

Observations of infanticide and cannibalism in four species of cordylid lizard (Squamata: Cordylidae) in captivity and the wild

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Cannibalism, the consumption of conspecifics, is taxonomically widespread and occurs across a diversity of reptilian species (Polis and Myers, 1985). A long-standing, yet antiquated, perspective views cannibalism as an aberrant behaviour (as discussed in Fox, 1975), but contemporary investigations have noted its important role in the ecology and evolution of many wild populations (Robbins et al., 2013; Cooper et al., 2015; Van Kleek et al., 2018). Examples of this include habitat partitioning and optimising resource availability, as seen in juvenile Komodo Dragons, *Varanus komodoensis* Ouwens, 1912, taking to the trees to avoid ground-confined adults (Imansyah et al., 2008), or Skyros Wall Lizards, *Podarcis gaigeae* (Werner, 1930), optimising resource availability in dense or insular populations by eliminating future rivals through infanticide (i.e., the killing of juvenile conspecifics) and obtaining food resources immediately through cannibalism (Cooper et al., 2015). The evolutionary costs and benefits of infanticide and cannibalism become further complicated when a parent is killing and consuming their offspring (i.e., filial cannibalism), leading to fitness trade-offs (Huang, 2008). For example, increased predation pressure causes mother Long-tailed Sun Skinks, *Eutropis longicaudata* (Hallowell, 1857), to consume their offspring to recover energy from a perceived inevitable clutch failure (Huang, 2008).

The family Cordylidae consists of 70 species of sub-Saharan lizard (Uetz et al., 2020) that reside across much

of Africa (Reissig, 2014), from Ethiopia to South Africa (latitudinally) and Angola to Ethiopia (longitudinally). Here, we present observations of cannibalism by four species of cordylid lizard, two from free-living wild populations and another two from captive settings. Since the natural history of many cordylid species remains deficient, and several species have been observed to display reasonably high degrees of sociality, like group-living in Armadillo Lizards, *Ouroborus cataphractus* (Boie, 1828) (Mouton, 2011) and Sungazers, *Smaug giganteus* (Smith, 1844) (Parusnath, 2020), these observations provide important insights into one of the potential mechanisms shaping cordylid ecology and sociality.

Blue-spotted Lizard, *Ninurta coeruleopunctatus* (Hewitt & Methuen, 1913)

Ninurta coeruleopunctatus is a medium-sized cordylid (maximum snout–vent length, SVL = 82 mm) endemic to the southern Cape Fold Mountains and found along the moist fynbos regions of the Garden Route, South Africa (Bates et al., 2014; Reissig, 2014). This species is a diurnal, active forager with a primarily insectivorous diet, which is often found on outcrops, cliffs, and inside crevices, yet these lizards have also been seen to use burrows (Reissig, 2014). On 14 January 2021, within Tsitsikamma National Park, Eastern Cape, South Africa (centred on 33.9390°S, 23.8915°E), we observed an adult *N. coeruleopunctatus* preying upon a juvenile conspecific.

Initially the focal adult was seen to be chasing several lizards – a Red-sided Skink, *Trachylepis homalocephala* (Wiegmann, 1828), a Rock Agama, *Agama atra* Daudin, 1802, a conspecific adult, and lastly a juvenile *N. coeruleopunctatus*. We initially thought this behaviour was related to potential territorial disputes, but when the adult *N. coeruleopunctatus* eventually caught the juvenile conspecific, it took hold of it by the head and neck and after a short time (approximately 30 s) the juvenile appeared dead. The adult *N. coeruleopunctatus* then fled with the juvenile secured in its mouth. The act

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of capturing, killing, and carrying away a prey item is consistent with hunting behaviour and we presume the adult lizard consumed the juvenile shortly after we lost sight of it.

