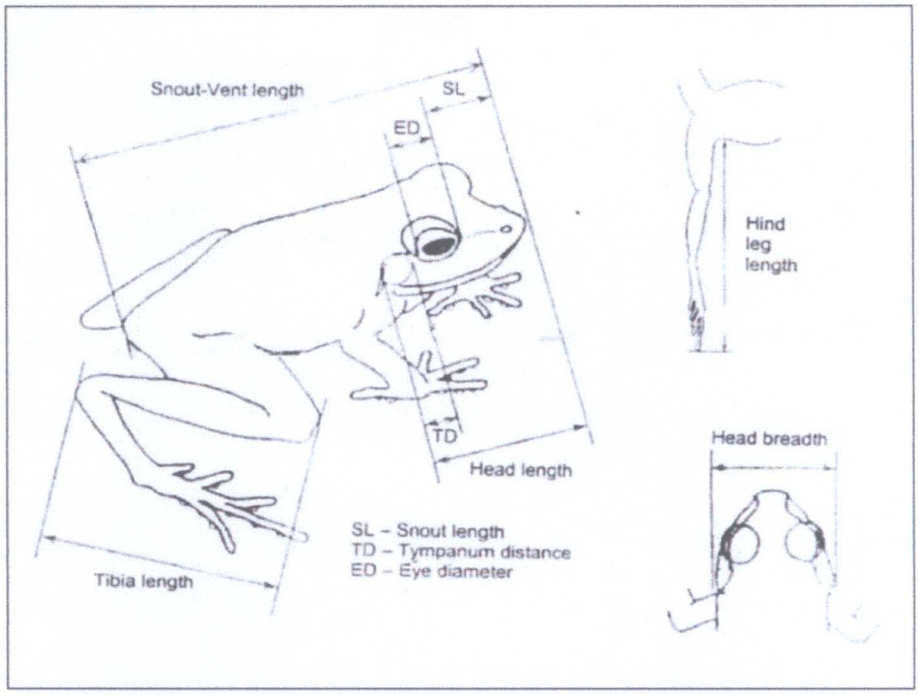


Figure 8. Morphological characteristics of frogs and toads to be measured

ii. Snakes (see Figure 9.)
    1. Snout-vent length (SVL)
    2. Tail length (TL)
    3. Total length (ToL)
    4. Head Length (HL)
    5. Head width (HW)
    6. Interorbital distance (IOB)
    7. Eye diameter (ED)
    8. Snout length (SL)
    9. Weight (Wt) in grams
    10. The following details should be recorded in the remarks section (see Figure 9.)
        a. Scale description
        b. Loreal scales
        c. Orbital scales
        d. Preorbital scales
        e. Presence of pits
        f. Dentition (if available i.e. ophistoglyphous, aglyphous, etc.)

