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Cohabitation by *Bothrops asper* (Garman 1883) and *Leptodactylus savagei* (Heyer 2005)

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Bothrops asper is one of the largest (up to 245 cm) pit vipers in Central America (Hardy, 1994; Rojas et al., 1997; Campbell and Lamar, 2004). Its range extends from northern Mexico to the Pacific Lowlands of Ecuador. In Costa Rica it is found predominantly in Atlantic Lowland Wet forests. *Leptodactylus savagei*, a large (up to 180 mm females: 170 mm males snout-vent length [SVL]), nocturnal, ground-dwelling anuran, is found in both Pacific and Atlantic rainforests from Honduras into Colombia (Heyer, 2005). Across their ranges, both species probably originated from old forest but now are also found in secondary forest, agricultural, disturbed and human inhabited land (McCranie and Wilson, 2002; Savage, 2002; Sasa et al., 2009). Such habitat adaptation is most likely aided by tolerance for a wide variety of prey and environments. Both species are carnivorous. From hatching *L. savagei* feeds on virtually any prey sizable to swallow. Its tadpoles survive on an omnivorous diet (Heyer et al., 1975). Prey items of adult *L. savagei* include small mammals, bird chicks, snakes, and other frogs, including *Dendrobates* spp. It is the only New World frog known to eat scorpions (Lourenco, 1995). *B. asper* is reported to feed on lizards and amphibians when young, but switch to a predominantly mammalian diet when adult (Leenders, 2001; Savage, 2002).

During an amphibian survey in an area of *Manicaria* swamp forest (Lewis et al., 2010) in the north coastal region of Tortuguero, Costa Rica, *Leptodactylus savagei* and *Bothrops asper* were observed cohabiting a single log-pile habitat. In 2002, 2003 and 2004, 11 juvenile and five adult *B. asper* were observed utilizing the same

log-pile habitat (approximately 50 x 70 x 100cm) during day and night. Two adults (with distinguishable size and markings) appeared resident with multiple counts (>20). Adults of *B. asper* were identified individually by approximate size, markings, and position on the log-pile. The above two adults were encountered on multiple occasions between November 2002 and December 2003 and both used the same single escape hole when disturbed during the day.

On 20 November 2002, two nights after first locating and observing the above two *Bothrops asper*, a large (131mm SVL) adult *Leptodactylus savagei* was seen less than 2m from two coiled pit vipers (23:00 PM local time). When disturbed, it retreated into the same hole the adult pit vipers previously escaped to in the daytime. The individual frog was then observed the following night and was subsequently toe-clipped for identification (cc LF3: using Donnelly's (1989) scheme as described by Heyer et al. (1994)). Individual LF3 was then observed multiple times over two weeks close to the pit vipers. It was then not seen for five days in December 2002, but was relocated close to the log-pile hunting in a different location. The frog remained resident close to the log-pile habitat for a further two months. Another *L. savagei* was also spotted on the habitat (cc LF4) but left after just two nights in residence. Similarly in 2003, a further five specimens of *L. savagei* were marked by toe-clipping and subsequently released during 25 nights of observation (1 - 26 November 2003). All five *L. savagei* specimens exhibited site tenacity to the same log-pile entrance hole for between one and five nights at a time on separate days. *Bothrops asper* were in residence with the log-pile during this period, too.

Habitat coexistence between organisms can have numerous causal factors that may include prey availability, competition and microhabitat resource scarcity (Tokesh, 1999). In this example, the contrasting diet behaviour of *Leptodactylus savagei* and *Bothrops asper* may have enabled the cohabitation of these two species. Both species were observed to use the same

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retreat in response to disturbance during their activity periods, whereas *Leptodactylus savagei* used it at night and *B. asper* during the day. At night, the adult pit vipers did not retreat to the hole, preferring static ambush and camouflage usually at the same sites. Interestingly, they did not react when LF3 escaped from disturbance into the hole at night, despite being in close proximity.

Both species are known to have spatial memory of their surroundings and can return to a preferred territory or microhabitat if relocated (Leenders, 2001). Both species are also known to inhabit areas of old and edge forest with tree-fall and human stacked horticultural vegetation (Savage, 2002). Their joint preference for this habitat could be prey related but could also be related to the large size of both species adults and the difficulty of finding suitable 'pocket hole' retreats. Availability of this habitat inside old forest could be scarce, encouraging both species to cohabit. It is possible that the individuals of *Leptodactylus savagei* observed were also using the hole during the day due to their nocturnal activity patterns and high site fidelity. If this is the case then the level of cohabitation between *L. savagei* and *Bothrops asper* could be much higher than observed herein. Individual LF3 could have also operated from a different chamber in the log-pile habitat, thus avoiding an encounter with *B. asper*'s diurnal activity.

Cohabitation between these two species is a feasible concept. Adult *Bothrops asper* predominantly feed on mammals rather than amphibians (Savage, 2002; Campbell and Lamar, 2004). Additionally, *Leptodactylus savagei* is known for its use of noxious skin secretions as a defence technique (Villa, 1969; Savage, 2002) which may reduce the threat of being preyed upon by *B. asper* during close encounters. Potential prey items for LF3 were spotted in and on the log-pile. These included; large katydids, centipedes and other species of frogs (*Craugastor fitzingeri* and *Oophaga pumilio*). The only observed potential prey items for the pitvipers were the diurnally active lizards *Holcosus festivus* and *Basiliscus plumifrons*. None of the potential prey items for *B. asper* were regularly observed close to the retreat.

Further observation and experimental study would unveil more answers to this unusual coexistence.

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Ethical Statement. We (the authors) are aware that the practice of 'toe-clipping' has ethical considerations and that there are, today, multiple alternatives to the technique. However, back in 2002 the supporting study conducted by TRL (Lewis, 2009) was licensed for toe-clipping and at that time the technique was still a well practiced, and accepted, field method. We thank readers for their interest and understanding.

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