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Front cover: Andaman bent-toed gecko (*Cyrtodactylus rubidus*) from the Andaman Islands. Photographed by Ashwini V Mohan.

Editorial

I grew up in a household that produced a newsletter; the Newsletter for Birdwatchers, of which my father Zafar Futehally was Founder-Editor. This had a forty year history, from the early 1950s to the early '90s, and was cyclostyled for about half this time. The cyclostyling machine was large, cumbersome and messy, with indelible black ink settling on clothes, face, limbs and furniture. The process began with typing the text on a stencil, banging as hard as possible so the letters cut through the first, thin page of the stencil creating a filigree of hieroglyphics. This sheet was then torn off and placed on the "printing drum", which had been evenly covered with the special ink with a brush. When rotated round and round with a tired hand, it printed off the text, uneven at the best of times, on sheets of A4 size paper. There was then the drying, sorting and stapling, and (for the experts) adding little drawings with a stylo, a metal tipped pen-like instrument.

It was an adventure in which the whole family participated, except my lucky brother who was in boarding school. "The newsletter" was either being "printed" or stapled or addressed or posted, and when that was done, another batch of stencils were being typed for the next issue. My parents conveniently didn't learn how to type, so this was done by my sister and myself.

So when I moved to Madras, to the Snake Park, after marrying Rom Whitaker, there was a big vacuum in my life. I missed the newsletter, and decided the Snake Pak needed one. We initially called it Newsletter of the Madras Snake Park Trust and then decided to name it *Hamadryad*. It turned out to be a very useful publication because in those days, in the mid 1970s, there was no network or communication platform for India's herpetologists. They were few and far-flung, and some of them had been in touch with the Park about their work. There was a subscription, Rs 10, which was later raised, with much apology, to 12. We solicited, edited, "published", notes on taxonomy, species distribution and range extension, snakebite, behaviour, snake mythology, herp books and papers, conservation. Our first survey reports on Indian crocodilians, sea turtles, freshwater turtles and more, by stalwarts like Satish Bhaskar, Dhurvajyothi Basu and J. Vijaya, became well known and well used, thanks to *Hamadryad* . Its reach spread to other areas of the subcontinent, and subscribers and contributors included the Sri Lankan herpetologists Anslem de Silva and Ranil Senanayake, Tom Roberts in Pakistan, Mohamed Ali Reza Khan in Bangladesh, U Thin Win in Burma and many enthusiastic friends right here in India. Soon, the skinny little publication was being sent out on "Journal Exchanges", and we began receiving fat, glossy magazines and journals that our staff, field teams and local reptile enthusiasts waited to check out from the library and read.

By the early ‘90s, when its home base was the Crocodile Bank, Rom and I felt that the time was right to hand over *Hamadryad* to another team. We asked Indraneil Das, who had been volunteer, then intern, then researcher, and finally Scientific Officer of the Croc Bank, if he would take over the editorship, and he agreed. He pulled in an impressive team of advisors, such as Dr Aaron Bauer, who was later to become its Editor. And thanks to its many well wishers *Hamadryad* continues, now as a respected journal with peer-reviewed articles and notes, and is in its 40th year of publication. It is now online and continues to be quoted and reference-listed as an important, wide-ranging journal on Indian herpetology.

Flipping through those 50-year-old issues of *Hamadryad,* there are moments of gladness that we managed to keep it going for so long, and that it continues to hold its place in Indian herpetology. It’s also an example of how much can be done, with meager resources. Gratitude to the volunteers and staff who, way back there in the 1970s, stood at that messy cyclostyling machine, turning the iron handle to run off page after page of what was to become a landmark publication. You can access all the scanned issues of *Hamadryad* by writing to *director@madrascrocodilebank.org.*

Zai Whitaker

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Catalogue of Indian Herpetological Specimens in Thiruvananthapuram Natural History Museum, Kerala, India

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ABSTRACT. We catalogued entire, fluid-preserved, voucher specimens of native Indian amphibian and reptilian species in the Thiruvananthapuram Natural History Museum (TNHM), Kerala, India. We inventoried and found a total of 152 species, comprising of one caecilian, 96 anurans, 11 saurians, 44 serpents and three chelonians. There are a few recently deposited or described primary and secondary types of some rhacophorid frogs (*Ghatixalus, Mercurana, Raorchestes*) and gekkonid lizards (*Cnemaspis*), while most others are non-type specimens. The collections almost wholly come from Kerala, including both historical and recently deposited materials. A few materials are those procured by exchange, or purchased or collected from elsewhere in India (e.g. Pondicherry; Tamil Nadu). Most of the recent collections are anurans collected by two noted batrachologists Sujith V. Gopalan and Anil Zachariah and their parties. Most of the snake and a few lizard collections were century old historical material collected from Thiruvananthapuram by a pioneering naturalist H.S. Ferguson.

KEYWORDS. Ferguson, Gekkonidae, historical specimens, Rhacophoridae, Serpentes, type specimens

Introduction

Natural history museums in India have been pivotal institutions for biodiversity discovery and research. In the Indian scenario, studies on herpetofauna perhaps beat all other vertebrate group explorations in bringing out the most number of new systematic discoveries in this century (Dubois 1999; Das 2003). Yet, we have perhaps known more about Indian herpetological material in repositories outside India (Hubrecht 1882; Boulenger 1890; Bauer 1998; Gill and Froggatt 2014) than those housed in the country (Theobald 1876; Sclater 1891; Phipson 1888). Post independence, many works have engaged with and enriched such natural history collection repositories. The most important of the country's repositories — the Bombay Natural History Society, Mumbai and the Zoological Survey of India, Kolkata have had their herpetological type collections catalogued (Das and Chaturvedi 1998; Das et al. 1998; Chanda et al. 2000; Das and Gayen 2004). Later, studies focussing on smaller, regional museums and their overall herpetological holdings, including non-types, were conducted. Such stock-takings were performed at the Govt. Museum Chennai (Ganesh and Asokan 2010), the Salim Ali Centre for Ornithology & Natural History (Ganesh et al. 2020; Chandramouli et al. 2021), St. Joseph's College Kozhikode (Zacharias and Bose 2020), Kerala Agricultural University Natural History Museum (Nameer et al. 2021) and the Chennai Snake Park Museum (Ganesh 2021).

One such historical, regional museum in the country is the Thiruvananthapuram Natural History Museum in Kerala (TNHM). It was started during 1852–55 by the joint efforts of many people, notably J. Allen Brown, ex. Director of Thiruvananthapuram Observatory, Gen. Cullen, a British Resident and the Travancore King Utharam Thirunal. The museum was thrown open to the public in 1857, as was a zoo annexed to it in 1859. Soon, other members such as Col. Heber Drury, Col. Ketchen, Sir William Flower, and the Scottish zoologist H.S. Ferguson, joined and contributed greatly to its honing. By 1880, a new building designed by Robert Chisholm, architect to the Governor of Madras, was constructed and the museum was shifted there, where it lies now (Anon. 1899). Recently, scientists who studied new species of amphibians and reptiles have deposited their new taxa's primary and secondary type specimens in TNHM (also see Sabaj 2020). These include studies on new bush frogs of the genus *Raorchestes* (Abraham et al. 2014), tree frogs of the genera *Mercurana, Ghatixalus* (Abraham et al. 2013; Zachariah et al. 2016), night frogs of the genus *Nyctibatrachus* (Abraham et al. 2022) and day geckoes of the genus *Cnemaspis* (Cyriac et al. 2014), making it a notable museum. Against this backdrop, we furnish the catalogue of herpetological holdings of the Thiruvananthapuram Natural History Museum.

Material and Methods

We here enlisted all fluid-preserved (both spirit and formalin), entire, herpetological voucher specimens representing native Indian species. We meticulously gleaned and furnished all hand-written jar label information alongside each specimen, to the best extent possible. Each entry gave the following basic information: species name, specimen registration number, number of specimens accessioned under that number in the jar, locality from where it was collected (wherever known or deducible), collector name(s), and any other important scientific remarks of interest.

Taxonomic identities of the non-type specimens were re-checked with their collectors and their claimed identities in case of recent ones, and as mentioned in jar labels in case of historical ones. We independently re-checked the same while consulting standard reference books (Daniel 2002; Das 2002; Whitaker & Captain 2004; Daniels 2005; Gururaja 2012; Ganesh 2015), updated with latest compilations on amphibians (Dinesh et al. 2024) and reptiles (Mohapatra et al. 2024).

The type specimens' identities were ascertained by tallying with the respective original description papers (Abraham et al. 2013, 2014; Cyriac et al. 2014; Zachariah et al. 2016). Most of the newly collected material, including the display collection and the reserve collection had jar label names in conformity with what is now in vogue and are hence not repeated here, except where sufficiently different. Names of those historical specimens that had jar labels furnishing currently-obsolete names were given here.

After comparing what was written in their jar labels, we updated the species names of amphibians following Frost (2024), and reptiles following Uetz et al. (2024), though not necessarily following their taxonomies. Museum acronym TNHM followed Sabaj (2020); collection code H – denotes herpetofauna. In some cases, for denoting multiple specimens accessioned together under a number, alphabets were used to discern individual specimens in that lot. Collector abbreviations: AZ: Anil Zachariah, HSF: Harold Stuart Ferguson (1851–1921), SVG: Sujith V. Gopalan, VPC: Vivek Phillip Cyriac, UKP: Umesh K Pavukandy.

Species Catalogue

Amphibia
Anura

Bufonidae

1. *Blairia ornata* (Günther, 1876)
   Material:
   - TNHM(H) 12.6.18.128 Coll. AZ

2. *Duttaphrynus beddomii* (Günther, 1876)
   Material:
   - TNHM(H) 12.6.18.125 Coll. AZ

3. *Duttaphrynus melanostictus* (Schneider, 1799)
   Material:
   - TNHM(H) 12.6.18.123 Coll. AZ

4. *Duttaphrynus parietalis* (Boulenger, 1882)
   Material:
   - TNHM(H) 12.6.18.124 Coll. AZ

5. *Duttaphrynus scaber* (Schneider, 1799)
   Material:
   - TNHM(H) 13.7.06/87 Coll. AZ

6. *Pedostibes tuberculosus* (Günther, 1876)
   Material:
   - TNHM(H) 13.7.06/95,
   - TNHM(H)12.6.18.117 Coll. AZ

Dicroglossidae

7. *Phrynoderma hexadactylum* (Lesson, 1834)
   Material:
   - TNHM(H) 5949.125 Pondicherry, Tamil Nadu, Coll. SVG;
   - TNHM(H) 5951.149 Pondicherry, Tamil Nadu, Coll. SVG

8. *Phrynoderma karaavali* (Priti, Naik, Seshadri, Singal, Vidisha, Ravikanth, and Gururaja, 2016)
   Material:
   - TNHM(H) 5910.151;
   - TNHM(H) 5919;
   - TNHM(H) 5921.150;
   - TNHM(H) 5910.151;
   - TNHM(H) 5950.123,
   - TNHM(H) 5951.149;
   - TNHM(H) 6215.154;
   - TNHM(H) 6216.156;
   - TNHM(H) 6217.153;
   - TNHM(H) 6218.157;
   - TNHM(H) 5922.160;
   - TNHM(H) 5795.127 Nenmara, Palakkad, Coll. SVG

9. *Hoplobatrachus tigerinus* (Daudin, 1802)
   Material:
   - TNHM(H) 118 Thiruvananthapuram, Coll. HSF;
   - TNHM(H) 5226.155 Kannur, Coll. SVG;
   - TNHM(H) 5794.152 Jagathy, Thiruvananthapuram, Coll. SVG;
   - TNHM(H) 5795 Nenmara, Palakkad, Coll. SVG

10. *Minervarya agricola* (Jerdon, 1853)
    Material:
    - TNHM(H) 5717.112 Punchakari, Thiruvananthapuram, Coll. SVG;
    - TNHM(H) 5726.145 Punchakari, Thiruvananthapuram, Coll. SVG

11. *Minervarya nilagirica* (Jerdon, 1853)
    Material:
    - TNHM(H) 5755.141,
    - TNHM(H) 5755.101,
    - TNHM(H) 5775.161 Devikulam, Harrison Estate, Munnar, Coll. SVG;
    - TNHM(H)12.6.18.111 Coll. AZ

12. *Minervarya sahyadris* Dubois, Ohler & Biju, 2001
    Material:
    - TNHM(H)12.6.18.110 Coll. AZ

Micrixalidae

13. *Micrixalus adonis* Biju, Garg, Gururaja, Shouche and Walujkar, 2014
    Material:
    - TNHM(H) 5790.144 Gavi, Pathanamthitta, Coll. SVG;
    - TNHM(H) 5791.121 Munnar, Idukki, Coll. SVG

14. *Micrixalus frigidus* Biju, Garg, Gururaja, Shouche and Walujkar, 2014
    Material:
    - TNHM(H) MIC105.108 Eravikulam, Munnar, Coll. SVG

15. *Micrixalus fuscus* (Boulenger, 1882)
    Material:
    - TNHM(H) 13.7.06/93 Coll. AZ

16. *Micrixalus saxicola* (Jerdon, 1853)
    Material:
    - TNHM(H) MC 101.165 Kakadampoyil, Coll. SVG;
    - TNHM(H) MC 102.116 Kakadampoyil, Coll. SVG

Microhylidae

17. *Melanobatrachus indicus* Beddome, 1878
    Material:

- TNHM(H) 12.6.18.114 Coll. AZ

18. *Microhyla rubra* (Jerdon, 1853)
Material:
- TNHM(H) 13.7.06/97 a, b;
- TNHM(H)12.6.18.116 Coll. AZ

19. *Mysticellus franki* Garg & Biju, 2019
Material:
- TNHM(H) 13.7.06/91 Pulpally, Coll. AZ, labeled as *Micryletta aishani*

20. *Uperodon systoma* (Schneider, 1799)
Material:
- TNHM(H)12.6.18.109 Coll. AZ

21. *Uperodon taprobanicus* (Parker,1934)
Material:
- TNHM(H) 13.7.06/92 Coll. AZ;
- TNHM(H) 5667.107 Pookode, Wayanad, Coll. SVG;
- TNHM(H) 105 Kozhikode, Coll. SVG

22. *Uperodon triangularis* (Günther, 1876)
Material:
- TNHM(H) 5677.110 Sulthan Bathery, Wayanad Coll. SVG;
- TNHM(H) UD105.163, 105.139 Pookode, Wayanad, Coll. SVG

23. *Uperodon variegatus* (Stoliczka, 1872)
Material:
- TNHM(H) 13.7.06/86 Palakkad, Coll. AZ

Nasikabatrachidae

24. *Nasikabatrachus sahyadrensis* Biju & Bossuyt, 2003
Material:
- TNHM(H) 12 Kollam;
- TNHM(H)12.6.18.115 Coll. AZ

Nyctibatrachidae

25. *Nyctibatrachus aliciae* Inger, Shaffer, Koshy, and Bakde, 1984
Material:
- TNHM(H) 5582.142 Shendurney, Kollam, Coll. SVG;
- TNHM(H)12.6.18.118 Coll. AZ;
- TNHM(H) NY3, TNHM(H) NY5 Ponmudi, Thiruvananthapuram Coll. RKA

26. *Nyctibatrachus major* (Boulenger, 1882)
Material:
- TNHM(H) NY103.140, Coll. SVG;
- TNHM(H) NY104.158 Shendurney Coll. SVG;
- TNHM(H) 12.6.18.121 Coll. AZ;
- TNHM(H) 5686.147 Coll. SVG;
- TNHM(H) NY104 Shendurney Coll. SVG