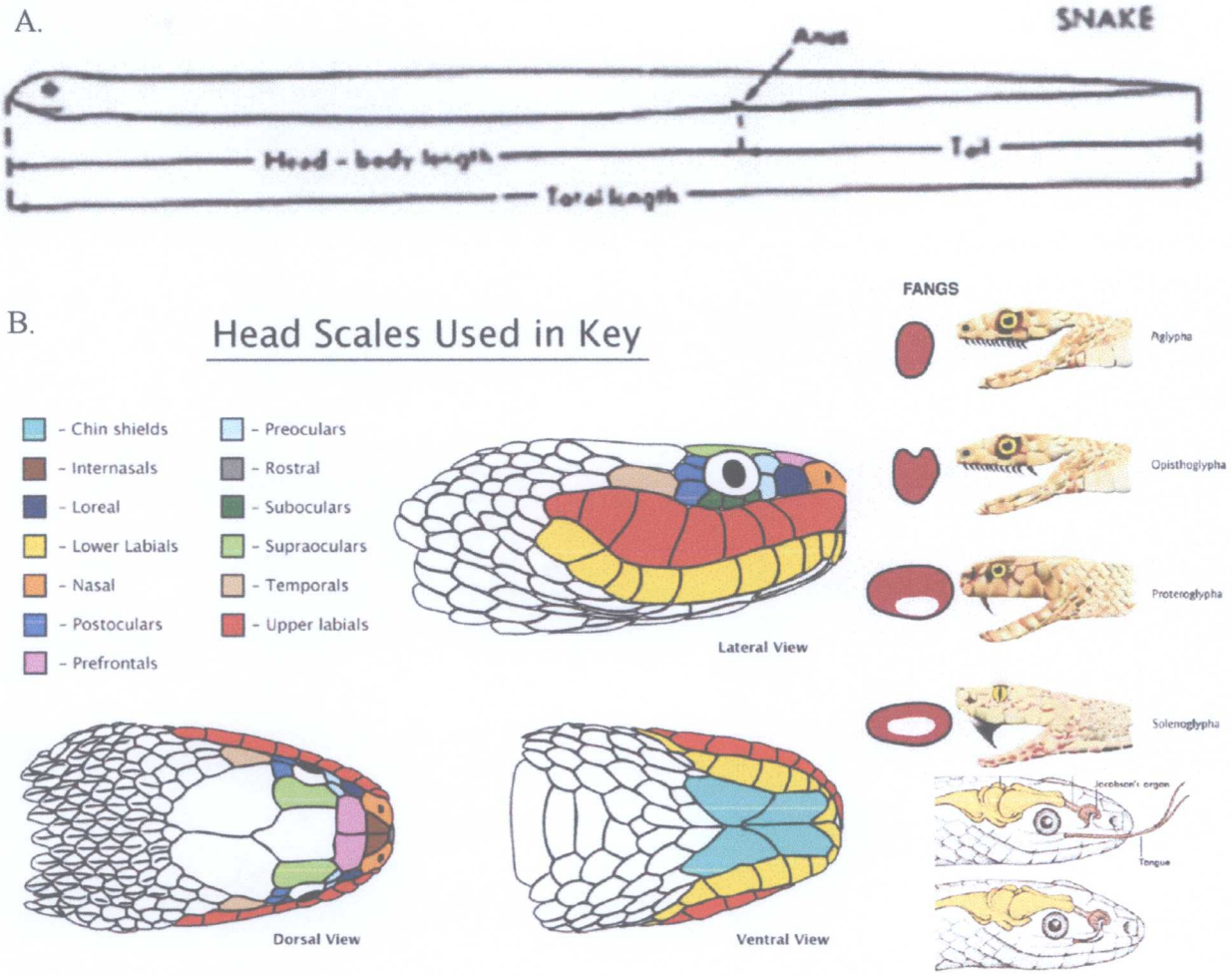


Figure 9. Guides for the morphological characteristics of snakes to be measured (A) and head scales and different kinds of fangs of snakes (B).

iii. Agamids/lizards (see Figure 10.)

1. Snout-vent length (SVL)
2. Head length (HL)
3. Total length (ToL)
4. Head width (HW)
5. Interorbital distance (IOB)
6. Head width (HW)
7. Interorbital distance (IOB)
8. Eye diameter (ED)
9. Snout length (SL)
10. Tail-vent length (TVL)

11. Forelimb length (FLL)
12. Hindlimb length (HLL)
13. Weight (Wt) in grams
14. The following details should be recorded in the remarks section
    a. Meristic characters
        i. 4th to lamellae/scales (4th TLS) to be counted
        ii. Mid-dorsal scales (MDS)
        iii. Midbody scale rows
        iv. Number of digits with claws
        v. Upper labials
        vi. Lower labials
        vii. Cranial/nuchial crests (if applicable)
        viii. Preanal pores
        ix. Femoral pores
        x. Scansors
        xi. Sabcaudals
    b. Qualitative characters
        i. Shape of digits
        ii. Shape of iris
        iii. Scale type (smooth or keeled)
        iv. Shape of head shields

