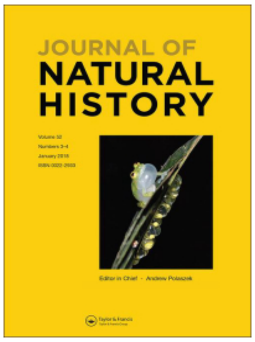

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Comparative dental morphology in sympatric Bornean *Eutropis* (Squamata: Sauria: Scincidae)

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ABSTRACT

Scincidae is a speciose squamate family that is both ecologically diverse and near-cosmopolitan in distribution. The osteology of Scincidae, and particularly the dentition, remains understudied. The tooth morphology of three sympatric skink species of the genus *Eutropis* (*E. multifasciata*, *E. rudis* and *E. rugifera*), collected from Kota Samarahan, western Sarawak (Borneo), was studied using scanning electron microscopy (SEM). The primary aim was to compare gross tooth as well as fine surface morphology, and to determine possible adaptive suites vis-à-vis their respective diets. Lizards were collected during visual encounter surveys, through the use of adhesive traps, then euthanised and decapitated. Following standard protocol, the maxilla, the mandible and the palatine region were prepared using an ethanol series, critically point-dried and examined under an electron microscope. To determine the possible functions of dental features, implements used in cutting and breaking (scalpel blades, knives and drills) tools were standardised according to the literature. Inter-specific variation in tooth structure was observed, suggesting that blade-like and drill-bit forms function to reduce food bolus size through slicing and drilling, respectively. Comparisons with scalpel blade ridges and edges of commercial drills with dentitional structures, particularly on occlusal surfaces, provide examples of an interdisciplinary approach to understanding the functional application of tooth morphology and its potential for inspiring biologically informed product design.

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Dentition; ecology; ecomorphology; scanning electron microscopy

Introduction

The squamate family Scincidae is speciose (nearly 1,800 extant species; Uetz *et al*. 2025), ecologically diverse and near-cosmopolitan, occurring on all continents except Antarctica (Greer 2007; Melville and Swain 2000). Nonetheless, relatively little has been published on its osteology, including dentition within the group, and its form–function correlation, if any, remains largely unknown. The genus *Eutropis* comprises up to 46 species, which are widely distributed throughout tropical Asia (Das 2010; Barley *et al*. 2015; Amarasinghe *et al*. 2022). Studies of dentition within the lineage are scarce, and restricted to gross morphology and variation, as well as growth and ontogeny.

Dietary competition and resource partitioning leading to morphological diversification are major selection pressures that shape ecological communities, potentially affecting morphology in sympatric species (Pinho *et al*. 2024). In particular, studies of dentition morphology in squamate reptiles are critical in understanding feeding preferences and niche selection (Christensen and Melstrom 2021), since their jaws have been assumed to lack significant masticatory action (Crompton and Hylander 1986, but see below). Melstrom (2017) documented a diversity of dentitional features in living and extinct lineages, correlated to diet, as shown across vertebrates as a group (Poyner 2011).

Scincid dentition has generally been described as isodont and cylindrical (Hutchinson 1993), and a dietary association is implied when corresponding ecological data are available (Paluh *et al*. 2017). The apical portion of the majority of scincid lizard teeth has been described as either obtuse or with a chisel-shaped crown, typically with a crest that is demarcated by a groove (which is known to disappear posterior to the symphysis in *Aethesia frangens* from the Plio–Pleistocene of Australia; Hutchinson and Scanlon 2009). Species that supposedly feed on durophagous prey, such as members of the Australasian skink genera *Tiliqua* and *Cyclodomorphus*, show molariform teeth (Edmund 1969; Estes and Williams 1984), and an apparent extreme condition is encountered in the

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New Caledonian *Phoboscincus bocourti*, a specialist of crustaceans (Jowers *et al*. 2022). Recurved dentitions, on the other hand, as in members of the genus *Coeranoscincus*, are considered specialisations for a diet of earthworms (Greer and Cogger 1985; Ehmann 1987). Two morphotypes are associated with herbivory: numerous, close-packed teeth, with reduced crown making a cutting edge, characteristic of certain members of the *Egernia cunninghami* species group; and of laterally compressed teeth for efficiency in chopping vegetation, as in the Solomon Islands *Corucia zebrata* (Kosma 2004). Finally, a quinquecuspid crown occurs in the recently extinct omnivorous (with a tendency towards herbivory) *Chioninia coctaei* (Böhme *et al*. 2022). As a caveat, it needs to be mentioned that robust teeth alone may not necessarily correspond to a diet of hard food (Cernanský *et al*. 2020), and other factors may be at play. For instance, significant portions of the diets of such species may, in fact, comprise other categories of food, depending on availability and physiological requirements. Additionally, ontogenetic effects on dentitional form have been reported by Estes and Williams (1984).

