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**Tests of the CBH and Expensive Brain Hypothesis**

**Ecological and Reproductive Predictors of Brain Size and Brain Shape**

**Abstract**

**Introduction**

1. Cognitive buffer hypothesis (ecology)
   1. Microhabitat (fossorial, scansorial, terrestrial)
   2. Foraging mode (active foraging, sit & wait, mixed)
   3. Activity patterns (cathemeral, diurnal, nocturnal)
   4. Substrate (arboreal, arboreal saxicolous, arboreal saxicolous terrestrial, arboreal terrestrial, cryptic, fossorial, fossorial terrestrial, semi aquatic, terrestrial)
2. Expensive brain hypothesis (life history)
   1. hSVL
   2. clutch size
   3. reproductive mode (oviparous, viviparous)

**Materials and Methods**

*Data collection and categorization*

This study was conducted with 29 lizard species across X many taxonomic affiliations.

The 3D coordinate brain data set (Macri et al. 2019) contains 61 anatomical landmarks that, when clustered into groups, create a 3D profile of the five major brain subdivisions: telencephalon, diencephalon, mesencephalon, cerebellum, and medulla oblongata. Following the methods of Macri et al. (2019), we used a Generalized Proctrustes Analysis (GPA) to extract shape and size data from the anatomical landmarks…. (this is where I describe in words what our R code is doing and also attach R code in the manuscript unlike Macri!)

The trait data set (refer to Supplementary information) was created by cross-referencing data from reptile databases and available literature: **main biogeographic realm** (Afrotropic, Australia, Madagascar, Neotropic, Oriental, Palearctic); **latitude**; **longitude**; **snout to vent length (SVL)**; **habitat modes** (aerial arboreal, aerial semiarboreal, arboreal, burrower, facultative burrower, semiarboreal, terrestrial); **activity time** (cathemeral, diurnal, nocturnal); **substrate** (arboreal, arboreal saxicolous, arboreal saxicolous terrestrial, arboreal terrestrial, cryptic, fossorial, fossorial terrestrial, semi aquatic, terrestrial); **microhabitat** (fossorial, scansorial, terrestrial); **foraging mode** (active foraging, sit & wait, mixed); **reproductive mode** (oviparous, viviparous); **clutch size**; **IUCN redlist assessment** (DD, LC, NE, NT); and **IUCN population trend** (decreasing, NE, stable, unknown).

For species with missing data for a continuous trait (SVL and clutch size), we used “phylopars” to estimate imputed values for those missing data. For species with missing data for a categorial trait (e.g., foraging mode and activity time), we either inferred the data based on other aspects of their life history or left them as unkown (refer to supplementary). (?maybe we can also put in all the possible values of the trait and see if it has an effect?)

Trait data

Tree data

Brain morphology data was Used morphometric CT scan data from Macri et al. (2019)

For foraging mode, we were only missing data from Melanoseps loveridgei. Since this species in a fossorial species, we categorized it as an active forager.

All traits ~ whole brain shape

All traits ~ whole brain size

**Results**

**With all life history traits groups and all ecology traits groups**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | | | | | |
| Brain Shape | Cognitive Buffer Hypothesis  (Ecology) | | | | Expensive Brain Hypothesis  (Life History) | | |
| Brain Region | Microhabitat | Foraging Mode | Activity Time | Substrate | Hatchling SVL | Clutch Size | Reproductive Mode |
| Telencephalon | ns | ns | ns | NA | ns | ns | ns |
| Diencephalon | ns | ns | ns | NA | ns | ns | 0.077 |
| Mesencephalon | ns | ns | 0.069 | NA | 0.006 | ns | ns |
| Cerebellum | ns | ns | 0.046 | NA | 0.090 | ns | ns |
| Medulla Oblongota | ns | ns | 0.090 | NA | ns | ns | ns |
| Whole Brain | ns | ns | ns | NA | 0.055 | ns | ns |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | | | | | |
| Brain Size | Cognitive Buffer Hypothesis  (Ecology) | | | | Expensive Brain Hypothesis  (Life History) | | |
| Brain Region | Microhabitat | Foraging Mode | Activity Time | Substrate | Hatchling SVL | Clutch Size | Reproductive Mode |
| Telencephalon |  |  |  |  |  |  |  |
| Diencephalon |  |  |  |  |  |  |  |
| Mesencephalon |  |  |  |  |  |  |  |
| Cerebellum |  |  |  |  |  |  |  |
| Medulla Oblongota |  |  |  |  |  |  |  |
| Whole Brain |  |  |  |  |  |  |  |

**Clutch size and foraging mode big patterns in whole brain size**

**Discussion**

**References**

**Figure Legends**

**Figures**

**Tables**