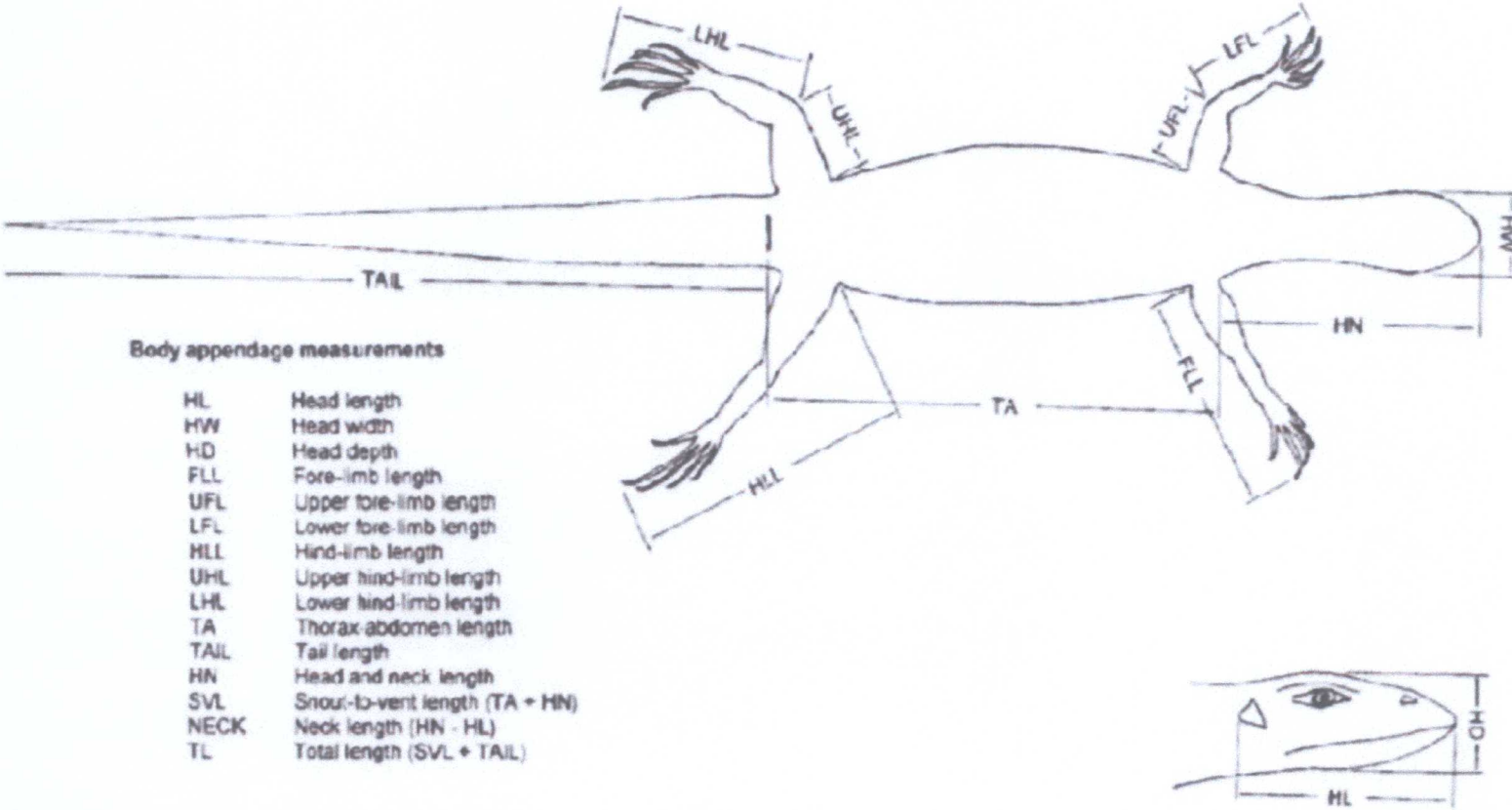


Figure 10. Morphological characteristics of agamids/lizards to be measured.