Southern Karusa Lizard, *Karusasaurus polyzonus* (Smith, 1838)

Karusasaurus polyzonus is a medium-sized cordylid (maximum SVL = 116 mm) with a wide distribution across western South Africa and Namibia (Reissig, 2014). *Karusasaurus polyzonus* is found across a variety of rocky habitats of the Nama-Karoo, Succulent Karoo, and Renosterveld (Bates et al., 2014; Reissig, 2014). This lizard is diurnally active, with a diet consisting primarily of insects (Broeckhoven and Mouton, 2014). They are generally thought to be largely solitary, however they can be found in basking groups of up to three individuals (J. Riley, unpublished data).

In April 2019, during a study of wild-caught, gravid cordylid lizards in captivity, females were brought into a lab at Stellenbosch University (centred on 33.9327°S, 18.8637°E) and housed individually. During this time, we noted four occurrences of infanticide by *K. polyzonus* mothers soon after parturition. These interactions were not directly observed, but their results were encountered and documented during daily husbandry procedures. In one of these four infanticidal events, the offspring was ingested by the mother (i.e., filial cannibalism). In all cases, the deceased were the first-born individual of the litter.

After these events occurred, we altered our husbandry protocol and separately fed females and offspring outside of their home enclosure, with the goal of disassociating the feeding response of mothers from the vicinity of their young. This approach appeared to be successful, as no other instances of infanticidal behaviour, or subsequent cannibalism, were observed. Although cannibalism appeared to be related to the mother's feeding response, other factors may also play a role in the occurrence of filial cannibalism in *K. polyzonus*. The captive environment may increase a lizard's perceived predation risk, which can in turn lead to filial cannibalism as mothers try to pre-emptively recuperate energy from what they perceive to be an inevitable clutch failure (e.g., *E. longicaudata*; Huang, 2008). Interestingly, during the same period when we made these observations, three other cordylid species – *O. cataphractus*, *Cordylus macropholis* (Boulenger, 1910), and *Namazonurus peersi* (Hewitt, 1932) – were also in captivity to monitor parturition. No infanticidal

or cannibalistic behaviour was observed in these three species, although they were housed in identical conditions to that of the *K. polyzonus*.

Swazi Dragon Lizard, *Smaug swazicus* Bates & Stanley, 2020

Smaug swazicus is a medium-sized cordylid (maximum SVL = 145 mm) with a restricted distribution, near-endemic to eSwatini (ca. 90% of its range) and extending southward into South Africa (ca. 10%; Bates and Stanley, 2020). This diurnal species is often found within rocky habitats, typically living within deep crevices along hillsides and usually in areas partially shaded by vegetation (Bates and Stanley, 2020). To date no formal examination of the diet of *S. swazicus* has been conducted, but closely related *Smaug* species are known to predominately feed on invertebrates, such as insects and land snails, but will also take vertebrate prey, like frogs and lizards (Bates and Stanley, 2020).

At midday on 25 February 2020, within Ithala Game Reserve, KwaZulu Natal, South Africa (centred on 27.5064°S, 31.2988°E), we observed an adult *S. swazicus* engaging in infanticide and cannibalism. The focal adult (Fig. 1) left the refuge of a rock crevice and moved about 5 m to capture a conspecific juvenile that was basking outside another crevice. Once captured and subdued, the adult then carried the prey item to the entrance of its original crevice and was observed to consume it.

Transvaal Girdled Lizard, *Cordylus vittifer* (Reichenow, 1887)

Cordylus vittifer is a medium-sized cordylid (maximum SVL = 95 mm) with a distribution covering northeastern South Africa and eSwatini, with the species range extending into southern Mozambique and southeastern Botswana (Bates et al., 2014; Reissig, 2014). They are diurnally active and are commonly found within rocky outcrops in grasslands and savannah (Bates et al., 2014; Reissig, 2014). To the best of our knowledge no formal examination of the diet of *C. vittifer* has been conducted. Early accounts of the species, including captive feeding observations, have suggested these lizards forage widely for invertebrate prey, particularly beetles, but this assertion is speculative (Jacobsen, 1972).