27. *Nyctibatrachus periyar* Biju, Van Bocxlaer, Mahony, Dinesh, Radhakrishnan, Zachariah, Giri and Bossuyt, 2011
Material:
- TNHM(H) 5788 Gavi, Pathanamthitta, Coll. SVG;
- TNHM(H) NY6 Uppukunnu, Idukki Coll. RKA

28. *Nyctibatrachus poocha* Biju, Van Bocxlaer, Mahony, Dinesh, Radhakrishnan, Zachariah, Giri and Bossuyt, 2011
Material:
- TNHM(H) 5811.124 Devikulam, Idukki, Coll. SVG

29. *Nyctibatrachus vasanthi* Ravichandran, 1997
Material:
- TNHM(H)12.6.18.120 Coll. AZ

30. *Nyctibatrachus vrijeuni* Biju, Van Bocxlaer, Mahony, Dinesh, Radhakrishnan, Zachariah, Giri and Bossuyt, 2011
Material:
- TNHM(H) 5120.146 Aaralam Coll. SVG;
- TNHM(H)12.6.18.119 Coll. AZ

Ranidae

31. *Hylarana aurantiaca* (Boulenger, 1904)
Material:
- TNHM(H) 5716.115 Punchakari, Thiruvananthapuram, Coll. SVG

32. *Hylarana magna* Biju, Garg, Mahony, Wijayathilaka, Senevirathne, and Meegaskumbura, 2014
    Material:
    - TNHM(H) 5793.126 Kochupamba, Kottayam, Coll. SVG

33. *Hylarana sreeni* Biju, Garg, Mahony, Wijayathilaka, Senevirathne, and Meegaskumbura, 2014
    Material:
    - TNHM(H) INS 102 Coll. SVG

Ranixalidae

34. *Indirana brachytarsus* (Günther, 1876)
    Material:
    - TNHM(H) 1718.162 Kallandichal, Vallakadavu, Periyar, Coll. SVG;
    - TNHM(H) IND 974.111 Ponmudi, Thriuvananthapuram, Coll. SVG

35. *Indirana paramakri* Garg & Biju, 2016
    Material:
    - TNHM(H) IN108.113 Anakampoyil, Kozhikode, Coll. SVG

36. *Indirana yadera* Dahanukar, Modak, Krutha, Nameer, Padhye, and Molur, 2016
    Material:
    - TNHM(H) IND1721.128 Kochupamba, Idukki, Coll. SVG

Rhacophoridae

37. *Beddomixalus bijui* (Zachariah, Dinesh, Radhakrishnan, Kunhikrishnan, Palot, and Vishnudas, 2011)
    Material:
    - TNHM(H) 12.6.18/57 Kadalar, Idukki, Coll. AZ

38. *Ghatixalus asterops* Biju, Roelants, and Bossuyt, 2008
    Material:
    - TNHM(H) 12.6.18/68 Coll. AZ;
    - TNHM(H) 13.7.06/96 Coll. AZ

39. *Ghatixalus magnus* Abraham, Mathew, Cyriac, Zachariah, Raju, and Zachariah, 2015
    Material:
    - TNHM(H) 15.5.20/80 (Holotype) Kadalar, Idukki, Coll. AZ;
    - TNHM(H) 14.8.01/81 (Paratype) Kadalar, Idukki, Coll. RA

40. *Ghatixalus variabilis* (Jerdon, 1853)
    Material:
    - TNHM(H) 12.6.18/67a,b Coll. AZ

41. *Mercurana myristicapalustris* Abraham, Pyron, Ansil, Zachariah, and Zachariah, 2013
    Material:
    - TNHM(H) 12.6.18/69 (Holotype) Arippa, Kulathupuzha, Coll. AZ;
    - TNHM(H) 12.6.18/70, 74 Arippa, Kulathupuzha, Coll. AZ;
    - TNHM(H) RA115.109 Vazhachal, Thrissur, Coll. SVG

42. *Polypedates maculatus* (Gray, 1830)
    Material:
    - TNHM(H) 5711.104 Edakkad, Kozhikode, Coll. SVG;
    - TNHM(H) 6222.143 Pullode, Palakkad Coll. SVG;
    - TNHM(H) 12.6.18/60 Coll. AZ

43. *Polypedates pseudocruciger* Das & Ravichandran, 1998
    Material:
    - TNHM(H) 5693.138 Kallarkutty, Idukki, Coll. SVG;
    - TNHM(H) 5694.136 Kallarkutty, Idukki, Coll. SVG;
    - TNHM(H) 12.6.18/58/59 Coll. AZ;
    - TNHM(H)12.6.18.112 Coll. AZ

44. *Pseudophilautus amboli* (Biju and Bossuyt, 2009)
    Material:
    - TNHM(H) 12.6.18/03 Coll. AZ

45. *Pseudophilautus kani* (Biju and Bossuyt, 2009)
    Material:
    - TNHM(H) 12.6.18/01 Coll. AZ;
    - TNHM(H) RA123.117 Ponmudi, Thiruvananthapuram, Coll. SVG;

- TNHM(H) RA124 Ponmudi, Thiruvananthapuram, Coll. SVG;
- TNHM(H) 12.6.18/02 Coll. AZ;
- TNHM(H)12.6.18.113 Coll. AZ

46. *Pseudophilautus wynaadensis* (Jerdon, 1853)

Material:
- TNHM(H) 13.7.06/88 Kalyetta, Coll. AZ;
- TNHM(H) RA109.126 Pookode, Wayanad, Coll. SVG;
- TNHM(H) RA110.127 Pookode, Wayanad, Coll. SVG;
- TNHM(H) RA111.128 Pookode, Wayanad, Coll. SVG;
- TNHM(H) RA112.129 Pookode, Wayanad, Coll. SVG;
- TNHM(H) PA 120 Coll. SVG;
- TNHM(H) RA116.131 Kozhimala, Idukki, Coll. SVG;
- TNHM(H) RA117.119 Kozhimala, Idukki, Coll. SVG;
- TNHM(H) RA118.132 Kozhimala, Idukki, Coll. SVG;
- TNHM(H) RA121.133 Kozhimala, Idukki, Coll. SVG

47. *Raochestes anili* (Biju and Bossuyt, 2009)

Material:
- TNHM(H) PHY 227.164 Kozhimala, Coll. SVG;
- TNHM(H) 12.6.18/04/05 Coll. AZ;
- TNHM(H) 12.6.18/24 Coll. AZ;
- TNHM(H) RA113.130 Pookode, Wayanad, Coll. SVG;
- TNHM(H)12.6.18.107 Coll. AZ

48. *Raorchestes agasthyaensis* Zachariah, Dinesh, Kunhikrishnan, Das, Raju, Radhakrishnan, Palot, and Kalesh, 2011

Material:
- TNHM(H) 12.6.18/11 Coll. AZ

49. *Raorchestes akroparallagi* (Biju and Bossuyt, 2009)

Material:
- TNHM(H) 12.6.18/13 Coll. AZ

50. *Raorchestes archeos* Vijayakumar, Dinesh, Prabhu and Shanker, 2014

Material:
- TNHM(H) 12.6.18/36 Coll. AZ

51. *Raorchestes beddomii* (Günther, 1876)

Material:
- TNHM(H) 13.7.06/94 a, b Munnar, Coll. AZ;
- TNHM(H) RA108.125 Munnar, Idukki, Coll. SVG;
- TNHM(H) 12.6.18/22 Coll. AZ;
- TNHM(H) RA252.120 Pandipath, Thiruvananthapuram, Coll. SVG

52. *Raorchestes bobingeri* (Biju and Bossuyt, 2009)

Material:
- TNHM(H) 12.6.18/14 Coll. AZ

53. *Raorchestes bombayensis* (Annandale, 1919)

Material:
- TNHM(H) 12.6.18/42 Coll. AZ

54. *Raorchestes chalazodes* (Günther, 1876)

Material:
- TNHM(H) 12.6.18/09 Coll. AZ

55. *Raorchestes charius* (Rao, 1937)

Material:
- TNHM(H) 12.6.18/37/38 Coll. AZ;
- TNHM(H) 13.7.06/85 Chembra Coll. AZ;
- TNHM(H)12.6.18.106 Coll. AZ

56. *Raorchestes chlorosomma* (Biju and Bossuyt, 2009)

Material:
- TNHM(H) 12.6.18/27 Coll. AZ;
- TNHM(H)12.6.18.103 Coll. AZ

57. *Raorchestes chotta* (Biju and Bossuyt, 2009)

Material:
- TNHM(H) 12.6.18/30 Coll. AZ

58. *Raorchestes chromasynchysi* (Biju and Bossuyt, 2009)

Material:

- TNHM(H) 12.6.18/34/35 Coll. AZ;
- TNHM(H)12.6.18.127 Coll. AZ

59. *Raorchestes coonoorensis* (Biju and Bossuyt, 2009)
Material:
- TNHM(H) 12.6.18/40 Coll. AZ

60. *Raorchestes crustai* Zachariah, Dinesh, Kunhikrishnan, Das, Raju, Radhakrishnan, Palot and Kalesh, 2011
Material:
- TNHM(H) 12.6.18/21 Coll. AZ;
- TNHM(H)12.6.18.101 Coll. AZ

61. *Raorchestes drutaahu* Garg, Suyesh, Das, Bee and Biju, 2021
Material:
- TNHM(H) PHY 243.122 Periyar, Pacchakanam, Coll. SVG

62. *Raorchestes dubois* (Biju and Bossuyt, 2006)
Material:
- TNHM(H) 12.6.18/23 Coll. AZ;
- TNHM(H) 5668.105 Devikulam, Idukki, Coll. SVG;
- TNHM(H)12.6.18.104 Coll. AZ

63. *Raorchestes flavioculari*s Vijayakumar, Dinesh, Prabhu and Shanker, 2014
Material:
- TNHM(H) 12.6.18/44, 45 Coll. AZ

64. *Raorchestes flaviventris* (Boulenger, 1882)
Material:
- TNHM(H) 12.6.18/47a,b Kadalar, Idukki, Coll. AZ

65. *Raorchestes glandulosus* (Jerdon, 1853)
Material:
- TNHM(H) 12.6.18/16 Coll. AZ

66. *Raorchestes graminirupes* (Biju and Bossuyt, 2005)
Material:
- TNHM(H) 12.6.18/17/18 Coll. AZ

67. *Raorchestes griet* (Bossuyt, 2002)
Material:
- TNHM(H) 12.6.18/39 Coll. AZ

68. *Raorchestes jayarami* (Biju and Bossuyt, 2009)
Material:
- TNHM(H) 12.6.18/15 Coll. AZ;
- TNHM(H)12.6.18.108 Coll. AZ

69. *Raorchestes johnceei* Zachariah, Dinesh, Kunhikrishnan, Das, Raju, Radhakrishnan, Palot and Kalesh, 2011
Material:
- TNHM(H) 12.6.18/50 Coll. AZ

70. *Raorchestes kadalarensis* Zachariah, Dinesh, Kunhikrishnan, Das, Raju, Radhakrishnan, Palot and Kalesh, 2011
Material:
- TNHM(H) 12.6.18/12 Coll. AZ

71. *Raorchestes kaikatti* (Biju and Bossuyt, 2009)
Material:
- TNHM(H) 12.6.18/07 Coll. AZ

72. *Raorchestes kakachi* Seshadri, Gururaja and Aravind, 2012
Material:
- TNHM(H) 12.6.18/08 Coll. AZ;
- TNHM(H)12.6.18.105 Coll. AZ

73. *Raorchestes lechia* Zachariah, Cyriac, Chandramohan, Ansil, Mathew, Raju and Abraham, 2016
Material:
- TNHM(H) 12.6.18/55 (Holotype) Sispara, Silent Valley, Coll. AZ;
- TNHM(H) 12.6.18/56 (Paratype) Sispara, Silent Valley, Coll. AZ

74. *Raorchestes luteolus* (Kuramoto and Joshy, 2003)
Material:
- TNHM(H) 12.6.18/29 Coll. AZ

75. *Raorchestes manohari* Zachariah, Dinesh, Kunhikrishnan, Das, Raju, Radhakrishnan, Palot and Kalesh, 2011
Material:
- TNHM(H) 12.6.18/48 Coll. AZ

76. *Raorchestes marki* (Biju and Bossuyt, 2009)
Material:
- TNHM(H) RA122.102 Kozhimala, Idukki, Coll. SVG

77. *Raorchestes munnarensis* (Biju and Bossuyt, 2009)
Material:
- TNHM(H) 12.6.18/25 Coll. AZ

78. *Raorchestes nerostagana* (Biju and Bossuyt, 2005)
Material:
- TNHM(H) 12.6.18/19/20 Coll. AZ

79. *Raorchestes ochlandrae* (Gururaja, Dinesh, Palot, Radhakrishnan, and Ramachandra, 2007)
Material:
- TNHM(H) RA101.123 Ponmudi, Thiruvananthapuram, Coll. SVG;
- TNHM(H) RA102.124 Pookode, Wayanad, Coll. SVG;
- TNHM(H) RA103.118 Pookode, Wayanad, Coll. SVG;
- TNHM(H) RA241.135 Vazhachal, Thrissur, Coll. SVG;
- TNHM(H) 12.6.18/10 Coll. AZ

80. *Raorchestes ponmudi* (Biju and Bossuyt, 2005)
Material:
- TNHM(H) RA104.114 Nedumkandam, Idukki, Coll. SVG

81. *Raorchestes ravii* Zachariah, Dinesh, Kunhikrishnan, Das, Raju, Radhakrishnan, Palot and Kalesh, 2011
Material:
- TNHM(H) 12.6.18/41 Coll. AZ

82. *Raorchestes resplendens* Biju, Shouche, Dubois, Dutta and Bossuyt, 2010
Material:
- TNHM(H) 12.6.18/26 Coll. AZ

83. *Raorchestes signatus* (Boulenger, 1882)
Material:
- TNHM(H) 12.6.18/31 Coll. AZ;
- TNHM(H) 13.7.06/89 Coll. AZ

84. *Raorchestes silentvalley* Zachariah, Cyriac, Chandramohan, Ansil, Mathew, Raju and Abraham, 2016
Material:
- TNHM(H) 12.6.18/54 (Paratype) Sispara, Silent Valley, Coll. AZ;
- TNHM(H) 12.6.18/53 (Holotype) Sispara, Silent Valley, Coll. AZ

85. *Raorchestes sushili* (Biju and Bossuyt, 2009)
Material:
- TNHM(H) 12.6.18/06 Coll. AZ

86. *Raorchestes tinniens* (Jerdon, 1853)
Material:
- TNHM(H) 12.6.18/32/33 Coll. AZ;
- TNHM(H)12.6.18.102 Coll. AZ

87. *Raorchestes travancoricus* (Boulenger, 1891)
Material:
- TNHM(H) 12.6.18/28 Coll. AZ

88. *Raorchestes tuberohumerus* (Kuramoto and Joshy, 2003)
Material:
- TNHM(H) 12.6.18/43 Coll. AZ

89. *Raorchestes uthamani* Zachariah, Dinesh, Kunhikrishnan, Das, Raju, Radhakrishnan, Palot and Kalesh, 2011
Material:
- TNHM(H) 12.6.18/49 Coll. AZ

90. *Tamixalus calcadensis* (Ahl, 1927)
Material:
- TNHM(H) 13.7.06/90 Coll. AZ;
- TNHM(H) 12.6.18/66 Coll. AZ

91. *Rhacophorus lateralis* Boulenger, 1883
Material:
- TNHM(H) 5674.137 Pookode, Wayanad, Coll. SVG;
- TNHM(H) 5675.106 Pookode, Wayanad, Coll. SVG;
- TNHM(H) 12.6.18/64/65 Coll. AZ

92. *Rhacophorus malabaricus* Jerdon, 1870
Material:

- TNHM(H) 119, Kallar, Coll. HSF; 12.6.18/61 Coll. AZ

93. *Rhacophorus pseudomalabaricus* Vasudevan and Dutta, 2000
Material:
- TNHM(H) 12.6.18/63 Coll. AZ

Gymnophiona

Ichthyophiidae

94. *Uraeotyphlus bombayensis* (Taylor, 1960)
Material:
- TNHM(H) 101, Thiruvananthapuram, Coll. unknown

Reptilia
Squamata

Gekkonidae

95. *Cnemaspis kottiyoorensis* Cyriac and Umesh, 2014
Material:
- TNHM(H) 13.7.06/80 (Holotype) Perumalmudi, Kottiyoor, Coll. VPC;
- TNHM(H) 13.7.06/81 (Paratype) Perumalmudi, Kottiyoor, Coll. VPC;
- TNHM(H) 13.7.06/82 (Paratype) Chandanathodu, Periya, Coll. VPC, UPK;
- TNHM(H) 13.7.06/83 (Paratype) Makkimala, Wayanad, Coll. VPC

96. *Cnemaspis wynadensis* (Beddome, 1870)
Material:
- TNHM(H) 13.7.06/84 Sugandhagiri, Wayanad, Coll. VPC

Agamidae

97. *Calotes calotes* (Linnaeus, 1758)
Material:
- TNHM(H) 115, Thiruvananthapuram, Coll. HSF in Sept. 1888, labeled "*Calotes ophiomachus*"

98. *Calotes grandisquamis* Günther, 1875
Material:
- TNHM(H) 114, Ponmudi, Thiruvananthapuram, Coll. HSF in Jan. 1891

99. *Calotes nemoricola* Jerdon, 1853
Material:
- TNHM(H) 112, Kallar, Thiruvananthapuram, Coll. HSF in Sept. 1891

100. *Calotes versicolor* (Daudin, 1803)
Material:
- TNHM(H) 113 (2 ex.), Thiruvananthapuram, Coll. HSF

101. *Salea anamallayana* (Beddome, 1878)
Material:
- TNHM(H) 107 (2 ex.) High Range, Coll. HW Turner in May 1891

102. *Psammophilus* cf. *dorsalis* (Gray, 1831)
Material:
- TNHM(H) 111 (2 ex.) Kallar, Coll. HSF

Chamaeleonidae

103. *Chamaeleo zeylanicus* Laurenti, 1768
Material:
- TNHM(H) 108, 109, Thiruvananthapuram, Coll. HSF in Sept. 1891, 8/1/1956 in zoo,

Scincidae

104. *Sphenomorphus dussumieri* (Duméril and Bibron, 1839)
Material:
- TNHM(H) 110 (2 ex.) Thiruvananthapuram, Coll. HSF, labeled "*Lygosoma dussumieri*"

Varanidae

105. *Varanus bengalensis* (Daudin, 1802)
Material:
- TNHM(H) 116, 117, Thiruvananthapuram, Coll. HSF; from Samagooling Coll. Capt. Butler

Typhlopidae

106. *Indotyphlops braminus* (Daudin, 1803)
Material:

- TNHM(H) 157, Thiruvananthapuram, Coll. HSF, labeled "*Typhlops braminus*"

107. Grypotyphlops acutus (Duméril and Bibron, 1844)
Material:
- TNHM(H) 168, Thiruvananthapuram, Coll. HSF, labeled "*Typhlops acutus*"

Uropeltidae

108. Uropeltis cf. *brevis* (Günther, 1862)
Material:
- TNHM(H) 155, Ponmudi, Coll. HSF, labeled "*Silybura brevis*"

109. Uropeltis myhendrae (Beddome, 1886)
Material:
- TNHM(H) 159, Kallar, Coll. HSF, labeled "*Silybura myhendrae*"

110. Uropeltis cf. *dupeni* (Beddome 1878)
Material:
- TNHM(H) 154, High Range, Coll. HSF, labeled "*Silybura ocellata*"

Erycidae

111. Eryx conicus (Schneider, 1801)
Material:
- TNHM(H) 162, 163 Thiruvananthapuram, Coll. HSF, labeled "*Gongylophis conicus*"

112. Eryx johnii (Russell, 1801)
Material:
- TNHM(H) 161, Cape Comerin

113. Eryx whitakeri Das, 1991
Material:
- TNHM(H) 164, locality not given

Pythonidae

114. Python molurus (Linnaeus, 1758)
Material:
- TNHM(H) 165, Thiruvananthapuram, Coll. HSF

Acrochordidae

115. Acrochordus granulatus (Schneider, 1799)
Material:
- TNHM(H)134 Thiruvananthapuram, Coll. HSF, labeled "*Chersydrus granulatus*"

Pareiidae

116. Xylophis captaini Gower and Winkler, 2007
Material:
- TNHM(H) 158 (2 ex.), Kallar, Coll. HSF, labeled "*Xylophis stenorhynchus*"

Viperidae

117. Daboia russelii (Shaw and Nodder, 1797)
Material:
- TNHM(H) 121, 122, Thiruvananthapuram, Coll. HSF in 1902 from Bornianlli garden, in 1900 from Poojapura, labeled "*Vipera russelli*"

118. Hypnale hypnale (Merrem, 1820)
Material:
- TNHM(H) 123, Kallar hills, Coll. N.G. Pillai from Black Rock Estate on 9/6/1953, labeled "*Ancistrodon hypnale*"

Homalopsidae

119. Dieurostus dussumierii (Duméril, Bibron and Duméril, 1854)
Material:
- TNHM(H) 149, Kulathupuzha, Coll. HSF, labeled "*Hypsirhina* sp."

Elapidae

120. Bungarus caeruleus (Schneider, 1801)
Material:
- TNHM(H) (13 ex.) Thiruvananthapuram, Coll. HSF in July 1891; Thiruvananthapuram Zoo Kowdiar, Coll. NG Pillai on 20/10/1942, 26/5/1952, 27/8/1952, 8/1/1956; Peermed Coll. W.W. Edwards in Nov. 1892

121. Bungarus fasciatus (Schneider, 1801)
Material:
- TNHM(H) 120, by exchange

122. Naja naja (Linnaeus, 1758)
Material:
- TNHM(H) 123, Thiruvananthapuram, Coll. HSF

123. Hydrophis curtus (Shaw, 1802)
Material:
- TNHM(H) 127, 128, 129, Thiruvananthapuram, Coll. HSF in June-Sept. 1893; from Anjengo Coll. Shankar Narayana Pillai in Oct. 1908, labeled "*Enhydris curtus*"

124. Hydrophis cyanocinctus Daudin, 1803
Material:
- TNHM(H) 131, Thiruvananthapuram, Coll. HSF, labeled "*Hydrophis torquatus*"

125. Hydrophis fasciatus (Schneider, 1799)
Material:
- TNHM(H) 132, Thiruvananthapuram, Coll. HSF

*126. Hydrophis platurus (*Linnaeus, 1766)
Material:
- TNHM(H) 125, Thiruvananthapuram, Coll. HSF, labeled "*Pelamis platurus*"

127. Hydrophis schistosus Daudin, 1803
Material:
- TNHM(H) 126, 170 Thiruvananthapuram, Coll. HSF, labeled "*Enhydrina valakadyen*"

128. Hydrophis spiralis (Shaw, 1802)
Material:
- TNHM(H) 135, Thiruvananthapuram, Coll. HSF

129. Hydrophis stokesii (Gray, 1846)
Material:
- TNHM(H) 133, purchased, "Trev." [Thiruvananthapuram], on 4/11/1894, labeled "*Distira stokesii*"

130. Hydrophis viperinus (Schmidt, 1852)
Material:
- TNHM(H) 130, Thiruvananthapuram, Coll. HSF, labeled "*Thalassophina viperina*"

Natricidae

131. Amphiesma monticola (Jerdon, 1853)
Material:
- TNHM(H) 148, Thiruvanathapuram, Coll. HSF, labeled "*Tropidonotus monticolus*"

132. Fowlea cf. *piscator* (Schneider, 1799)
Material:
- TNHM(H) 151, 171, 3 specimens Thiruvananthapuram, labeled "*Tropidonotus piscator*"

133. Atretium schistosum (Daudin, 1803)
Material:
- TNHM(H) 168, 152, Thiruvananthapuram, Coll. HSF, labeled "*Helicops schistosus*"

134. Sahyadriophis beddomii (Günther, 1864)
Material:
- TNHM(H) (2 ex.) Thiruvananthapuram, Coll. HSF, labeled "*Tropidonotus beddomii*"

Colubridae

135. Ahaetulla isabellina (Wall, 1910)
Material:
- TNHM(H)139, 169, Thiruvananthapuram, Coll. on 18/1/1952, labeled "*Dryophis dispar*"

136. Ahaetulla oxyrhynca (Bell, 1825)
Material:
- TNHM(H) 136, Thiruvananthapuram, Coll. HSF, labeled "*Dryophis mycterizans*"

137. Ahaetulla sahyadrensis Mallik, Srikanthan, Pal, D'souza, Shanker and Ganesh, 2020
Material:
- TNHM(H) 137, 138, Thiruvananthapuram, Coll. HSF in 1902; from Vellany

on 7/4/1942, labeled "*Dryophis pulverulentus*"

138. Boiga cf. *nuchalis* (Günther, 1875)

Material:

- TNHM(H) 144, (5 ex.) Thiruvananthapuram, Coll. HSF, labeled "*Dipsas ceylonensis*"

139. Boiga trigonata (Schneider, 1802)

Material:

- TNHM(H) (3 ex.) Thiruvananthapuram, Coll. HSF in June 1892, 1900, labeled "*Dipsas trigonata*"

140. Boiga forsteni (Duméril, Bibron and Duméril, 1854)

Material:

- TNHM(H) 143, Thiruvananthapuram, Coll. HSF, labeled "*Dipsas forstennii*"

141. Coelognathus helena monticollaris (Schulz, 1992)

Material:

- TNHM(H) 140, Thiruvananthapuram, Coll. HSF, labeled "*Coluber helena*"

142. Chrysopelea ornata (Shaw, 1802)

Material:

- TNHM(H) 141, 142, Thiruvananthapuram, Coll. HSF

143. Dendrelaphis tristis (Daudin, 1803)

Material:

- TNHM(H) 147, (5 ex.) Thiruvananthapuram, Coll. HSF, labeled "*Dendrophis pictus*"

144. Dendrelaphis girii Vogel & Van Rooijen, 2011

Material:

- TNHM(H) 156, Thiruvananthapuram, Coll. HSF, labeled "*Dendrophis bifrenalis*"

145. Oligodon affinis Günther, 1862

Material:

- TNHM(H) 145, Ponmudi, Coll. HSF

146. Oligodon taeniolatus (Jerdon, 1853)

Material:

- TNHM(H) 167,146, (3 ex.) Thiruvananthapuram, Coll. HSF, labeled "*Oligodon subgriseus*"

147. Lycodon aulicus (Linnaeus, 1758)

Material:

- TNHM(H) 159 Jagathy, Thiruvananthapuram, Coll. SVG

148. Lycodon travancoricus (Beddome, 1871)

Material:

- TNHM(H) 150 (3 ex.) Thiruvananathapuram, Nathancode, Coll. on 30/9/1944, 11/10/1953

149. Lycodon fasciolatus (Shaw, 1802)

Material:

- TNHM(H) 153 (6 ex.) Thiruvananthapuram, Vellayambalam, Puthenchenthal, Vazhuthacaud, Coll. T.P. Pillai, C.G. Nair, on 31/7/1943, 25/2/1944, 22/4/1944, labeled "*Lycodon aulicus*".

Chelonia

Cheloniidae

150. Lepidochelys olivacea (Eschscholtz, 1829)

Material:

- TNHM(H) 105 a,b,c Thiruvananthapuram, Coll. HSF

Trionychidae

151. Pelochelys cantori Gray, 1864

Material:

- TNHM(H) 104, Neyyar, Coll. HSF

Testudinidae

152. Geochelone elegans (Schoepff, 1795)

Material:

- TNHM(H) 106, Kanyakumari, labeled "*Testudo elegans*"

Discussion

In all, a total of 153 species of herpetofauna, with one caecilian, 96 anurans, 11 saurians, 44 serpents and three chelonian species were documented by us here at the TNHM. Understandably, most of the material lodged here are non-type specimens. It is indeed noteworthy that there were primary and secondary types of some recently described rhacophorid frogs (*Ghatixalus, Mercurana, Raorchestes*) and gekkonid lizards (*Cnemaspis*).

Most of the specimens' provenances were Kerala, be it historical or recent materials. However, some specimens were obtained by exchange, or purchased or collected from the nearby Pondicherry and Tamil Nadu. These include specimens that were recently collected/deposited by contemporary experts (alphabetically): Anil Zachariah, Sujith V. Gopalan, Umesh K. Pavukandy, Vivek P. Cyriac and their allies.

The bulk of the snake specimens and a few lizards were those collected a century ago, largely from Thiruvananthapuram by the pioneering naturalist H.S. Ferguson. It is noteworthy that a few publications pertaining to the collections exist, in case of the recent material (Abraham et al. 2013, 2015, 2022; Cyriac and Umesh 2014; Zachariah et al. 2016).

In case of the historical specimens, the mud snake *Dieurostus dussumierii* was recently published (deSouza et al. 2024), while the sea snake *Hydrophis stokesii* is under publication processing (Ganesh, accepted). We hope that this catalogue will help fill in the lacuna regarding herpetological holdings in under-studied museums in our country and encourage future studies there.

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A preliminary study on the herpetofaunal diversity and distribution in Madurai hills across the Vaigai basin, southern India

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ABSTRACT. We studied the herpetological assemblage and community structure in and around Madurai, targeting a biogeographically complex crossroad at the intersection of the Western Ghats, the Eastern Ghats, and the Vaigai River. Based on a short, three-month-long survey, amounting to 210 hours of fieldwork, we recorded a total of 391 sightings representing 43 species of herpetofauna, consisting of ten species of amphibians, one species of turtle, 15 species of lizards, and 17 species of snakes. Among the 43 species, the 10 commonest species with sighting frequency > 10, including five species each of amphibians and lizards, alone accounted for 321 out of the overall 391 sightings, i.e., 82.0%. Five out of ten amphibian species, ten out of 15 lizards, all 17 snakes, and one turtle species were all represented by < 10 sightings each. These 391 sightings were distributed across eight microhabitat categories spanning fossorial, terrestrial, arboreal, and aquatic guilds. Our analysis revealed a non-random distribution of herpetofauna, where many species were found in water bodies, largely attributable to dicroglossid frogs. The encounter rates of species ranged between 0.005 and 0.324, with the snakes and chelonian being rare species with low encounter rates. Further surveys during rainy season will reveal greater diversity in the study areas.

KEYWORDS. Sirumalai, species richness, species evenness, Srivilliputhur hills

Introduction

Unlike the better-studied ectotherms, less vagile taxa like herpetofauna with lower dispersal and higher endemism (Vitt and Caldwell 2013) occurring in complex biogeographic crossroads (Spector 2002) are best suited to test out questions on diversity and distributions. In the Indian Peninsula, Madurai is one such complex region where the Eastern Ghats (Sirumalai) closely abuts the Western Ghats (Meghamalai-Srivilliputhur hills) and is provided with a riverine barrier — the Vaigai (Chellasamy and Balasubramanian 1991). There have been a few herpetofaunal studies focused on this landscape. One of the earliest works was conducted by Malhotra and Davis (1991) who surveyed the Srivilliputhur hills. Additionally, Hutton and David (2009) revisited their older collection of snakes from here, deposited at the Natural History Museum, London. Chandramouli and Ganesh (2010) reported on the herpetofauna of the Cardamom Hills (Meghamalai plus Srivilliputhur hills). Later, Srinivas and Bhupathy (2013) and Bhupathy and Kumar (2013) reported on the amphibians and reptiles of Meghamalai, respectively. Ganesh et al. (2014) combined the aforementioned works and presented a detailed overview of the ophiofaunal diversity of

Meghamalai. Subsequently, Chaitanya et al. (2019) presented an updated checklist of the Meghamalai herpetofauna.