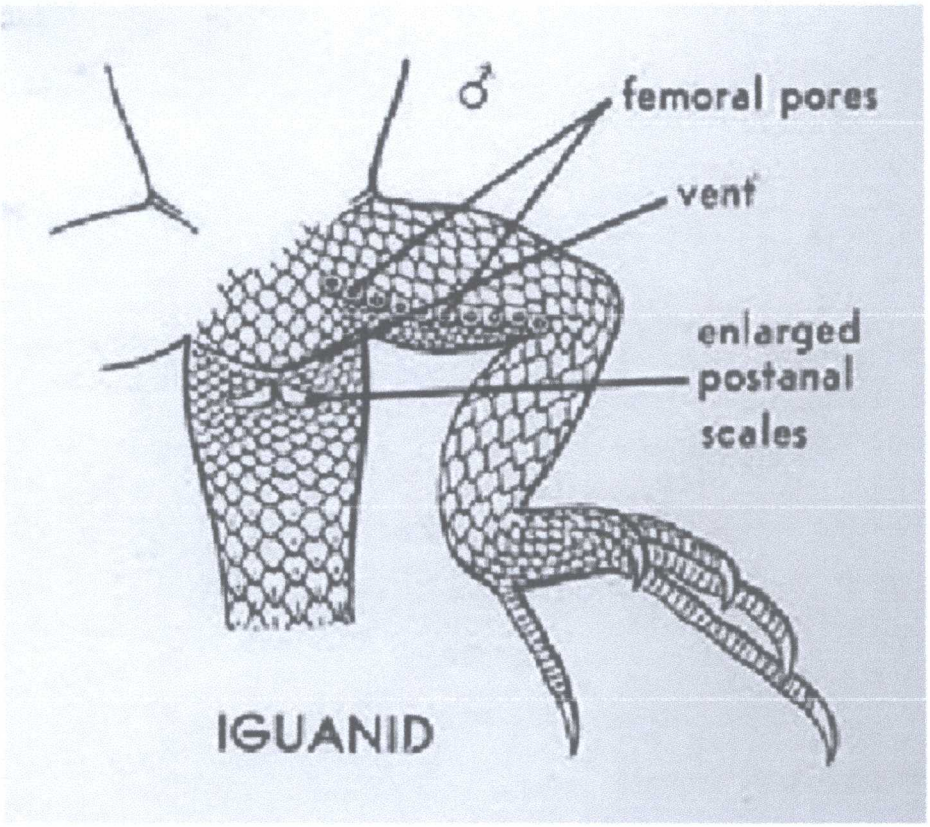


Figure 11. Meristic characters of geckoes to be noted in the remarks column in the data sheet.

iv. Geckoes (see Figure 10.)
    1. Snout-vent length (SVL)
    2. Head length (HL)
    3. Total length (ToL)
    4. Head width (HW)
    5. Interorbital distance (IOB)
    6. Head width (HW)
    7. Interorbital distance (IOB)
    8. Eye diameter (ED)
    9. Snout length (SL)
    10. Tail-vent length (TVL)
    11. Forelimb length (FLL)
    12. Hindlimb length (HLL)
    13. Weight (Wt) in grams
    14. The following details should be recorded in the remarks section
        a. Meristic characters (see Figure 11.)
            i. 4^{th} to lamellae/scales (4^{th} TLS) to be counted
            ii. Number of digits with claws

iii. Cranial/nuchial crests (if applicable)
iv. Preanal pores
v. Femoral pores
vi. Scansors

b. Qualitative characters
i. Shape of tongue
ii. Shape of iris
iii. Scale type (smooth or keeled)
iv. Shape of head shields

