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Front Cover: A metamorph of *R. pseudomalabaricus*. See Research article on page 1.
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Note on range extension, local knowledge and conservation status of the Critically Endangered Anamalai gliding frog *Rhacophorus pseudomalabaricus* in the Cardamom Hills of Western Ghats, India

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ABSTRACT - *Rhacophorus pseudomalabaricus* is a Critically Endangered, range-restricted frog found in the southern Western Ghats of India. We report new distribution records outside the protected area network in the Cardamom Hills of Kerala State through direct sightings and local ecological knowledge. These records increase the distribution by 12 km to the south-east of its currently known range and increase the altitudinal range of the species to 1600 m asl. We present a preliminary call analysis of the species that is distinct from the call of its nearest congener *R. malabaricus*. Foam nests, tadpoles and metamorphs were sighted in agricultural land suggesting the importance of these landscapes for breeding. Breeding continues into the month of November extending the known length of its breeding season. Breeding occurred in highly disturbed areas and oviposition sites varied according to the vegetation around breeding sites and included the use of non-native plants. This suggests the need to exercise caution while conducting habitat restoration programs that involve a standard removal of non-native plants. The IUCN Red List status for this species could be revised from 'Critically Endangered' to 'Endangered' in light of our findings. Local ecological knowledge on amphibians could provide supplementary information on distinct species with local names and those that have short periods of activity, which may not be frequently encountered during field surveys.

INTRODUCTION

The Anamalai gliding frog *Rhacophorus pseudomalabaricus* Vasudevan and Dutta, 2000, is a Critically Endangered species associated with tropical moist evergreen forests of the southern Western Ghats between altitudes of 955-1430 m asl (Biju et al., 2004a; Biju et al., 2013). It is currently known from six locations in the states of Tamil Nadu and Kerala, both within and outside the protected area network (Fig. 1; Table 1). It is the only amphibian from the Indian subcontinent to adorn a postage stamp (Department of Posts - Government of India, 2012).

We report two new localities for this species in the Cardamom Hills of Kerala in the southern Western Ghats, specifically at Munnar and Mankulam (Fig. 1; Table 1). While the species was physically sighted at two sites in Munnar, at Mankulam species occurrence was only confirmed by the local ecological knowledge of indigenous and non-indigenous communities. The geographical coordinates of the locations are not provided here to safeguard the locations from collection for research purposes that is currently rampant outside the protected area network in the Western Ghats.

FIELD OBSERVATIONS AND DISCUSSION

R. pseudomalabaricus was sighted on multiple occasions at two sites in Munnar, a cardamom plantation and a tea plantation. Individuals were sighted inside an active, shade-grown cardamom (*Elettaria cardamomum*) plantation, which had retained some of its primary vegetation in the form of mature trees, during the monsoon from 14th September to 10th November 2014 between 19:00-23:57 h (Munnar 1: Fig. 1; Table 1). A total of seven adult individuals (aggregation of three individuals on one occasion) were observed at the site around a concrete water tank (4.2 × 5.8 × 2.2 m) on different days. Foam nests, tadpoles and metamorphs were also observed (Figure 2a, b, d, e). The adults (identity

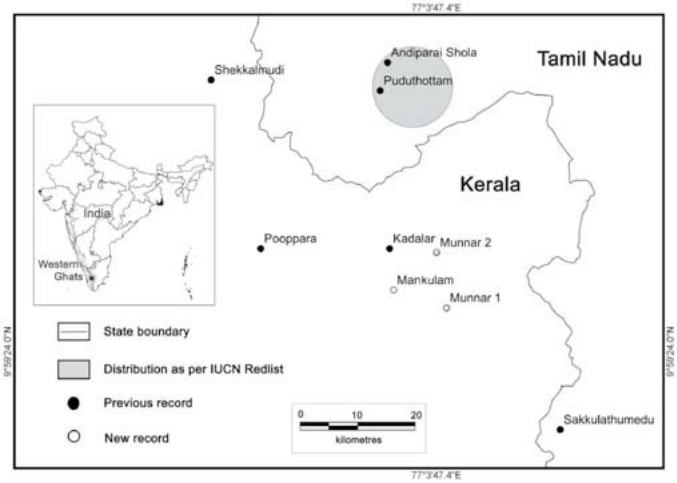

Figure 1. Distribution of *R. pseudomalabaricus* in the southern Western Ghats, India