Likewise, a few studies have also been done in the Eastern Ghats, in Sirumalai on the other side of the Vaigai river. Vanak et al. (2001) reported on the herpetofaunal checklist of the Khandige Estate in Sirumalai. Later, a series of studies by Ganesh and Arumugam (2015, 2016) shed new light on the herpetofauna of Sirumalai and a few other ranges in the adjacent parts of the Eastern Ghats. Thus, compared to the myriad studies conducted on the Western Ghats biodiversity, very few studies exist for the Eastern Ghats, here represented by Sirumalai and surrounding massifs. Perhaps the only one of the past studies that had generally enumerated on the reptile diversity of Madurai district is the brief work by Murthy and Chandrasekar (1996). In addition to being brief and patchy, this study has not been revisited since, in almost three decades. Barring these, the only other mention of herpetofauna includes a few new gecko descriptions (Sayyed et al. 2023a-c). Therefore, detailed and updated information on the herpetological diversity in the hills and drainage systems in Madurai is still needed. Therefore, we conducted a study on the herpetofauna of the hills near Madurai city, on either side of the Vaigai river.

Study Area

Three hill ranges, namely Elumalai, Nagamalai, and Alagarmalai, were selected for this survey as they represented areas situated on the west and east banks and along the Vaigai river, aligning with the aim of this study. Elumalai (9.89ºN 77.64ºE; 790 m asl) is to the west of Vaigai, closer to the Western Ghats where it dovetails with the Srivilliputhur hills to the southwest. Nagamalai (9.95ºN, 78.02ºE; 390 m asl) is part of a long, linear hill range that runs along the Vaigai river next to Madurai, situated in the middle. Alagarmalai (10.10ºN 78.23ºE; 800 m asl) is to the east of Vaigai, closer to the Eastern Ghats where it meets Sirumalai and Karanthamalai to the northeast. These hills are typically covered with dry thorn forests in the foothills (< 200 m asl), dry deciduous forests in mid-elevation (200–600 m asl), and moist deciduous forests in the higher slopes and summits (> 600 m asl). Some of these hills are also intersected by a few rivulets and water bodies (Pauline et al. 2006; Jayakumar et al. 2009). All the study sites are Reserved Forests under statutory protection.

Methodology

Fieldwork was conducted for three months from January to March 2023, by a two-member team. About one month was spent surveying each range, with around 21 field days, for 3 or 4 hours of survey per day. All hill ranges were surveyed during all the months to avoid seasonal bias in sighting records. A total of 210 hours of fieldwork was conducted, roughly corresponding to 70 hours per hill range. Field surveys were conducted following the diurnal time-constrained search method (Ribeiro-Junior et al. 2008) and the nocturnal visual encounter method (Crump and Scott 1994). Most of the surveys (70%) were done during daytime and some hours of surveys (30%) were done at night, especially the surveys closer to human habitations. Individuals thus sighted were identified, maturity and sex externally determined (wherever possible), and photographed in situ. This was a visual study and did not involve any voucher specimen collection and deposition in museums. Taxon identifications were based on consultation of the following literature — amphibians (Daniel 2002; Daniels 2005; Gururaja 2012; Ganesh 2015) and reptiles (Das 2002; Daniel 2002; Whitaker and Captain 2008; Ganesh 2015). These were further updated using (Sayyed et al. 2023 a-c; Agarwal et al. 2016, 2024; Mallik et al. 2020).

Results

Overall, a total of 43 species of herpetofauna, consisting of 10 species of amphibians and 33 species of reptiles, were recorded in this study. The reptile fauna in turn consisted of one species of turtle, 15 species of lizards, and 17 species of snakes. The following are quantified accounts of the herpetofauna sighted during the study, detailing the sighting frequencies and microhabitat associations.

Our records (Table 1) revealed that five frogs, 10 lizards, all 17 snakes, and one turtle species, equating to 33 species (76.7%), had less than 10 sightings each. Only two lizard species were present in the next category (11–20 sightings per species). To draw further inferences, we categorised the dataset into frogs, lizards, snakes

Table 1. Break-up of herpetofaunal taxa – frogs (F), lizards (L), snakes (S), and turtle (T) detailing the no. of species (sp.) and encounter rate (ER) in each abundance category.

No. of sightings	F sp.	F ER	L sp.	L ER	S sp.	S ER	T sp.	T ER
1–10	5	0.005–0.021	10	0.005–0.021	17	0.005	1	0.005
11–20	0	0	2	0.065–0.082	0	0	0	0
21–30	0	0	3	0.115–0.137	0	0	0	0
31–40	2	0.192	0	0	0	0	0	0
41–50	3	0.225–0.269	0	0	0	0	0	0
51–60	1	0.324	0	0	0	0	0	0

and turtles. We then found that only six species of amphibians were present in categories that included species with > 31 sightings. Since the highest number of sightings of any species in this study is 59 (*D. melanostictus*), the cut-off value 31 forms almost 50% of the maximum value.

Of the fauna represented by > 10 sightings, five were amphibian species and five were species of lizards. The values range from 12 to 59 sightings, or 3.0 to 15.0% of total sightings (Table 2). The total number of species sighted more than 10 times (n = 10) among the overall species sighted (n = 43) was 23.2%, or roughly between one fifth and one fourth, which collectively constituted 321 out of 391 sightings, i.e. 82.0% of the total number of sightings. It is noteworthy to mention here that, surprisingly, a few species that are highly habitat specific and do not tolerate human-mediated disturbances also featured in this list. Examples include two species of agamid lizards — *Psammophilus cf. blanfordanus* and *Sitana ponticeriana* — which are highly specific to rocky outcrops and open grasslands, respectively.

Table 2. Sighting frequency and relative abundance (%) of species with > 10 sightings

Scientific Name	No. sightings	% of total
Amphibia		
Duttaphrynus melanostictus	59	15.0
Euphlyctis cyanophlyctis	46	11.7
Minervarya agricola	44	11.2
Sphaerotheca breviceps	41	10.4
Hoplobatrachus tigerinus	35	8.9
Reptilia		
Hemidactylus frenatus	25	6.3
Calotes versicolor	23	5.8
Psammophilus cf. blanfordanus	21	5.3
Sitana ponticeriana	15	3.8
Hemidactylus leschenaultii	12	3.0

The 43 species of herpetofauna occupied several categories of microhabitats (see Table 3). The greatest number of sightings were in the water bodies, viz. 202 (51.7%). This was followed by rocks, viz. 49 (16.8%), followed by an equal number on tree branches 38 (9.7%) and building walls 38 (9.7%), followed by leaf litter 36 (9.2%), tar road 11 (2.8%), grass 10 (2.5%) and lastly, bare ground 6 (1.5%). Assuming a non-random distribution, the number of sightings in each of the eight categories of microhabitats were 48.8 (12.5%). Only two categories, namely tree branches and building wall with 9.7% comes the closest to this hypothesised ideal mean value. As for the taxonomic break-up of the number of sightings, in the various families, the values ranged from 1 (0.2%) (geoemydid turtle, typhlopid, erycid, pythonid snakes) to as much as 166 (42.4%) (dicroglossid frogs).

Discussion

The present study revealed the occurrence of 43 species of herpetofauna in the study area. However, there are still some species that are known from the region (Daniel 2002; Das 2002; Whitaker and Captain 2004), but remain undetected in the present work. Examples include two Chelonians; flapshell turtle (*Lissemys punctata*) and star tortoise (*Geochelone elegans*). As for the lizards, scaly gecko (*Hemidactylus scabriceps*), Erode ground gecko (*Cyrtodactylus* cf. *speciosus*), supple skinks (*Riopa punctata, R.*

Table 3. Family-wise break-up of sightings of taxa among the various microhabitat types (spp – no. of species; grd – ground; ltr – litter; grs – grass; sight – no. of sightings)

Taxa (Families)	Spp	Water	Wall	Tree	Grd	Ltr	Grs	Rock	Road	Sight
Bufonidae	1	32	0	0	0	27	0	0	0	59
Microhyldiae	3	1	0	0	0	0	3	0	1	5
Rhacophoridae	1	0	1	2	0	0	0	0	0	3
Dicroglossidae	5	166	0	0	0	0	0	0	0	166
Geoemydidae	1	1	0	0	0	0	0	0	0	1
Gekkonidae	7	0	37	7	1	0	1	5	0	51
Scincidae	2	0	0	0	0	7	0	1	1	10
Lacertidae	1	0	0	0	0	0	0	4	0	4
Agamidae	4	0	0	22	3	0	1	36	0	62
Chameleonidae	1	0	0	2	0	0	0	0	0	2
Typhlopidae	1	0	0	0	0	0	0	0	1	1
Erycidae	1	0	0	0	0	0	0	0	1	1
Pythonidae	1	0	0	0	0	0	0	0	1	1
Viperidae	2	0	0	0	1	0	1	1	0	3
Elapidae	2	0	0	0	0	0	1	0	1	2
Natricidae	3	2	0	0	0	1	1	0	3	7
Colubridae	7	0	0	5	1	1	2	2	2	13

albopunctata), Dravid skinks (*Dravidoseps* sp.), Bibron's skink (*Eutropis* cf. *bibronii*) and Bengal monitor lizard (*Varanus bengalensis*) are such examples (Vanak et al. 2001; Ganesh and Arumugam 2016; Karthik 2017; Agarwal et al. 2016). Among snakes, beaked worm snake (*Grypotyphlops acutus*), common sand boa (*Eryx conicus*), banded kukri snake (*Oligodon arnensis*), Russell's wolf snake (*Lycodon fasciolatus*), common bridal snake (*Dryocalamus nympha*), common trinket snake (*Coelognathus helena*), Joseph's racer (*Platyceps josephi*), common cat snake (*Boiga trigonata*) and slender coral snake (*Calliophis melanurus*) remain undetected in this work.

Some unrecorded species of snakes are truly rare ones (Daniel 2002; Das 2002; Whitaker and Captain 2004). Similarly, one species that was seen, the black-headed snake (*Sibynophis subpunctatus*) is rare among other snakes seen in the area. Also, a few range-restricted snake species such as shieldtail snakes (*Uropeltis* sp.), bamboo pitviper (*Craspedocephalus gramineus*), green keelback (*Rhabdophis plumbicolor*), Indian reed snake (*Gongylosoma calamaria*), flying snakes (*Chrysopelea taprobanica, C. ornata*), Boulenger's bronzeback (*Dendrelaphis bifrenalis*), Forsten's cat snake (*Boiga forsteni*), yellow-green cat snake (*Boiga flaviviridis*) and Travancore wolf snake (*Lycodon travancoricus*) could potentially occur in the hill forest tracts of the study areas based on their published records nearby (Ganesh and Arumugam 2016; Chaitanya et al. 2019; Aengals et al. 2022; Agarwal et al. 2024). Much longer-term sampling, including road-cruising, preferably during the wet season would certainly yield these snake sightings in the study area.

This study's record of 43 species (33 reptiles) is much higher when compared to the 15 reptile species reported by Murthy and Chandrasekar (1996). All species reported by them were also sighted in the present study, except for one species *Uropeltis pulneyensis*, which is a high-elevation Shola forest species that is absent in the study area (Whitaker and Captain 2004; Ganesh et al. 2023). Literature specifically mentions Alagarkoil hills in the distribution of the brown vine snake (*Ahaetulla sahyadrensis*) (Whitaker and Captain 2004 read with Mallik et al., 2020).

However, that species was not sighted during the present study. The relatively range-restricted, non-commensal reticulated gecko (*Hemidactylus reticulatus*), which was recorded by Murthy and Chandrasekar (1996), was also sighted in this work. But, another lizard, the scaly gecko (*Hemidactylus scabriceps*) that was recorded in the nearby Pasumalai (Ganesh et al. 2017) could not be recorded in this study. Regarding the unrecorded species of herpetofauna, it is hypothesised that the survey undertaken during the hot and dry summer months is a major reason for the incomplete dataset at present.

As for the amphibians, the frog fauna of this region is similar to that prevailing in any plains country in southern India (Daniels 2005; Gururaja 2012). The frog species recorded in this work is comparable to those reported in Puducherry (Seshadri et al. 2012) and in Kalpakkam (Ramesh et al. 2013). Apart from those reported here, only a few species of amphibians might still be present in the current study sites. Such examples include the two species of toads *Duttpahrynus scaber* and *D. peninsularis* (Ganesh et al. 2020 read with Bisht et al. 2021). Another possible species occurrence in this region is the rock toad (*Duttaphrynus hololius*) that has been seen in the northerly Pudukottai hills (Rameshwaran and Sayyed 2018). The recently studied burrowing frogs (*Sphaerotheca pluvialis* and *S. rolandae*) might also be occurring here (Dahanukar et al. 2017). Given that the study was carried out during the dry season, future surveys during the monsoon might record these above-mentioned species. Future surveys will likely yield the presence of all these frogs in the study sites. However, the proportional number of amphibian species recorded vs. reported from the study area, fared much better than that of reptiles, even though the study was conducted during the dry season.

Sighting endangered species like the Indian rock python (*Python molurus*) is also an encouraging prospect. The presence of another such species, the Bengal monitor lizard (*Varanus bengalensis*), would have further enriched this dataset. The presence of the endangered marsh crocodile or mugger (*Crocodylus palustris*) in the area is questionable. This species has been reported from places north (Moyar, fide Whitaker and Srinivasan 2020) and south (Neyyar, fide Jayson et al. 2006) of the Vaigai basin. Since the focus of the survey was more in the hilly terrestrial ecosystems and not the actual Vaigai river, we were unable to record this species. Another similar case is with the Leith's softshell turtle (*Nilssonia leithii*) that is also known to occur in Tamil Nadu's rivers (Das et al. 2014). Surveys

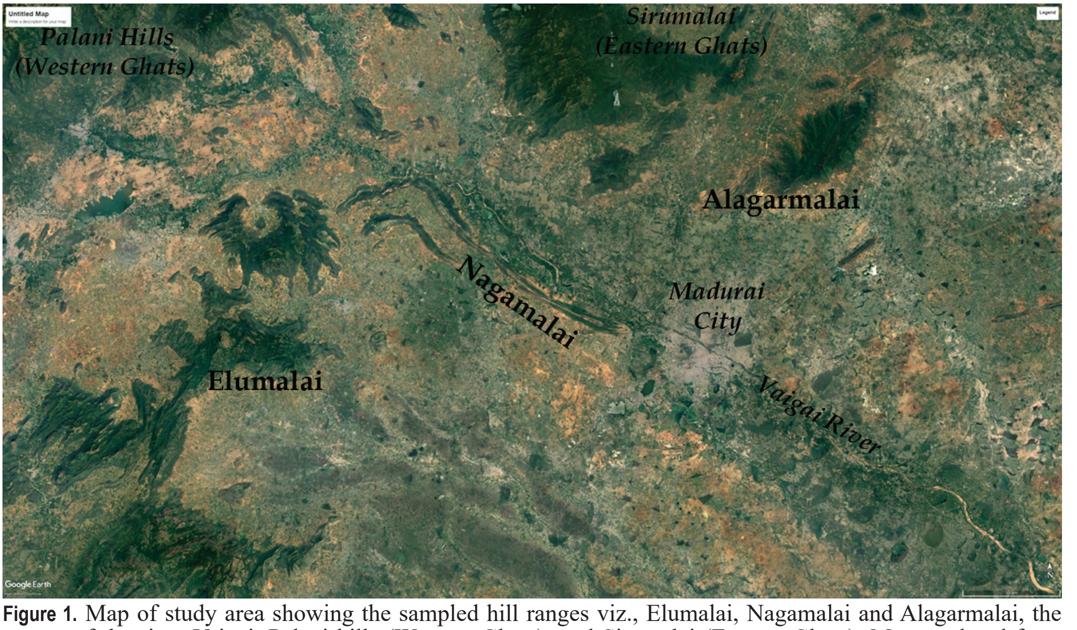

Figure 1. Map of study area showing the sampled hill ranges viz., Elumalai, Nagamalai and Alagarmalai, the course of the river Vaigai, Palani hills (Western Ghats), and Sirumalai (Eastern Ghats). Map rendered from Google Earth.

targeting the lotic aquatic ecosystems around Madurai might yield the aforementioned species. Future works should target the aforesaid microhabitats to fully unravel the diversity of the biogeographically-composite Madurai region.