v. Skinks
1. Snout-vent length (SVL)
2. Head length (HL)
3. Total length (ToL)
4. Head width (HW)
5. Interorbital distance (IOB)
6. Head width (HW)
7. Interorbital distance (IOB)
8. Eye diameter (ED)
9. Snout length (SL)
10. Tail-vent length (TVL)
11. Forelimb length (FLL)
12. Hindlimb length (HLL)
13. Weight (Wt) in grams
14. The following details should be recorded in the remarks section
a. Meristic characters
i. 4^{th} to lamellae/scales
ii. Mid-dorsal scales
iii. Mid-body scale rows
iv. Number of digits with claws
v. Upper labials
vi. Lower labials
vii. Cranial/nuchal crests
b. Qualitative characters
i. Shape of tongue
ii. Shape of iris
iii. Scale type (smooth or keeled)
iv. Shape and position of external ear
v. Loreals
vi. Scale type

- Collected specimen should be released after species identification
- Form _ should be accomplished

Cage trapping (for non-volant mammals)

Sampling Design

Foraging pathways of non-volant mammals should be identified.

Equipment

1. Bait (unshelled seeds, mixture of rolled oats, peanut butter or bread)
2. 9"x3"x3.5" Hard wire cage trap/Elliot's cage (bigger size may be used depending on the sizes of mammals that may be present in the surroundings) (see Figure 12)
3. Pitfall bucket
4. Cloth bag (should be washed between each use; free of loose ends; should be checked regularly for weakening and rips)

A. B.

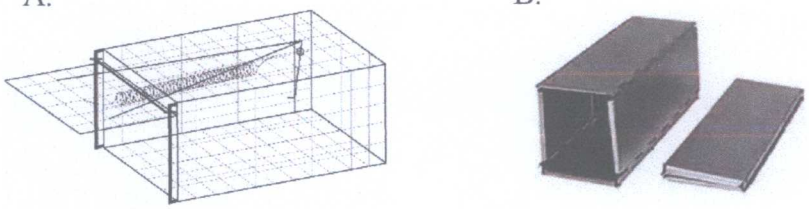


Figure 12. Two types of traps, hard wire cage trap (A) and Elliot's cage (B) than can be used in capturing non-volant mammals.

Procedure

1. Prepare the bait and place inside each cage trap.
2. Place at least two (2) traps in between stations; the number of cages may vary depending on the distance between the stations selected.
3. Baits should be placed inside the cage before planting on the identified sites
4. Traps should be checked twice a day, once in the morning and once in the afternoon, and must be collected after one (1) day. Check the traps from a blind-side of the animal.
    a. If a small mammal is caught,
        i. it should be transferred into a bucket, then
        ii. placed inside a cloth bag to reduce animal stress during transport.
    b. If a large mammal is caught,
        i. stand the trap with the opening facing upwards, then
        ii. reaching into the trap, grab the animal by its tail, then
        iii. transfer the animal straight into a cloth bag.
5. The following details should be recorded:

a. Species name
b. Age
c. Sex
d. Morphological measurements to be measured (see Figure 13.)
    i. Head body length (HBL)
    ii. Tail length (TL)
    iii. Ear length (EL)
    iv. Hindfoot length (HL)
    v. Weight (Wt.) in grams

Figure 13. Morphological characteristic of non-volant mammals to be measured.