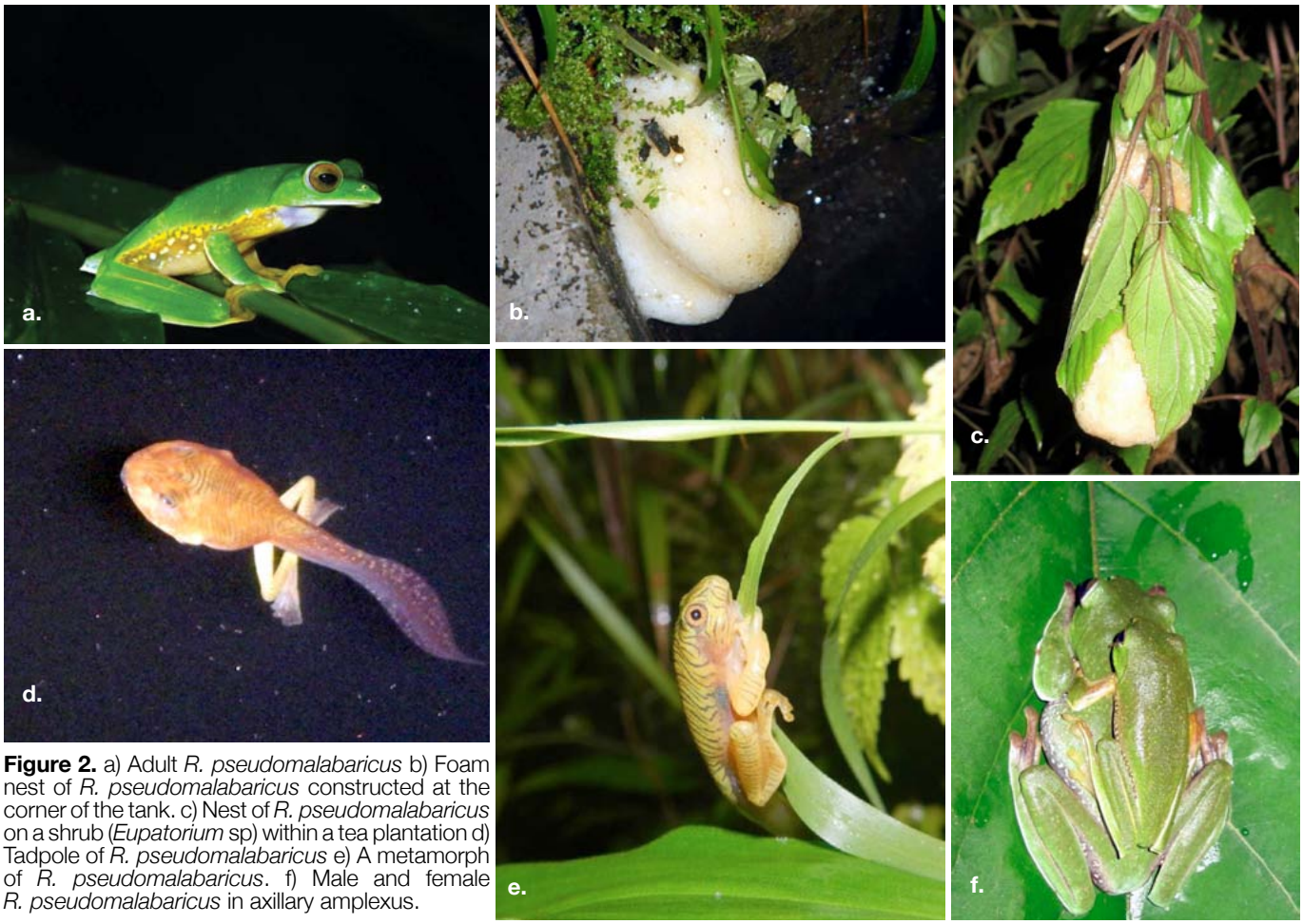

Figure 2. a) Adult *R. pseudomalabaricus* b) Foam nest of *R. pseudomalabaricus* constructed at the corner of the tank. c) Nest of *R. pseudomalabaricus* on a shrub (*Eupatorium* sp) within a tea plantation d) Tadpole of *R. pseudomalabaricus* e) A metamorph of *R. pseudomalabaricus*. f) Male and female *R. pseudomalabaricus* in axillary amplexus.

confirmed from green dorsum with light yellowish-orange webbing between fingers and toes, flanks with white mottling; see Vasudevan & Dutta, 2000; Gururaja, 2012), were found resting or calling on the edges of the tank and on cardamom leaves, while some were seen floating inside the tank. Male individuals had a single vocal sac and the advertisement calls consisted of a series of notes (trrr tik tik tik tik trrrr). The call of a single, vocalising male was recorded with a Nikon Coolpix AW100 camera on 7th October, 2014 at 21:21 h (air temperature: 17.7 ºC, substrate temperature: 21.5 ºC, humidity: 71 %). Four consecutive calls of one individual were analysed using Raven Pro 1.4. Each call lasted for an average 2.5 s, which attained peak amplitude of 1059 kU at the beginning and 2727 kU towards the end (Fig. 3). The interval between two consecutive calls ranged from 4.2-14.1 s. Three foam nests were observed at the corners of the tank deriving support from herbaceous plants growing on the tank's edges and were not covered with leaves. No direct observations of breeding or foam nest construction were observed at this site. A fresh foam nest was observed on 3rd November, 2014. *R. pseudomalabaricus* tadpoles of varying sizes (Gosner stages 26-41; Gosner, 1960) were seen inside and around the tank, species identification was confirmed from their overall green colouration with black dorsal markings (see Vasudevan & Dutta, 2000). Metamorphs (Gosner stages 44-46; Gosner, 1960) had a green dorsum with leaf venation-like markings (see Vasudevan & Dutta, 2000) and were observed outside the tank clinging onto the cardamom and herbaceous plants.