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Appendix 1. Encounter rate of herpetofauna in Vaigai Basin Hills during the study

S. no	Scientific name	Sighting frequency	Encounter rate
1	*Duttaphrynus melanostictus*	59	0.3241
2	*Uperodon systoma*	3	0.0164
3	*Uperodon taprobanicus*	1	0.0054
4	*Microhyla ornata*	1	0.0054
5	*Polypedates maculatus*	3	0.0164
6	*Hoplobatrachus tigerinus*	35	0.1923
7	*Hoplobatrachus crassus*	4	0.0219
8	*Sphaerotheca breviceps*	41	0.2252
9	*Minervarya agricola*	44	0.2417
10	*Euphlyctis cyanophlyctis*	46	0.2692
11	*Melanocelys trijuga*	1	0.0054
12	*Hemidactylus leschenaultii*	12	0.0659
13	*Hemidactylus frenatus*	25	0.1373
14	*Hemidactylus parvimaculatus*	3	0.0164
15	*Hemidactylus triedrus*	3	0.0164
16	*Hemidactylus multisulcatus*	1	0.0054
17	*Hemidactylus reticulatus*	1	0.0054
18	*Cnemaspis reticulata*	3	0.0164
19	*Eutropis carinata*	4	0.0219
20	*Eutropis macularia*	4	0.0219
21	*Ophisops leschenaultii*	4	0.0219
22	*Sitana ponticeriana*	15	0.0824
23	*Calotes versicolor*	23	0.1263
24	*Calotes calotes*	2	0.0109
25	*Psammophilus cf. blanfordanus*	21	0.1153
26	*Chamaeleo zeylanicus*	2	0.0109
27	*Indotyphlops braminus*	1	0.0054
28	*Eryx johnii*	1	0.0054
29	*Python molurus*	1	0.0054
30	*Daboia russelii*	2	0.0109
31	*Echis carinatus*	1	0.0054
32	*Naja naja*	2	0.0109
33	*Bungarus caeruleus*	1	0.0054
34	*Fowlea piscator*	4	0.0219
35	*Atretium schistosum*	2	0.0109
36	*Amphiesma stolatum*	1	0.0054
37	*Sibynophis subpunctatus*	1	0.0054
38	*Lycodon striatus*	1	0.0054
39	*Lycodon aulicus*	2	0.0109
40	*Oligodon taeniolatus*	1	0.0054
41	*Ptyas mucosa*	4	0.0219
42	*Dendrelaphis tristis*	4	0.0219
43	*Ahaetulla oxyrhynca*	1	0.0054

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Life history of a neglected predator of the coral reef ecosystem: amphibious Yellow-lipped Sea Krait *Laticauda colubrina*, Schneider, 1799

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ABSTRACT. The yellow-lipped sea krait (*Laticauda colubrina*), also known as the colubrine sea krait or banded sea krait, is a venomous marine snake belonging to the family Elapidae and is found in the tropical and subtropical coastal waters of the eastern Indian Ocean, Southeast Asia, and the western Pacific Ocean archipelagos. Due to limitations in geographic distribution, there is a dearth of information about its life history. In this study, detailed information on the life history of *L. colubrina* is compiled to assess the thrust areas of research. The yellow-lipped sea krait is designated as a schedule II species under India's Wildlife Protection (Amendment) Act 2022. Furthermore, it is imperative to understand the impacts of climate change on their habitats for vulnerability assessments. Additionally, no bite or casualty reports have been confirmed from India. Hence, habitat assessment must be conducted in distributional locations to understand fine-scale spatial overlap and encounter rates between sea snakes and humans. This paper will review the distribution, ecology, and threats to yellow-lipped sea kraits and highlight potential research gaps related to *L. colubrina* in India.

KEYWORDS. Elapidae, ecology, research gaps, Ophiology, Colubrine sea krait, Coastal and marine habitat

Introduction

Snakes that live entirely or occasionally in marine and estuarine environments account for roughly 90% of all living marine reptile species (Wallach et al. 2014; Uetz & Hosek 2017). Hydrophiine snakes are taxonomically and morphologically the most diverse clade within the venomous family Elapidae, with more than 160 species recognized in approximately 50 genera (Sanders et al. 2008). Multiple habitats, including mangrove forests, coral reefs, lagoons, tidal flats, and estuaries, are home to marine snakes (Voris & Murphy 2012). Four different lineages make up elapids: the sea kraits (Family Elapidae; subfamily Laticaudinae), the mud snakes (Family Colubridae; subfamily Homalopsidae), the water snakes (Family Colubridae: subfamily Natricinae), and the true sea snakes (Family Elapidae; subfamily Hydrophiidae; Heatwole 1999). All true sea snakes have venomous fixed front fangs and are distinguished by their laterally compressed paddle-like tails. Unlike many land-based snakes, they do not make lightning-fast strikes. Instead, they tend to hang on and chew (Heatwole 1999).

The 'sea kraits' represent a classic intermediate land and sea state. Sea kraits are often encountered in the tropical and subtropical coastal waters of the eastern Indian Ocean, southeast Asia, and the western Pacific Ocean archipelagos (Heatwole et al. 2005). The islets of coral reefs are a major food source for sea kraits

(Heatwole 1999; Ineich & Laboute 2002). They play a vital role in maintaining the functions of coral reef ecosystems (Brischoux et al. 2009). Beaches that are freely reachable from the water and frequently submerged during high tide are known to be used by them as hiding places (Bonnet et al. 2009). Being nocturnal, they feed entirely on aquatic prey, such as eels, diving up to 80 m in depth (*Motani 2009)*. These amphibious snakes have a variety of adaptations to marine life, such as a vertically flattened paddle-like tail for propulsion, dorsally positioned nostrils, each with a valve, salt regulating glands including lachrimal glands that remove salt as tears, and a single lung that extends nearly the entire length of the body (Dunson 1975). All sea snakes have valvular nostrils that can close firmly to keep out water from the top of the snout (Gow 1977). Unlike other genera of marine snakes, sea kraits still practice oviparous reproduction, which means they must travel back to land to lay their eggs (Shetty and Shine 2002b). More significantly, they return to land to breed, feed, and shed their skin. As a result, it appears likely that many sea kraits spend a significant amount of time on land (Greer 1997). Before 2006, *L. saintigironsi* (New Caledonian sea krait), *L. guineai,* and *L. frontalis*, a dwarf species restricted to Vanuatu, were all considered subspecies of *L. colubrina* (Heatwole et al. 2005; Cogger and Heatwole 2006).

Only two krait species have been reported from India (Ganesh et al. 2019). The yellow-lipped sea krait (*Laticauda colubrina,* Schneider, 1799), also known as the banded sea krait or colubrine sea krait, has a highly potent neurotoxic venom. *Laticauda colubrina* is one of the most widespread members of the genus *Laticauda* (Heatwole et al. 2005). It is protected under Schedule II of the Wildlife (Protection) Amendment Act of India 2022. In the IUCN Red List, the yellow-lipped sea krait is classified as Least Concerned (Lane et al. 2010).

Scanlon and Lees (2004) combined morphological and molecular results to support the findings that sea kraits (*Laticauda*) and Solomon Islands elapids are basal to the remaining Australian terrestrial elapids and true sea snakes (Hydrophiinae). It implies that the *Laticauda* group is either a basal clade within an elapid subfamily (the Hydrophiinae) or a sister clade to the Hydrophiinae (Scanlon and Lee 2004). Earlier studies by Cadle and Gorman (1981), McDowell (1985 and 1987), and Greer (1997) provided evidence for variations in this phylogenetic interpretation; the Laticaudinae subfamily was arbitrarily assigned to this clade. Most discussions have concerned the connection between the amphibious *Laticauda* and the true aquatic hydrophiine sea snakes (Rasmussen 1997). *Laticauda* species and the true sea snakes do not form a monophyletic group and most likely represent two distinct invasions of the marine environment, even though it is evident that all the lineages that are referred to as sea snakes are closely related and descended from terrestrial elapid ancestors (Keogh 1998). Out of seven, only two species are reported from India (Ganesh et al. 2019).

Geographical distribution

Laticauda colubrina is found in India, Bangladesh, Myanmar, Malaysia, Indonesia, Cambodia, Vietnam, China, Taiwan, Philippines, Fiji, Vanuatu, Papua New Guinea, Japan, Thailand, New Zealand, Samoa, Palau, Australia, Japan, Tongan archipelago, South Korea, and New Caledonia (Figure 5; Dunson and Minton 1978, Bhaskar 1996; Shine et al. 2003; Heatwole et al. 2005; Cogger and Heatwole, 2006; Brischoux and Bonnet, 2009; Gill and Whitaker 2014; Kabir et al. 2009; Lane et al. 2010; Rasmussen et al. 2014; Park et al. 2017; Vijaykumar and David 2006; Tyabji et al. 2018).

Distribution along the Indian coast

Laticauda colubrina is common in Andaman and Nicobar Islands viz., Wandoor Beach, Trinkat, Nancowry, Narcondam, Ross, Smith, Katchal, Tillangchong, and Menchal Island, along with the only reports from Parangipettai coast of Tamil Nadu, which is the westernmost limit of the range (Shetty and Sivasundar 1997; Das 1999; Heatwole et al. 2005; Damotharan et al. 2010; Figure 1,2,3,4). However, it has rarely been spotted off islands near the Indian mainland (Damotharan et al. 2010, Figure 2). On the South Reef Island of North Andaman, the relative abundance of yellow-lipped sea krait and blue-lipped sea krait (*L. laticauda*) was 200:1 (Bhaskar 1996). The occurrence rate of *L. colubrina* was 20 times greater than that of

L. laticauda in the Andaman Islands (Tyabji et al. 2018).

Habitat

Laticauda colubrina is amphibious in nature. While choosing a habitat, they consider the availability of shelter and clean water (Liu et al. 2012). They are commonly encountered in shallow waters up to a depth of ten meters (Cogger 2007). On land, they live on sandy beaches, coral islands, and in mangrove swamps (Damotharan et al. 2010). It was observed that sea kraits preferred the habitat of fallen trees since it offered them a natural, safe refuge (Tyabji et al. 2018).

Cracks in tree trunks caused by thick bark or rotting sections of the coastal forest trees are likely to be a significant habitat characteristic for sea kraits since these microhabitats have only been found in mature or dying trees (Lowe et al. 2022). An ideal microhabitat for incubating eggs may be found in the cracks of uprooted trees and rocks whose areas are thermally sealed and comparatively warm (Tyabji et al. 2018). They have also been observed congregating on the seashore at night in huge numbers (Chandramouli 2022).

External Morphology

In the Andaman Islands, the total length of males ranged from 74.4–114 cm and 100.5–169.8 cm in females, in a study conducted from 1992 to 1995 (Bhaskar 1996; Chandramouli 2022). Males mature at 70 cm Snout Vent Length (SVL) and females at 90 cm (Guinea 1986), whereas the average SVL in males is around 90 cm and 110 cm in females (Shetty and Shine 2002c). Males weigh only 600 g on average and are 75 to 100 cm long, while females weigh about 1800 g and are about 150 cm long, as reported from the Fiji Islands (Shetty 2000). Brischoux and Bonnet (2009) recorded a maximum body size of about 149 cm in total body length (137 cm SVL) on a female in New Caledonia.

Males and females exhibit sexual dimorphism; females are larger than males (Shetty and Shine 2001a). Females have short, thin, flattened tails, whereas males have long, pear-shaped, fleshy tails (Shetty and Shine 2002c). Adult males need more terrestrial locomotive capabilities since they hunt in shallower depths and are more terrestrially active during mating (Shetty and Shine 2001a).

Scalation

Except for the head, the body is cylindrical, slightly compressed, and nearly uniform in width throughout (Murthy 2007). One preocular and two postoculars, five infralabials in contact with genitals, entire head shield, lateral nostrils, a nasal shield divided by the inter-nasals, seven to eight supralabials, the third and fourth touching the eye, and temporals one and two (Murthy 2007). Ventrals 213–245 and large, half as broad as the body, caudals 37–47 (males), 29–35 (females), scales smooth and overlapping in rows of 21–23, rarely 25 (Murthy 2007).

Colouration

The body is light or dark bluish-grey above and yellowish below, with prominent dark-brown or black bands running across the belly that may often be interrupted in some or all directions (Murthy 2007). The yellow colour of the snout extends backwards on each side of the head, crossing the eye and upper lip (Sharma 2003). The lower jaw has a streak on either side, with an elongated yellow patch in the middle (Murthy 2007). However, the typical colouration is a banded pattern of regularly spaced black rings varying in number from 35 to 55 (Brischoux and Bonnet 2009). Ontogenic melanism (progressive darkening of the skin) has been documented in snakes (Lorioux et al. 2008). Also, Lorioux et al. (2008) observed that melanism occurred infrequently in adult kraits from New Caledonia. Several cases of melanism and a relatively high proportion of incomplete or divided black rings were also reported (Brischoux and Bonnet 2009).

Reproduction

Males reach sexual maturity at about one and a half years, and females are sexually mature at one and a half to two years (Heatwole et al. 2005). The male identifies the female through the vomeronasal organ, the snake's main olfactory apparatus, to detect sexual and conspecific scents (Aleksiuk and Gregory 1974). As per observations of their mating habits, it facilitates pheromonally mediated mate choice (Bhaskar

1996; Shine 2003). Males gather in groups around gently sloping areas at high tide every year during the warmer months of September through December. Males prefer larger females because they produce larger and more offspring (Shetty and Shine 2002b). Sivapushanam et al. (2023) observed a congregation of yellow-lipped sea kraits inside the cavity of a dead Andaman Bullet-Wood tree (*Manilkara littoralis*) about 1.5 m above the ground. A study of mating groups on a small Fijian island found that they spend an average of two hours mating after courtship (Shetty and Shine 2002b). A male snake pursues a female and starts mating when he spots her, then entangles itself around a single female. Then the male snakes rhythmically contact after aligning their bodies with the females; the resulting mass of snakes can remain almost motionless for several days (Shetty and Shine 2002b; Shetty and Shine 2002d).

Oviparous females lay up to 10 eggs per clutch, which they deposit on land and lay in small gaps until they hatch (Guinea 1994). Females choose caves and cracks in rocks land for roosting and egg laying. However, the nesting habits of *L. colubrina* are unknown because only two instances of egg-laying in the wild have been documented (Guinea 1986). Therefore, it can be said that their reproductive habits are very elusive (Lane et al. 2010).

Adaptations

The snake's tail has been modified to swim by taking the form of a paddle (Shetty and Shine 2002b). Due to the differences in motion between crawling and swimming, these adaptations are also present in more distantly related 'true' or ovo-viviparous sea snakes (Hydrophiinae; Shetty and Shine 2001). Aside from *Laticauda* species, most sea snake species are less mobile on land (Shetty and Shine 2001). Although there hasbeen no data on movements in the ocean, adult female *L. colubrina* eats large (deep-water) eels, whereas males and juveniles eat small (shallow-water) eels (Pernetta, 1977). Thus, females may be under more intense selection for effective aquatic locomotion (Shetty and Shine 2001). Larger snakes have been observed to move more quickly than smaller ones, but on land, they are slower. Particularly on land, male sea kraits move more quickly than females. Both on land and in the water, prey items in the gut decrease locomotor speed (Shetty and Shine 2001).