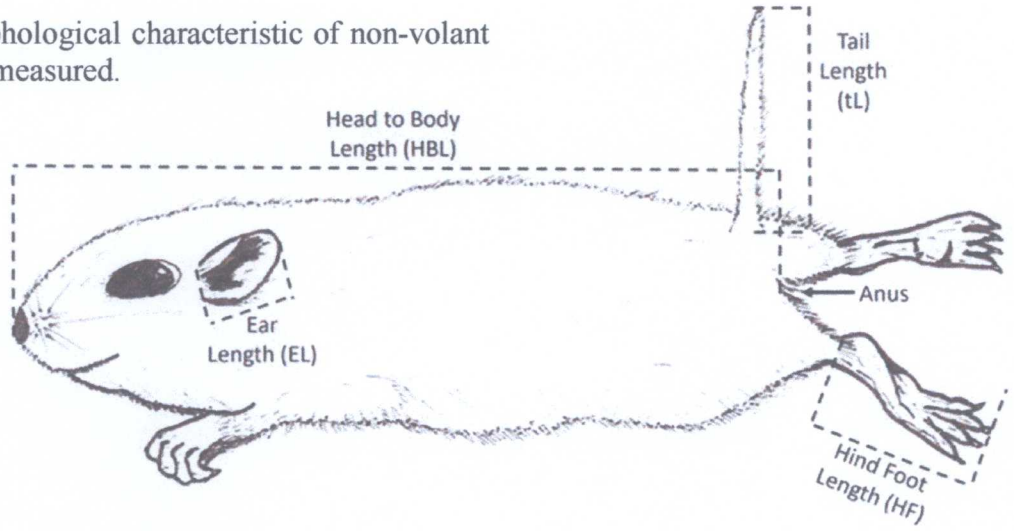


Illustration by DAP Fernandez (2017)

6. All specimens should undergo photographic documentation.
7. If a bat cannot be identified, a specimen photograph should be sent to experts. Preserved specimen may also be sent but as last resort.
8. After measurement and species identification, the collected specimen should be released.

Harp trap (for volant mammals – insect bats)

Sampling design

Sites for the set-up should be selected using the following criteria:

1. Corridor/watercourse/pathway where bats are likely to be foraging
2. Stations near the cave's entrance
3. Enough space for harp trap
4. Other modification may be used depending on the site (i.e. traps may be hung on a tree, adjustment on the size of harp traps, etc) (see Figure 14.)

Equipment

1. Harp trap (adjustable) (see Figure 14.)
2. Catch bags
3. Cloth bags
4. Pesola
5. Caliper
6. Ropes (if necessary)

A.

B.

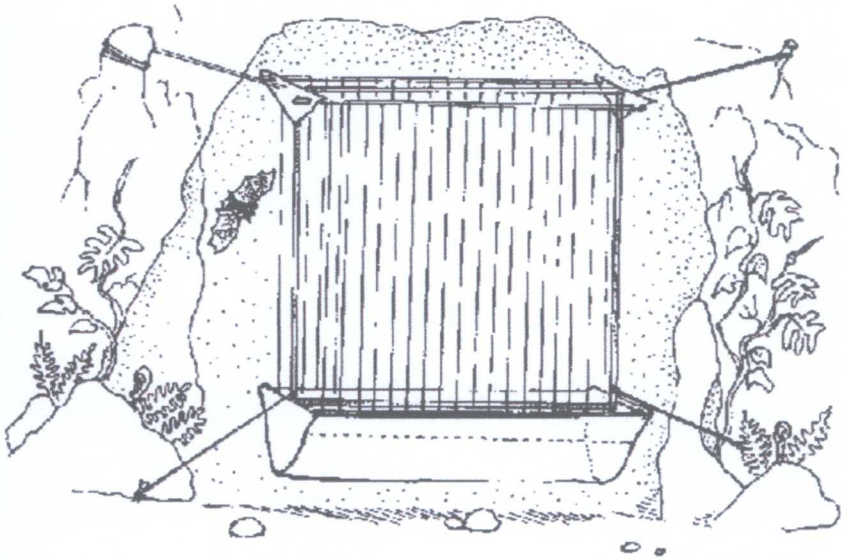


Figure 14. Standard set-up of harp trap (A) and a modified set-up (B) wherein the trap is ties to the rocks of the cave wall.