On 19 January 2018, a captive gravid female was seen to engage in infanticide and filial cannibalism on one of her own recently-born offspring. After parturition, two of three juveniles freed themselves from their embryonic sac and were left alone by their mother, however the remaining individual which did not



Figure 1. A wild adult Swazi Dragon Lizard, *Smaug swazicus* Bates & Stanley, 2020, after capturing, killing, and consuming a juvenile conspecific.

break free immediately was promptly consumed. The cannibalised juvenile appeared to be alive, but simply had yet to emerge from the embryonic sac. Accounts from the herpetocultural community have noted that mother cordylids will consume stillborn offspring and undeveloped ova (J. Reissig, unpublished data), which aligns with published accounts from other squamates (Lourdais et al., 2005; Mocino-Deloya et al., 2009; Caldwell et al., 2018). This observation is notable since the juvenile consumed appeared alive prior to the attack, making this account more akin to what we describe about filial cannibalism in *K. polyzonus*.

Discussion

Infanticide and cannibalism have not previously been reported in any of these four species. This is of particular interest for the observations of *N. coeruleopunctatus* and *S. swazicus*, as the only other account of cordylid cannibalism occurring in the wild – as far as we are aware – is from a dietary study on *S. giganteus*, where a juvenile was recovered from the stomach content of an adult female (Van Wyk, 2000). Interestingly, the cannibalised juvenile *S. giganteus* was

the only vertebrate prey item recovered in that study, from a relatively large sample size of stomach contents ($n = 480$), where all other prey items were invertebrates (Van Wyk, 2000). This may suggest that even when natural diets are almost exclusively invertebrate-centric, individuals will occasionally take conspecific prey, albeit rarely. With respect to the two instances of infanticide and filial cannibalism of captive cordylids, it is difficult to disentangle from natural feeding behaviour or captivity stress. However, previously this behaviour has been recorded for *S. giganteus* adult males in captive settings (Marais, 1984) and generalised statements have been made about species from the genera *Smaug* and *Pseudocordylus* as known to cannibalise juveniles in herpetocultural collections (Reissig, 2014).

Cordylid lizards are well-known to display a diversity of social systems, ranging from solitary to group-living species (Mouton, 2011). In another social squamate group, Australian skinks of the subfamily Egerniinae, filial cannibalism has also been observed in captive settings, such as in *Egernia striolata* (Peters, 1870) (J. Riley, unpublished data). Similarly, infanticide has been recorded in wild populations of several egeriinae

skinks, including *E. saxatilis* Cogger, 1960 (O'Connor and Shine, 2004), *E. stokesii* (Gray, 1845) (Lanham and Bull, 2000), and *Liopholis whitii* (Lacépède, 1804) (Sinn et al., 2008). Infanticide is thought to be commonplace in egeriine skinks (While et al., 2015) and an important driver for the evolution of parental care and kin discrimination in this clade. In fact, simple associations between mother egeriine skinks and offspring can virtually eliminate the threat of infanticide by other conspecifics (O'Connor and Shine, 2004). As the social and mating systems of cordylid lizards are largely undescribed, the role of infanticide in the evolution of social behaviours, such as parental care, remains unknown. Future research on this topic is likely to be fruitful and may serve to inform hypotheses regarding convergent evolution of reptile sociality.

In general, there remain significant gaps in our understanding of many aspects of cordylid natural history, including the potential ecological, evolutionary, and social impacts of conspecific aggression, infanticide, and cannibalism. Ostensibly, it appears that under normal, natural conditions the rate of cannibalism in cordylids may be relatively low (as reported by Van Wyk, 2000), yet the potential for it to impact spatial ecology and social structure, particularly across ontogeny, does exist. We hope our observations can spur future research into the intraspecific interactions of this fascinating and diverse family of African lizards, particularly in wild settings.

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