When the level of pulmonary oxygen saturation changes, *L. colubrina* can alter cutaneous uptake. Yellow-lipped sea kraits spent more time outside but breathed less frequently when subjected to 20% stepwise reductions in the aerial oxygen saturation from 100% to 40%. Between 100% and 60% saturation, there was a notable graded increase in cutaneous uptake, most likely caused by the recruitment of subcutaneous capillaries (Dabruzzi et al. 2016). Reducing subcutaneous perfusion optimizes swimming performance during foraging, whereas redirecting blood to skin surfaces maximizes dive times when subduing prey or avoiding aerial predators (Dabruzzi et al. 2016). *Laticauda colubrina* twist their tail around their length axis so that the tail tip's lateral aspect corresponds to the dorsal view of the head. In doing so, colouration and pattern, in combination with tail movement and posture, make the tail appear very similar to the head; this behaviour helps them to avoid becoming prey (Rasmussen and Elmberg 2009). A locomotor performance study by Wang et al. (2013) found that *L. colubrina* was the most terrestrial species in habits and moved significantly faster than the other sea krait species during terrestrial locomotion.

Behavioural Ecology

Preliminary studies on the behaviour of sea kraits were conducted in the late 1990s at South Reef Island, Andaman Islands (Bhaskar 1996; Shetty and Devi Prasad 1996). The current studies show that sea kraits restrict their terrestrial activities between 1800 and 0400 hours (Tyabji et al. 2018). Sea kraits seek refuge during the day in the cool microclimates of the cracks in living and dead trees (Shetty and Devi Prasad 1996). Adult females hunt for larger conger eels in deeper water, and males prefer to hunt for smaller moray eels in shallower water (Shetty and Shine 2001a). Despite being venomous, it is non-aggressive underwater (Desai pers. comm. 2023). It does not pose a significant threat to humans as it is generally docile and avoids human contact (Desai pers. comm. 2023). However, caution should still be exercised when encountering this species. They displayed aggressive behaviour and signs of disturbance when tourists photographed them using a flash (Tyabji et al. 2018).

They display philopatric behaviour (Lawrence and Henderson 1995). As per (Shetty and Shine 2002a), yellow-lipped sea kraits in Australia have moved from the Fijian Islands to other islands five kilometres away, returning to their home islands, as all recaptured individuals were found on their home islands in an average of 31 days. When rapid locomotion was possible (i.e., in the case of juveniles rather than adults, and in the water rather than on land), kraits were more likely to escape into the water than remain stationary (Shine et al. 2003). Additionally, nighttime is more difficult for predators to pursue them than daytime. These trends imply snakes modify their antipredator strategies to survive (Shine et al. 2003).

Physiology

Studies have suggested that rainfall and the accessibility of surface water may be contributing factors as they drink fresh water or very diluted seawater to regulate their water balance and compensate for dehydration on land and in the ocean (Lillywhite et al. 2008). Consequently, drought and global warming may impact the population demographics of some *Laticauda* species (Lillywhite 2008). In sea kraits that had been first transferred to fresh water and then to seawater, Brischoux et al. (2013) looked at patterns of salt regulation, specifically variations in natremia (plasma sodium) and body mass (net water flow). Brischoux et al. (2013) found that sea kraits that were allowed to roam freely exhibited hypernatremia (up to 205 mmo. l-1).

The number of encounters with *L. colubrina* correlated significantly with abiotic factors like atmospheric humidity, temperature, sand temperature, and humidity; however, these relationships were not biologically substantial (Tyabji et al. 2018). The number of encounters was unaffected by lunar or tidal phases (Tyabji et al. 2018). They are typically not categorized as strictly nocturnal animals despite the reality that most of their interactions happen at night or dusk, frequently gathering in small clusters during the daytime in search of cover under beach debris, tree roots, and rock crevices (Heatwole et al. 2005). To regulate their body temperature, they typically alternate between periods of shade and sunlight (Heatwole et al. 2005). Also, they have been observed resting in the tree shadows (Lowe et al. 2022).

Old-growth coastal forests have created considerable environmental heterogeneity, which appears essential for L. colubrina to maintain healthy populations. This suggests that they rely on healthy coral reef systems for hunting and specific environmental conditions in their terrestrial habitats, underscoring the importance of conserving both habitats for L. colubrina and other sea krait species (Lowe et al. 2022).

Therefore, *L. colubrina* may make a suitable flagship species for promoting effective land-sea management, given its need for balanced coastal areas (Lowe et al. 2022).

Food and Feeding pattern

Their diet consists almost entirely of eels from the order Anguilliformes and families Congridae, Muraenidae, and Ophichthidae (Glodek and Voris 1982). Although often described as strictly eel-eaters, examples of other types of bony fish of Synodontidae and Pomacentridae have been recorded from the stomachs of some sea kraits (Gorman et al. 1981). Also, the striped eel catfish *Plotosus lineatus* and dartfish of *Ptereleotris* sp. were reported from New Caledonia (Brischoux and Bonnet 2009).

In addition, males frequently hunt multiple prey items, whereas females only hunt one item per foraging session (Shetty and Shine 2001; Shetty and Shine 2002c).Despite preying on eels, one eel species, the banded snake eel *Myrichthys colubrinus,* might be crucial for their survival (McCoy 1980). In terms of appearance and behaviour, this species of Indo-Pacific eel is very similar to the yellow-lipped sea krait. The eel may use this advantage by projecting a threatening and venomous aura to potential attackers (McCoy 1980 In the Fiji Islands, adult males feed upon smaller moray eels and frequently hunt multiple prey items (Shetty and Shine 2008). Prey size increases with body size in both males and females, but the sexes follow different trajectories in this respect (Shetty and Shine 2008). Female sea kraits consume larger eels relative to predator head size and body length than males; hence, the larger head size of female sea kraits is interpreted as an adaptation to consuming more oversized prey items (Shetty and Shine 2002c). After a hunt, yellow-lipped sea kraits return to land to digest their catch (Shetty and Shine 2002a). However, adult females spend less time on land during mating and hunt in deeper waters, necessitating a greater capacity for aquatic locomotion (Shetty and Shine 2001). In captivity, they are exposed to a damp environment, leading to respiratory issues due to unstable temperatures in the tank.

Movement ecology

Radio transmitters were surgically implanted into kraits and were monitored for 80 days between November 1998 and January 1999 in the Fiji Islands (Shetty and Shine 2002b). Radio-tracked kraits spent an average of 23 days on land and ocean (Shetty and Shine 2002b). The average time spent by males in one habitat before returning to the other was 11 days and ten days in the case of females (Shetty and Shine 2002b). The studies indicate that yellow-lipped sea kraits are truly amphibious animals. The radio-tracked snakes spent approximately equal amounts of time in the ocean as on land (Shetty & Shine 2002b). *Laticauda colubrina* is heavier-bodied and stronger in body mass compared to *L. laticaudata*, as per a study conducted in New Caledonia (Bonnet et al. 2005). Thus, the ability of different species and sexes of sea kraits to climb cliffs correlates with their body shape, even though these primarily aquatic animals rarely use cliff edges and steep surfaces.

Predators

Although specific predators of *L. colubrina* have not received much attention, the white-breasted sea eagle (*Haliaetus leucogaster*) is a known predator of this species (Lading et al. 1991). Remains of *L. colubrina* have also been found in the stomach contents of wild captured elasmobranchs and tiger sharks (*Galeocerda cuvieri*) (Masunaga et al. 2008).

Bycatch

A total of 55 kraits were caught by night lighting at the Gigante Island in the Phillippines from August to September 1975 (Dunson and Minton, 1978). No bycatch incidences have been reported from India yet.

Diseases

The yellow-lipped sea krait is a host to parasites, including the sea snake tick *Amblyomma nitidum, Paraheterotyphlum ophiophagos, Kalicephalus laticaudae*, and chigger mites *Vatacarus ipoides* of the family Trombiculidae (Nadchatram 2006; Toriba, 2011; Kwak et al. 2020). One study reported multiple mortalities due to multicentric lymphoid neoplasia (abnormal tissue growth), and secondary sepsis potentially leading to the malfunctioning of various organs, shock, and death were observed in captive *L. colubrina* (Chinnadurai et al. 2008). A case of lymphoid leukaemia was also documented in an adult yellow-lipped sea krait found dead in an aquarium at the National Aquarium in Baltimore (Walker 2022).

Lifespan

The yellow-lipped sea krait has specific problems that restrict its life expectancy in captivity, and as a result, the species is rarely kept in captivity (Chinnadurai et al. 2008).

Venom toxicity

The yellow-lipped sea krait has a highly potent neurotoxic venom, with an LD50 of 0.45 mg/kg of mice, and 95% of the expected observation falls from 0.34 to 0.60 mg/kg (Levey 1969). The venom attacks post-synaptic membranes of muscle tissues and inhibits acetylcholine and carbochol (Levey 1969). Acetylcholine is an excitatory mediator that regulates cardiac contractions and blood pressure, and Carbachol acts primarily by stimulating muscarinic receptors (Hoover 2015; Sam and Bordoni, 2023). Victims of envenomation die rapidly due to respiratory arrest and subsequent cardiovascular collapse due to diaphragm and heart muscle failures (Levey 1969; Sato et al. 1969; Takasaki 1988). Sublethal doses cause paralysis and may still lead to death over an extended period of two to five hours (Levey 1969). The molecular size of the toxin of yellow-lipped sea krait is very similar to the erabutoxins a and b isolated by Tamiya and Arai (1966) and Sato et al. 1969 from *Laticauda semifasciata. Laticauda colubrina* specifically targets *Gymnothorax* eels from the Pacific ocean, and eels have been shown to withstand high doses of venom without suffering any negative effects. Research has shown

Table 1. Distributional records of *Laticauda colubrina*, Schneider, 1799 in India

SN	Species	Lattitude	Longitude	Place of Sighting	References
1	*Laticauda colubrina*	11.42950562	92.63738515	Rutland Island	Sivapushanam 2023
2	*Laticauda colubrina*	12.9137927	92.8969574	Mayabunder, Middle Andaman	Chandramouli 2022
3	*Laticauda colubrina*	11.5962399	92.6080082	North Wandoor	Chandramouli 2022
4	*Laticauda colubrina*	11.5071032	92.7018082	Chidiyatapu	Chandramouli 2022
5	*Laticauda colubrina*	11.594623	92.607428	Wandoor beach	Tyabji et al. 2018
6	*Laticauda colubrina*	11.600382	92.608973	Grub	Tyabji et al. 2018
7	*Laticauda colubrina*	9.126684	92.756352	Car Nicobar	Heatwole et al. 2005
8	*Laticauda colubrina*	8.123491	93.578133	Trinkat island	Heatwole et al. 2005
9	*Laticauda colubrina*	7.944241	93.558071	Nancowry	Heatwole et al. 2005
10	*Laticauda colubrina*	10.974	92.224564	South Sentinel	Heatwole et al. 2005
11	*Laticauda colubrina*	13.431481	94.257579	Narcondam	Heatwole et al. 2005
12	*Laticauda colubrina*	12.771147	92.655222	South Reef	Heatwole et al. 2005
13	*Laticauda colubrina*	13.168292	92.796973	Kinvar	Heatwole et al. 2005
14	*Laticauda colubrina*	13.302883	93.075297	Ross & Smith islands	Heatwole et al. 2005
15	*Laticauda colubrina*	11.522104	79.768587	Parangipettai coast	Damotharan et al. 2010
16	*Laticauda colubrina*	7.96726665	93.3576929	Katchal Island	Vijaykumar and David 2006
17	*Laticauda colubrina*	8.49927174	93.6332406	Tillangchong	Vijaykumar and David 2006
18	*Laticauda colubrina*	7.40059776	93.765682	Menchal Island	Vijaykumar and David 2006

that the Caribbean spotted moray *Gymnothorax moringa* is sensitive to the venom of the sea krait at doses as low as 0.01 mg dry weight of venom/kg wet weight of eel and proving lethal at 0.1 mg/kg. These findings imply that the resistance of Pacific *Gymnothorax* to sea krait's venom results from the coevolution of predator and prey (Heatwole and Powell 1998). The yellow-lipped sea krait is known to be docile and even tolerant to some degree of human handling (Shetty and Shine 2002b, Desai Per. Comm.). Not all bites result in venom injection (Takasaki et al. 1988). This sea krait's bite may go unnoticed as the bites are relatively painless or produce minimal pain (Purohit 2019). Symptoms and signs can vary across individuals and occur within hours, including bite marks or teeth marks on an arm or leg. There may be no slight pain or swelling at the bite site. The patient experiences nausea, vomiting, diarrhoea, abdominal pain, headache, unconsciousness, poor reflexes, fatigue, muscle weakness, enlarged lymph nodes, blurred vision, difficulty breathing, dizziness, convulsions, and bluish skin caused by poisoning in case of sea krait bite casualty (Purohit 2019). Currently, specific anti-venoms are unavailable for sea krait bites, and their venoms are poorly researched in India.

Use and trade

Three meat samples in Phuket showed adulteration with traces of yellow-lipped sea krait meat, raising serious consumer concerns (Suntrarachun et al. 2018). While there is no verified evidence, residents in the Andaman Islands claim that Karen migrants from Myanmar have killed this species for food (Gatus pers. comm. 2010).

Threats

Anthropogenic factors like habitat loss and coastal development may be the primary threats to this species. This includes the damage of coastal habitats necessary for egg laying and prey digestion. Since this species is drawn to light, coastal lighting makes them highly vulnerable to anthropogenic activities (Bhaskar 1996). Anecdotal evidence suggests that the number of *L. colubrina* populations on some Fijian islands may have declined due to tourism projects (Marsh et al. 1993).

Sea kraits primarily use the intertidal zone and need appropriate cover, such as beach rocks, between one and four meters from

Figure 1. *Laticauda colubrina*, Schneider, 1799 from the Andaman Islands (Photo credits Digant Desai)

the shoreline (Saint Girons 1964, Ineich and LaBoute 2002; Lane pers. comm 2010). *Laticuda colubrina* is harvested for use as smoked sea snake and exported to Japan (Gatus pers. comm. 2010). Despite not being consumed as food in India, numerous threats to this species exist, such as anthropogenic activities and habitat destruction (Das 2012; Sarker 2013; Cao Van et al. 2014). Suitable amphibious habitats in the inter-tidal region are lost due to rising sea levels associated with climate change. This is expected to constitute a direct future threat (Meehl et al. 2005; Bindoff et al. 2007).