Squamates, including members of the Scincidae, exhibit polyphyodonty, referring to the type of dentition where teeth can be generated and replaced multiple times (Razmadze *et al*. 2024). As skinks exhibit a diverse range of feeding habits, including insectivory, omnivory and herbivory, dentitional adaptations may be diverse even at the macro level – for instance, the apical crown can be thin and blunt, long and pointed, short and wide, or laterally compressed (Greer 2007).

Three sympatric *Eutropis* species were considered for the present study: *E. multifasciata*, *E. rudis* and *E. rugifera*. They are known to occur across Borneo, in both forested, edge and oil palm plantation areas (Das 2010; Amarasinghe *et al*. 2018; Kumar *et al*. 2025): *E. multifasciata* is a widespread, edge species with a generalised ecology; *E. rudis* is a terrestrial, forest-restricted species, presumed to have a specialised diet, and thus the narrowest dietary niche (Xuan 2025); and *E. rugifera* is a terrestrial/semi-arboreal, forest-restricted species. The diet of *E. multifasciata* is known to include members of the orders Araneae, Blattodea, Coleoptera, Dermaptera, Diptera, Hymenoptera, Odonata and Orthoptera (Das 2010; Kumar *et al*. 2025), and occasionally vertebrates such as frogs, geckos and skinks (Ngo *et al*. 2015; Hazarika and Sharma 2018). *Eutropis rudis* is known to predominately feed on Araneae, Blattodea, Orthroptera and Lepidoptera larvae (Inger 1959; Xuan 2025), whereas *E. rugifera* feeds on Aranae, Coleoptera and Hemiptera (Xuan 2025). In the present study, the dentitional morphology of these species was studied for possible association with their respective diets. We hypothesise that species ingesting larger prey types are likely to have more elongate teeth (for prey processing that include capture and immobilisation), while those consuming harder prey would show teeth adaptive for crushing and grinding.

Material and methods

Skink material

Three specimens each of *Eutropis multifasciata*, *E. rudis* and *E. rugifera* were collected with adhesive traps (Bauer and Sadlier 1992; Kumar *et al*. 2025) during field surveys in the Real Living Laboratory Arboretum of the Kota Samarahan campus of Universiti Malaysia Sarawak (UNIMAS). The site comprises an arboretum with an admixture of freshwater peat swamp and mangrove vegetation. Specimens were extracted from the traps using commercially available vegetable oil. All were adults, except UNIMAS 9822 (*E. rugifera*), identifiable by its small size and umbilical scar as a the hatchling. Dentigerous materials, including maxillary bones (premaxilla and maxilla), mandibular (dentary) bones and the palate (palatine bones) were prepared in the lab. Specimens were euthanised using tricaine injection, followed by decapitation, maceration and manual cleaning with the use of commercial detergents to remove muscles, fat and other tissues. Bone materials were dehydrated using an ethanol series and critically point dried (Das and Coe 1994), using a Quotum™ K 850 Dryer (12 v dc), rivetted to 4 mm aluminium stubs, platinum-coated using a Jeol™ JEC-3000FC Autofine Coater, set to auto function at 300 secs/20 mA. Prepared specimens were examined using a Jeol™ (JSM-6390 LA) Analytical Scanning Electron Microscope (Delgado *et al*. 2003). Screen captures of key areas were saved as tiff files and edited using Photoshop 2024 (version 26.1). Voucher specimens were retained in the systematic collection of the Museum of the Institute of Biodiversity and Environmental Conservation (*Eutropis multifasciata*: UNIMAS 9814–9816; *E. rudis*: UNIMAS 9817–9819; and *E. rugifera*: UNIMAS 9820–9822; see Table 1).