Procedure

1. Leave the trap open for at least three (3) hours preferably at 5:00 PM
2. Check the traps every 30 minutes (escaped bats, if seen, must be recorded) for the retrieval and processing of the captured bats.
3. The following details should be recorded
    - Species name
    - Age
    - Sex
    - Morphological measurements
        a. Head-to-body length (HBL)
        b. Tail length (TL)
        c. Ear length (EL)

d. Forearm length (FL)
e. Hindfoot length (HL)
f. Body weight (Wt) in grams

4. All specimen should undergo photographic documentation.
5. If a bat cannot be identified, a specimen photograph should be sent to experts. Preserved specimen may also be sent but as last resort.
6. After measurement and species identification, the collected specimen should be released.

Hand netting (for aquatic samples)

Sampling Design

Select cave waters which are generated within the cave by percolation rather than those which are fed directly from surface streams. Select areas within the cave where water infiltration is more frequent.

Equipment

1. Tray
2. Forceps
3. Thin glass pipettes with rubber
4. 70% Ethanol
5. Glycerine
6. Vials
7. Labelling materials

Procedure

1. Tumble stones to stir up the invertebrates, scrubbing any boulders, pebbles and the general substrate with the net position downwards while scrubbing
2. Larger debris should be removed and cleaned as much as possible, without losing the invertebrates
3. The sample should be transferred to a tray where it can be spread out for closer inspection.
    - Invertebrates that are obvious (larger in size) can be removed from the sample at this stage and place in alcohol.
    - For other species that can be difficult to pick out from the tray with forceps as they move too fast, a thin glass pipette with rubber can be used to suck up and drop the organisms into the

vial of alcohol. Lift them out with forceps into fresh alcohol, 70% ethanol with two drops of glycerine.

- For very small organisms, dissecting microscope will be needed. Sort by spreading small amount of sample in a petri dish and sift through it under the microscope, before transferring invertebrates into a vial containing 75-80% ethanol with two drops of glycerine (except gastropods and flatworms).
- Don't forget to label every vial.

Baited aquatic traps

Sampling design

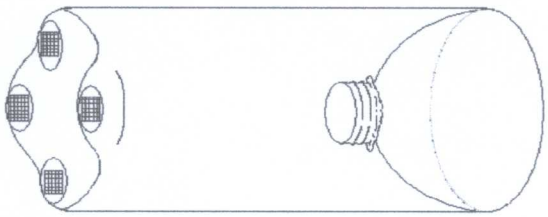
The sampling design for hand netting of aquatic samples should be used.

Equipment

1. Coke bottle
2. Mesh
3. Strings
4. Pins
5. 75-80% ethanol
6. Glycerine
7. Vials
8. Labelling materials

Procedure

1. Plastic coke bottles can be used as baited traps (Fig. 1). The mesh covered holes at the bottom of the bottle allow water to flow through the trap, while the inverted neck of the bottle forms a narrow funnel, allowing easy access for invertebrates to crawl into the trap.



3. To hold the trap in place, putting weight on the trap by placing a stone inside or by anchoring the trap with a string or wedging it with pins may be useful.
4. In choosing bait to be used in the trap, it should be the type that would hold together when left in water. The bait may also be placed in a mesh bag or stocking to avoid excessive contamination of sample.
5. Leaving traps for longer days may cause debris to block the mesh or the specimens to spoil. Leave the trap for five days to start with. If the catch is small, replacement of bait might be needed.
6. Invertebrates should be removed from the trap and transferred into a small container with 75-80% ethanol with two drops of glycerine (except gastropods and flatworms) before transporting out of the cave.
7. Don't forget to label every vial.

Photo documentation

In taking photographs of animals, the safety of the animals must not be at risk (i.e. reptiles, amphibians and arthropods must not be subjected to freezing in order for the animal to move slow). Proper animal handling must be observed and only experiences handlers are allowed to handle venomous snakes. Two-person approach, one handling the animal and the other, taking photographs, is recommended in order to reduce both handling and photography session time. Caught animals should be photographed at the release site so that the animal is not endangered in the event of the animal trying to escape. Sudden movement and loud noises must be minimized.