Furthermore, *Laticauda* species have specific oviposition requirements, which have rarely been recorded (Bacolod 1983; Guinea pers. Comm, 2010). In the published literature, egg laying was observed in rocky inter-tidal caves, accessible to kraits only at certain tides. If sea level changes prevent access to suitable egg-laying sites or render these sites unusable, this would also directly threaten the persistence of sea kraits (Lane et al. 2010). Because they switch between land and water, they usually hunt and swim in coral reefs. The indirect threat is due to the degradation of their ecosystems, like coral reefs, and the destruction of mangrove forest habitats (Lane et al. 2010). Mass coral bleaching is associated with elevated sea surface temperature episodes, resulting in significant loss of live cor-

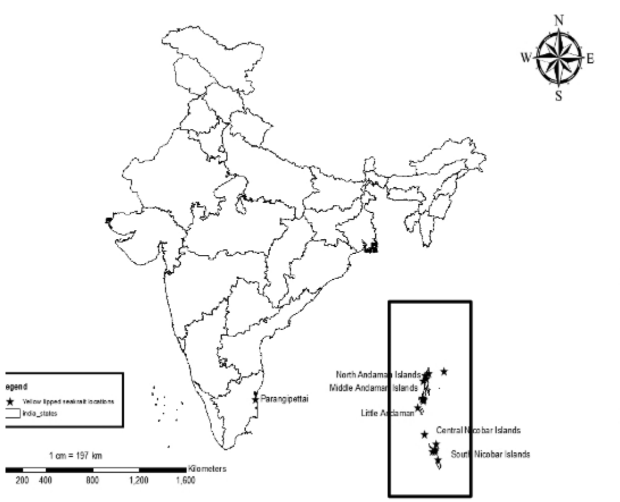

Figure 2. Distribution map of *Laticauda colubrina* in India, Schneider, 1799

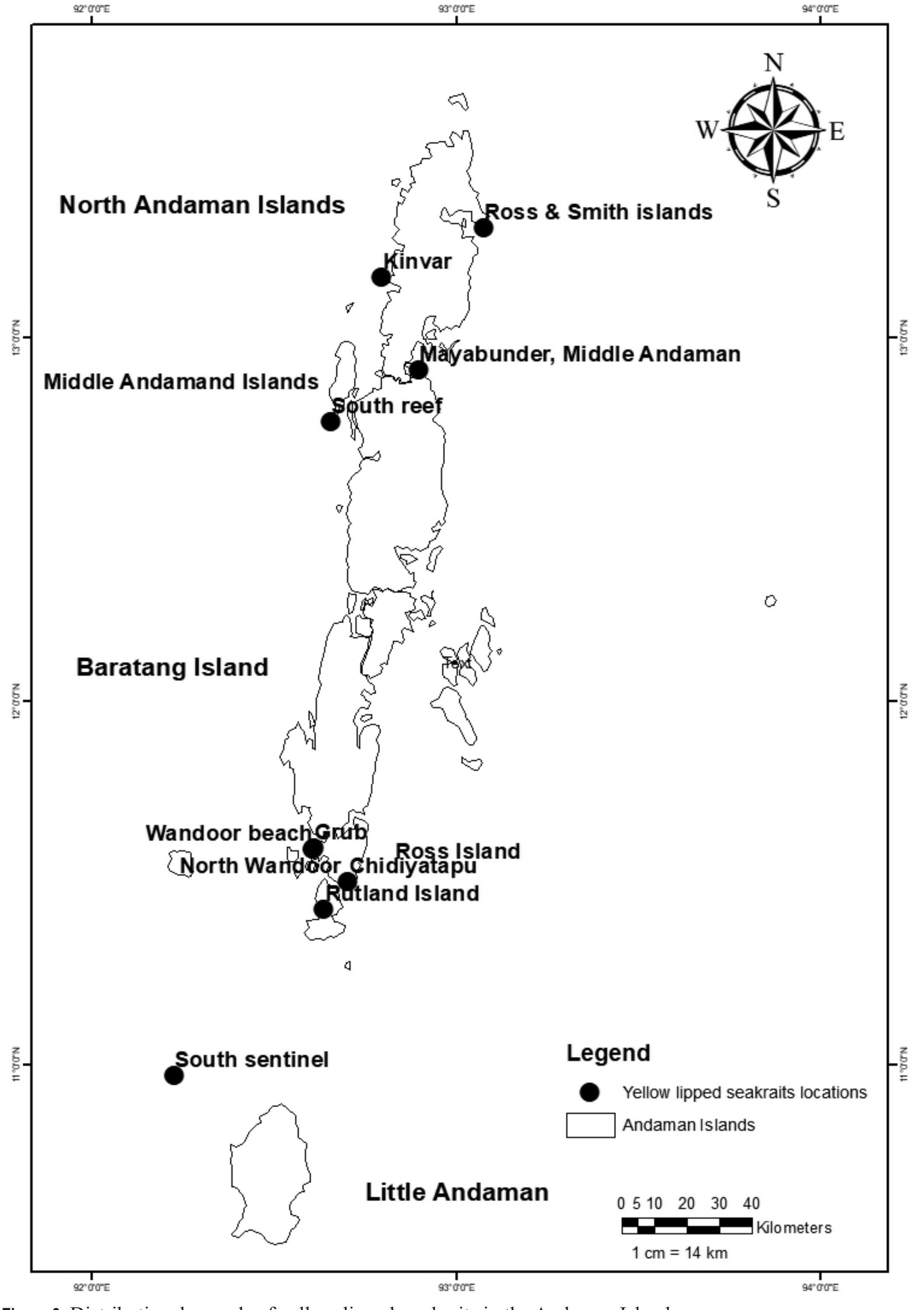

Figure 3. Distributional records of yellow-lipped sea kraits in the Andaman Islands

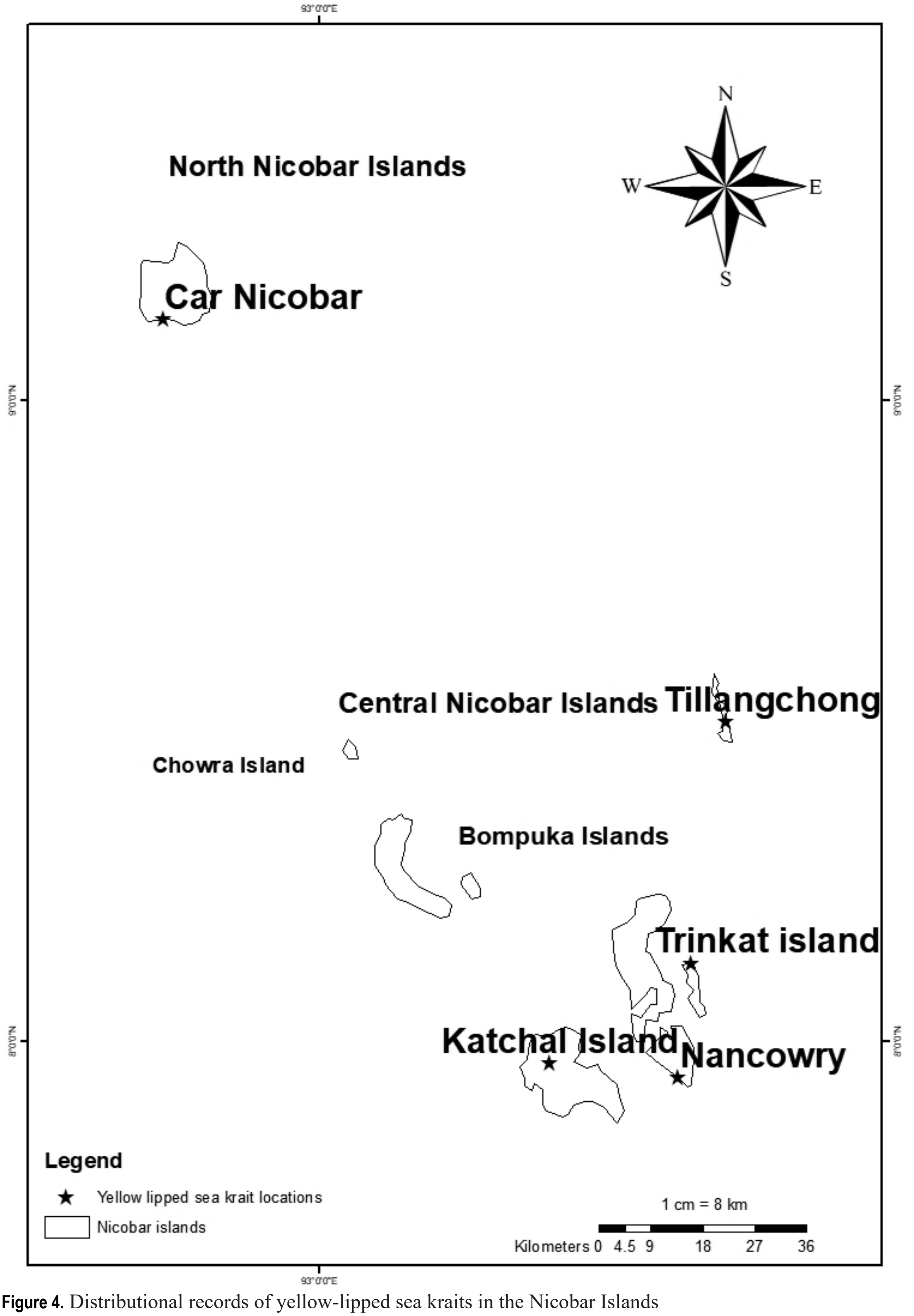

Figure 4. Distributional records of yellow-lipped sea kraits in the Nicobar Islands

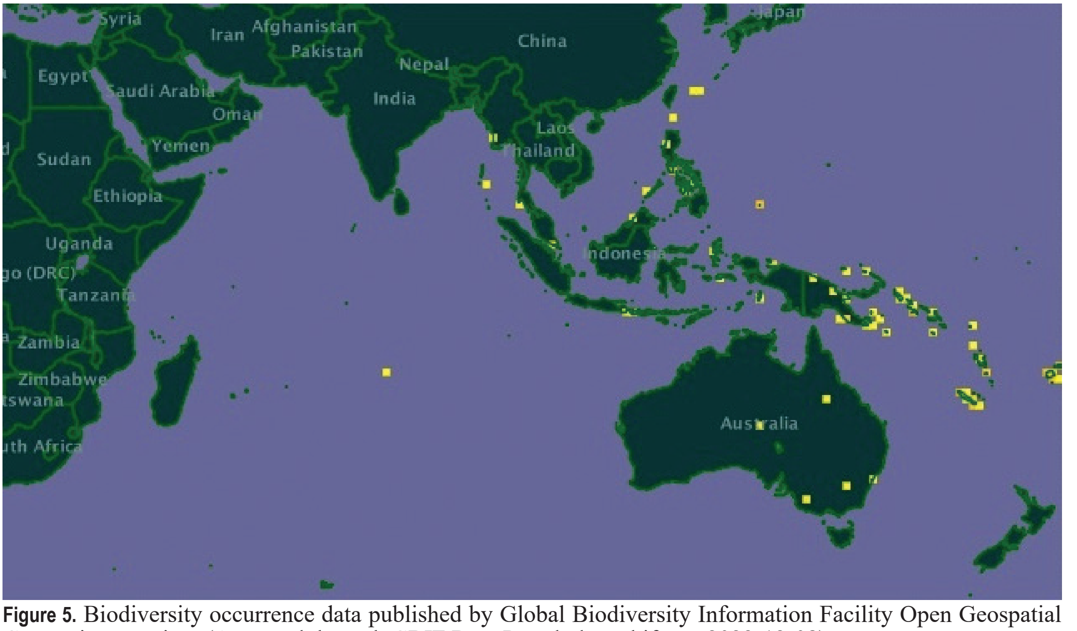

Figure 5. Biodiversity occurrence data published by Global Biodiversity Information Facility Open Geospatial Consortium services (Accessed through GBIF Data Portal, data.gbif.org, 2023-12-08)

al (Hoegh-Guldberg 1999). This reduces habitat complexity, with a consequent decrease in prey abundance (Pratchett et al. 2008) and the loss of refuge sites. Two sea snake sanctuaries have been declared in the Philippines, Gato Island, Cebu, and Pulo Laum, Zamboanga (Department of Tourism, Philippines , 2023).

Conclusion

Yellow-lipped sea kraits only consume eels and aid in regulating eel populations in coral reef ecosystems where they live (McCoy 1980). Although they are designated as a scheduled species in India, it is necessary to understand the impacts of climate change on sea krait's distribution and ecology to prevent exploitation. Human-induced threats to this species are not documented clearly, as they have been sporadically sighted and not adequately documented by researchers in India. A better understanding of the population dynamics, bycatch composition, breeding and nesting habits, and medicinal uses of this species will fill the knowledge gaps currently in India. Detailed research needs to be carried out on factors influencing their distribution and the effect of climate change on their distribution in the future.

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Oriental Rat snake *Ptyas mucosa* (Linnaeus 1758) feeding on an Indian Rock Python *Python molurus* (Linnaeus 1758) from Mumbai, Maharashtra, India

CITATION. Gokarankar, P.K., Hadkar, S.M. and Joshi, P (2024) Oriental Rat snake *Ptyas mucosa* (Linnaeus 1758) feeding on an Indian Rock Python *Python molurus* (Linnaeus 1758) from Mumbai, Maharashtra, India. *Hamadryad*. Vol. 41 (1&2), pp. 41–42.

Snakes frequently engage in ophiophagy (the practice of feeding on snakes), especially the genera *Bungarus, Clelia, Cylindrophis, Drymarchon, Lampropeltis, Micrurus, Naja,* and *Ophiophagus* (Jackson et al. 2004; Maritz et al. 2019). Ophiophagy provides snakes with increased energy due to the higher mass relative to cross-sectional size compared to alternative prey, and some species can eat other snakes that are as long or even longer than they are (Cundall and Greene 2000; Jackson et al. 2004; Maritz et al. 2019). *Ptyas mucosa* (oriental rat snake) is a diurnal snake species with a wide distribution stretching across Iran, Turkmenistan, the Indian Subcontinent, and parts of Southeast Asia (Das 2010). Being a diurnal snake, it is also known to forage during the night (Ghosh et al. 2020). *Ptyas mucosa* is a predatory generalist and is also known to feed on other snakes, including the species *Chrysopelea ornata, Fowlea piscator, Naja naja, Oligodon taeniolatus, Psammophis condanarus, Rhabdophis plumbicolor,* and uropeltid snakes (Weiss and Kalki 2023). In addition, several studies have also reported instances of cannibalism in *P. mucosa* (Saha and Chaudhari 2017; Joshi et al 2023). Herein we report another instance of ophiophagy in the oriental rat snake from Maharashtra Nature Park (MNP), Mumbai, India (Location co-ordinates: 19°03'09.8"N 72°51'46.1" E).

On 22nd July 2022, at 14:48 h Indian Standard Time (IST), we observed an adult *Ptyas mucosa* attacking a juvenile/sub-adult *Python molurus* (much smaller in size compared to *Ptyas mucosa*) on the ground. As the two snakes were sparring, the rat snake captured the python's mid-body in, its mouth (Fig 1A). In response, the python coiled its body around the rat snake's head and began constricting. This predator-prey interaction lasted for approximately 20 minutes. After some time, around 15:15 h, as soon as the python's grip around the rat snake's mouth loosened, the rat snake started swallowing the python from its tail end. By 15:30, after 42 minutes, the rat snake had completely engulfed the python. The rat snake did not kill the python, it engulfed its prey alive (Fig 1B). This instance of ophiophagy was recorded on Oppo A3s Mobile phone (Guangdong Oppo Mobile Telecommunications Corp., Ltd., China) and the snakes were identified based on the characters mentioned in Whitaker and Captain (2004).

Ptyas mucosa is a generalist snake that mainly feeds on frogs, snakes, rodents, lizards, and birds (Whitaker and Captain 2004; Weiss and Kalki 2023). Consumption of inorganic substances was also documented in *P. mucosa*. There have been instances documented where the snakes were seen consuming substances like a piece of cloth, male contraceptive, discarded sock, polythene roll, and plastic bottles (Sharma et al. 2016; Parmar and Patel 2022). However, the intent behind any of these feedings is unknown. In *P. mucosa*, the adult snakes are more inclined towards ophiophagy or cannibalism than subadults or smaller individuals (Saha and Chaudhuri 2017; Weiss and Kalki 2023). Our observation recording an adult *P. mucosa* feeding on *P. molurus* is the first documented instance of such an interaction. This observation adds to the growing knowledge about the diet and generalist nature of *P. mucosa.*

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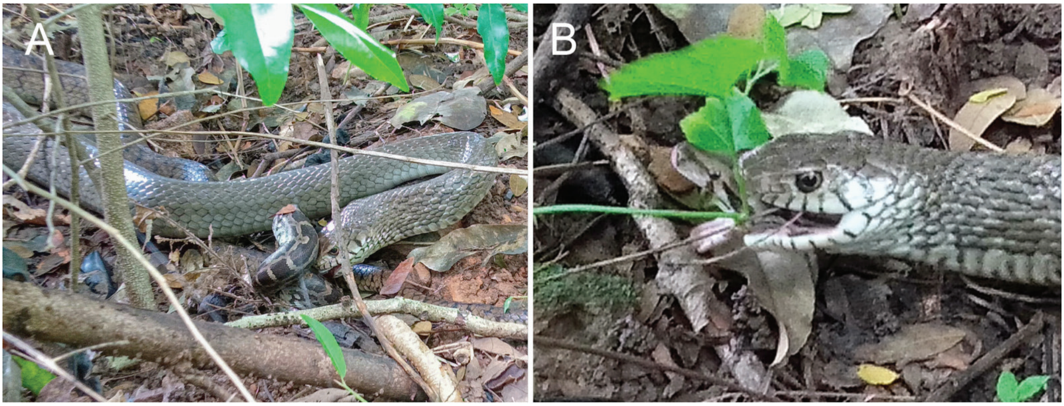

Figure 1. Predation of *Python molurus* (prey) by *Ptyas mucosa* (predator). (A) *Ptyas mucosa* attacking and holding *Python molurus* by its mid-body. (B) *Ptyas mucosa* engulfing *Python molurus* alive.

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Ahaetulla farnsworthi **(Farnsworth's Vine Snake) predation on *Oligodon affinis* (Malabar Brown Kukri Snake)**

CITATION. Hakim., J. and Gowda., S. (2024) *Ahaetulla farnsworthi* (Farnsworth's Vine Snake) predation on *Oligodon affinis* (Malabar Brown Kukri Snake). *Hamadryad*. Vol. 41 (1&2), pp. 43– 44.

Ahaetulla farnsworthi is an arboreal, diurnal predator of the central Western Ghats. Until its description in Mallik et al. (2020), *A. farnsworthi* was lumped within *Ahaetulla nasuta*, a species complex which ranged across most of the Indian subcontinent. Kalki and Weiss (2020) reviewed 209 published notes, citizen science records, and social media posts and found that the observed diet of the *A. nasuta* complex is primarily comprised of frogs, lizards, and snakes, with 20% of the total diet being snake prey. *Oligodon affinis*, a nocturnal snake which ranges across the central and southern Western Ghats (Whitaker and Captain 2004), was not recorded as a prey item of any species in the *A. nasuta* complex.

Reported here is the first observation of *A. farnsworthi* preying on *O. affinis*. On 1 August

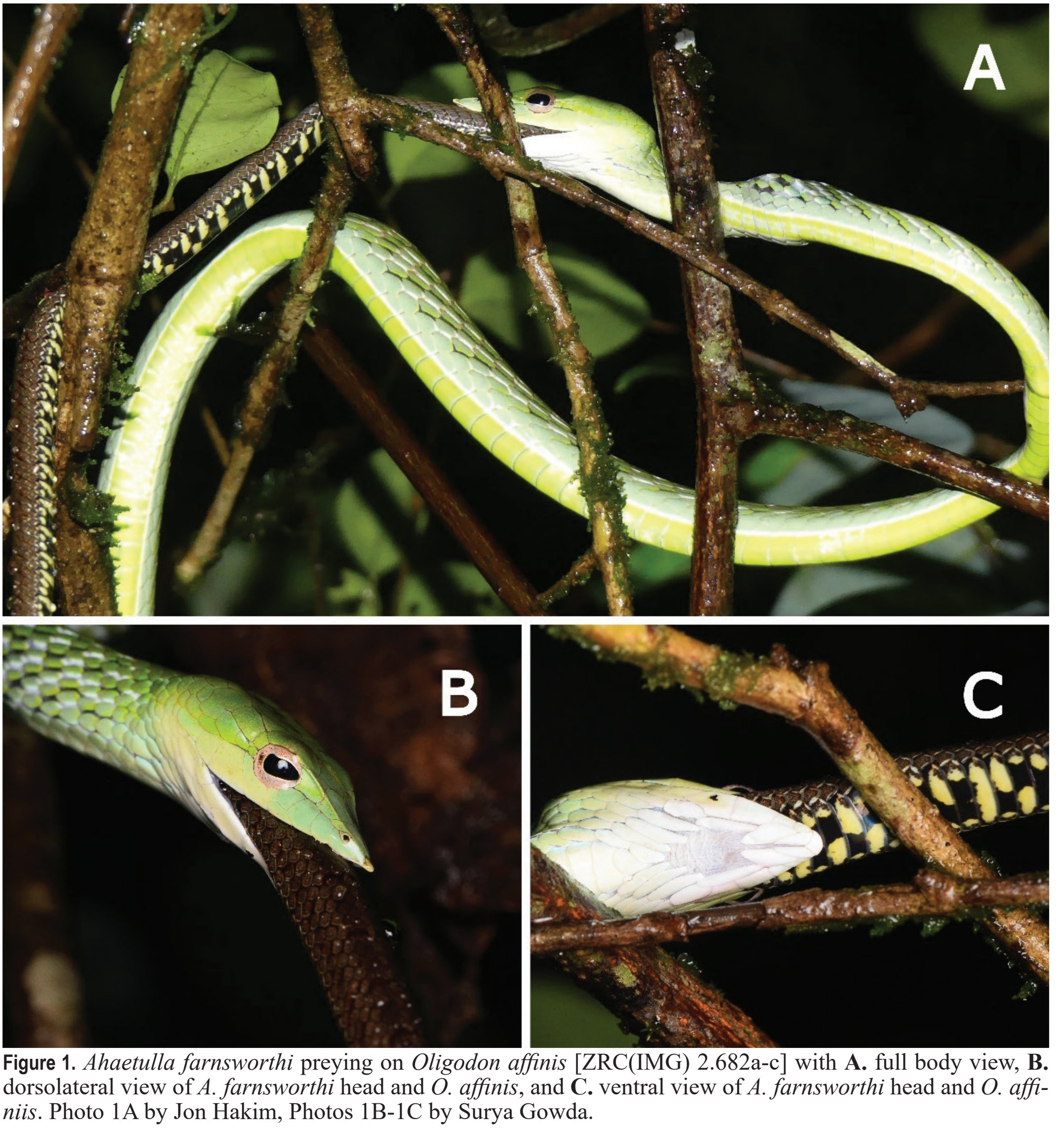

Figure 1. *Ahaetulla farnsworthi* preying on *Oligodon affinis* [ZRC(IMG) 2.682a-c] with **A.** full body view, **B.** dorsolateral view of *A. farnsworthi* head and *O. affinis*, and **C.** ventral view of *A. farnsworthi* head and *O. affiniis*. Photo 1A by Jon Hakim, Photos 1B-1C by Surya Gowda.

2023, the authors walked a dirt road at the Kalinga Centre for Rainforest Ecology, a research station in the mid-elevation rainforest near Agumbe in the Western Ghats of Karnataka (13.574665°N, 75.106837°E, ca. 650 m a.s.l.). At 19:50 h, we observed an adult *A. farnsworthi* swallowing a significantly smaller *O. affinis* (Fig. 1a-c). The *A. farnsworthi* was positioned ~2 m above the ground, potentially having retreated to a higher perch after initially striking down to take the *O. affinis* off the forest floor. The observation is interesting in that it occurred an hour after sundown, unusually late for this diurnal *Ahaetulla*. We suspect it is most likely that the *A. farnsworthi* captured its prey in the fading light of dusk and had taken this long to progress in the feeding process. Photos of the encounter were deposited at the Lee Kong Chian Natural History Museum as ZRC(IMG) 2.682a-c.

The *A. farnsworthi* was identified via the Mallik et al. (2020) diagnostic of a green vine snake with short rostral appendage and presence in the Agumbe-Kodachadri range. The *O. affinis* was identified based on it being a small brown kukri snake with dark, broken crossbars and a yellow venter with rectangular black marks (Whitaker and Captain 2004). Both identifications were confirmed by Vivek Sharma (pers. comm.).

This incident elucidates how snakes can interact across the boundaries of their attributed diurnal/nocturnal and arboreal/terrestrial activity patterns, reminding us of the lack of hard boundaries. As is often said in the field, "snakes don't read the guides."

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Vocalization by the agamid lizard *Calotes emma* Gray, 1845 (Reptilia: Sauria)

CITATION. Bhardwaj, V. K., Lalremsanga, H. T., and Zeeshan, A. M. (2024) Vocalization by the agamid lizard *Calotes emma* Gray, 1845 (Rep- tilia: Sauria). *Hamadryad*. Vol. 41 (1&2), pp. 44–47.

Acoustic communications are a means of passing information from one individual to another of the same species or another species. The information, for example, may be used to attract members of the same species as a means of sexual signalling, to warn off opponents or predators, or to exhibit distress under specific circumstances (Fletcher 1997; Russell and Bauer 2021). The ability to produce sound is widespread across the animal kingdom, spanning invertebrate and vertebrate groups. However, vertebrates, especially mammals, birds, and amphibians (Brudzynski 2009; Duellman and Trueb, 1994; Thorpe 1969), are prime examples of taxa that exhibit simple to extremely complex

Table 1. Summary of the attributes of the call by *Calotes emma*

	Range	Mean	±SD
Call duration (ms)	265–301	289	20.78
Low Freq (kHz)	0.34–0.55	0.48	0.12
High Freq (kHz)	15.8–16.21	16.03	0.21
Delta Freq (kHz)	15.3–15.9	15.57	0.3
Max Amp (U)	2007–5593	3042	2222.28
Max Freq (kHz)	8.61–13.8	11.77	2.77
Harmonics	18–23	20.33	2.52

vocalizations not only to communicate but also to imitate sounds produced by other distantly related species (Thorpe 1969). Conversely, only a few groups of reptiles have the ability to produce sound as a means of communication. Sounds produced by most reptiles, for example, large varanid lizards, chameleons, crocodilians and several species of snakes, can be classified as a hiss, grunt or a growl. Many of these sounds are produced by exhaling air from the lungs, which passes through the larynx and is extruded from the glottis (Russell and Bauer 2021). The sound produced through this process, if at all, is unstructured and cannot be termed as true vocalization. True structured vocalization in reptiles is primarily attributed to lizards, especially gekkonid lizards and, to an extent, a few other lizard genera of other families (Vitt and Caldwell 2013). To produce true vocalization, modulated acoustic expulsions of air pass through a modified larynx or glottis, with vocal cords or similar structures that obstruct the airflow, thereby altering the pattern of airflow and producing tonal sound (Russell and Bauer 2021). Several examples of non-gekkonid lizards that vocalize are Dactyloidae (several species of *Anolis*) (Russell and Bauer 2021), Lacertidae (*Psammodromus algirus*) (Baeckens et al. 2019), Liolaemidae (*Liolaemus chiliensis*) (Carothers et al. 2001), Scincidae (*Tribolonotus gracilis*) (Hartdegen et al. 2001) , Pygopodidae (*Delma tincta* and *Lialis burtonis*) (Weber and Werner 1977) and a single species of the Agamidae (*Calotes minor*) (Cockburn 1882).

A recent observation has enabled us to add another species of agamid lizard of the genus *Calotes* to the list of species capable of vocalizing. An adult male *Calotes emma* Gray 1845, (snout to vent length 103 mm) was collected as part of an ongoing study of reptiles of Mizoram state. The individual was housed in a large plastic container with several holes punctured

Figure 1. Image of the male individual of *Calotes emma*. Photograph by Virender K. Bhardwaj

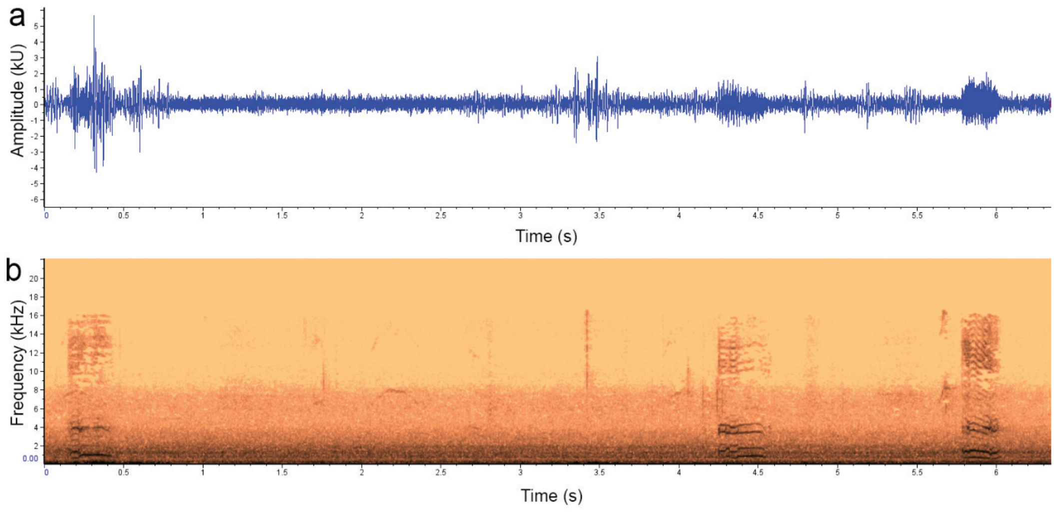

Figure 2. Call of male *Calotes emma* (a) Amplitude (b) spectrogram showing harmonics.

on the container for ventilation. The animal was retrieved from the container by one of us (VKB) for examination, upon which the animal produced an audible squeak. The animal was placed back in the container and was caught again by its trunk, and the animal produced the same squeak. Upon observing the consistent vocalization of the lizard upon handling, we decided to record and analyse its call. To do this, we stimulated the lizard to produce the sound by holding it by its trunk. We then recorded the call using an Apple iPhone 14 pro max in cinematic mode, extracted the audio in mp4 format, and analysed it using Raven Pro v.1.6.5 software. The call's attributes were recorded from the software, and the details are presented in Table 1. The recording was done on 6th April 2024 at 2350 hours.

The animal's call consists of short, tonal, low-pitched vocalization with several harmonics (Fig. 1, Table 1). The summary is based on three notes of the call. The call duration ranged from 265–301 ms with a low-frequency range of 0.34–0.55 kHz, whereas the high-frequency range was 15.8–16.10 kHz. The animal produced the sound every time it was caught, suggesting it might be a distress call. However, another juvenile of the species was captured to see if it, too, could vocalize, but interestingly, the juvenile did not produce any sound. It is likely that only adult individuals can call. However, further research is necessary to confirm if females can produce the sounds as well or if only males are capable of vocalizing, in which case, the sound might be used as a means of sexual signalling.

The present observation constitutes the second record of vocalization by an agamid lizard and the first for *C. emma*. The first one is *Calotes minor*, which, too, was recorded to produce a squeak when captured (Cockburn 1882). However, further confirmation is required to assess the species' vocalization ability. The two *Calotes* species, *C. emma* and *C. minor* are members of different clades (Deepak et al. 2015), and the origin of the ability to vocalize could have evolved independently hinting at a convergent evolution of the trait. Further work on the vocalization by *C. emma* will be necessary to ascertain if the ability to vocalize is limited to adults or only the males. This information will help categorise if the call is a distress call or if it is also employed for other forms of communication, such as sexual signalling or intraspecific or interspecific interactions. The findings of the present work and the aforementioned investigations will open new avenues for future research.

Acknowledgements

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A rapid assessment of herpetofaunal diversity and mortality along a railway track in Northern Western Ghats, India

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