When using electronic flash or video lights, photography session must be quick as it may cause disturbance especially inside the cave. When photographing bats and birds in their roosting and nesting sites, respectively, the use of speed lights and tripod is recommended with the camera settings of at least 500 ISO and at least 1600 shutter speed.

Distinct characteristics of the animal should be the focus of the photographs for easier identification. Below are the distinguishable features for the different taxa.

Avifauna

- Bill
  - Shape
  -
- Body form
  - Neck
  - Legs
  - Use reference point for comparative size
- Feet
- Wing
  - Shape

- Tail
  - shape

Mammals

- Tails
  - Presence
  - Relationship to tail membrane
  - length
- Ears
  - Shape and size
  - Tragus or antitragus
- Noses
  - Simple or noseleaf
    - Shape of noseleaf
    - Lateral structures
- Nostrils
- Fur
  - Color/markings
  - Presence of hair on the forearms, tails, membrane and feet

Herpetofauna

Reptiles

- Color markings
- Scales
  - Abaxial
  - Adaxial
- Digits
  - Digital pods (for geckos)
- Iris

Amphibians

- Texture of skin
- Skin markings
- Digital and nuptial pods
- Foot webbing
-

Arthropods

- Head
- Thorax
- Abdomen
- Appendages
- Antennae
- Wing venation

Preservation

The use of voucher codes for the collected specimens that will be preserved is recommended. The codes must be recorded when and where the specimen was collected.

Mammals

Equipment/Materials

- ID tags (voucher tags)

Procedure

Birds

Equipment/Materials

- ID tags (voucher tags)

Procedure

Herpetofauna

Equipment/Materials

Procedure

Arthropods

Equipment/Materials

- ID tags (voucher tags)

Procedure

Data Analysis

Data collected will can be used to determine the taxa composition, abundance, species density, species dominance, species evenness and species diversity. Species accumulation curve shall be derived by using a line graph based on the cumulative number of species recorded against the number of sampling days to determine minimum effort. The density can be calculated by dividing the total number of individuals samples divided by area sampled (see Figure A). The species diversity can be computed by using the Shannon Diversity Index (**H'**) (see Figure B.), also known as Shannon-Weaver or Shannon-Wiener. The species dominance can be computed by using Simpson's Dominance Index (**D**) (see Figure C.). For the species evenness, Shannon's Equitability (E_H) will be followed (see Figure D.).

$$\text{Density} = \frac{Number\ of\ Individuals\ Samples}{Area\ Sampled}$$

Figure A. Species Density Formula

Shannon Diversity Index (**H'**) aka Shannon-Weaver or Shannon-Wiener

$$H' = -\Sigma\, pi\, ln(pi)$$

Figure B. Shannon Diversity Index formula

$$pi = \frac{n}{N}$$

n = total number of organisms of a particular species
N = the total number of organisms of all species
Relative Abundance (***pi***) – number of individuals per species against the total number of individuals of all species or number of individuals per km transect

Simpson's Dominance Index (**D**)

$$D = \Sigma\, pi^2$$

Figure C. Simpson's Dominance Index formula

$$pi = \frac{n}{N}$$

n = total number of organisms of a particular species
N = the total number of organisms of all species

Shannon's equitability (evenness) (E_H)

$$E_H = \frac{H'}{H_{max}} = \frac{H'}{lnS}$$

Figure D. Shannon's Equitability formula

Species Richness (**S**) – total number of species in a sampling site

Trapping/netting success by species or for all species can be determined by dividing the total number of species by total number of trap/net day, multiplied by 100 and dividing the total number of captures by total number of trap/net day, multiplied by 100.

Trapping/Netting Success per species

$$\frac{Total\ number\ of\ species}{Total\ number\ of\ trap\ or\ net\ day} \times 100$$

Trapping/Netting Success regardless of species

$$\frac{Total\ number\ of\ captures}{Total\ number\ of\ trap\ or\ net\ day} \times 100$$

IV. Biological Monitoring Process
V. Reporting