R. pseudomalabaricus was sighted and opportunistically observed in an active tea (*Camellia sinensis*) plantation in Munnar on multiple occasions between the months of July and November during the years 2012 to 2014 (Munnar 2: Fig. 1; Table 1). The species were usually observed on eucalyptus trees and *Eupatorium* and *Lantana* shrubs growing alongside a small marsh (>0.5 ha) within the plantation after 19:00 h to as late as 01:30 h on days when moderate precipitation was recorded. The marsh is a common grazing ground for cattle owned by the plantation workers. It accumulates run off from the plantation and has standing water during the monsoon (June - November). A maximum of 42 adult *R. pseudomalabaricus* were observed during a single night at the marsh. A pair in axillary amplexus was observed on the night of 15th July, 2012 (Fig. 2f). A total of nine nests were observed during the three year period, from the water level where they were deposited on clumps of grass to 9 m above the ground on an eucalyptus tree with *Eupatorium* and *Lantana* bushes directly below, as well as on *Eupatorium* (Fig. 2c) and *Lantana* bushes overhanging the water in the marsh. These nests were on the sharp ecotone of the road and the marsh and ranged from having some form of leafy cover to being completely exposed. Tadpoles of *R. pseudomalabaricus*, as well as those of a *Zakerana* species were frequently observed in the marsh post September. As many as seven metamorphs were observed on the bushes on a single night. Tarred roads on either side of the swamp were used regularly by the tea-picking community. A road-kill of an adult individual was observed here in September, 2012 (Fig. 4).

Our records extend the range of the species by 12.4 km

	Site Name	State	Elevation (m asl)	Habitat	Land Status	Literature
1	Andiparai	Tamil Nadu	1190	Artificial pond in rainforest	Protected Area - Anamalai Wildlife Sanctuary and Tiger Reserve	Vasudevan & Dutta, 2000
2	Puduthot-tam	Tamil Nadu	1000	Degraded rainforest fragment	Private forest fragment under the jurisdiction of Anamalai Wildlife Sanctuary and Tiger Reserve	Vasudevan & Dutta, 2000
3	Sakku-lathumedu+	Tamil Nadu & Kerala	1080	Close to plantation and rainforest fragment	Outside protected area network	Srinivas et al., 2009, G. Srinivas, pers. comm.
4	Shekkalmudi	Kerala	1118	Artificial water hole between evergreen forest and tea estate	Protected Area -Parambikulam Wildlife Sanctuary and Tiger Reserve	Jobin & Nameer, 2012
5	Kadalar	Kerala	1429	Marsh beside perennial stream outside cardamom plantation	Outside protected area network	Biju et al., 2013
6	Pooppara	Kerala	955	Secondary forests on the fringe of abandoned cardamom plantation	Outside protected area network	Biju et al., 2013
7	Munnar 1	Kerala	1350	Artificial water tank within cardamom plantation and on surrounding vegetation	Outside protected area network	Current Study
8	Munnar 2	Kerala	1573	Vegetation surrounding a marsh within a tea plantation	Outside protected area network	Current Study
9	Mankulam*	Kerala	1640	Forests, cardamom plantations, streams	Outside protected area network	Current Study

Table 1. Current and new distribution records of the Anamalai gliding frog *R. pseudomalabaricus*

+Srinivas et al (2009) state that Sakkulathumedu occurs in Kerala, however the GPS co-ordinates they have provided points to a location in Tamil Nadu. This site borders the two States and the species is known to occur around this site across both the States (G. Srinivas, pers. comm.)
**R. pseudomalabaricus* has not been physically sighted here but this record is the result of ecological knowledge surveys with local communities.

to the south-east of its closest known locality in Kerala and 34.4 km south of the reported range according to the IUCN Red List (Biju et al., 2004). We also extend its altitudinal range to 1600m asl. Biju et al., (2013) and Jobin and Nameer (2012) had also encountered *R. pseudomalabaricus* in and around cardamom and tea plantations. The vocalisation of the morphologically similar *R. malabaricus* has been formerly described (Hampson & Bennet, 2002) and its call is distinct and can be used to differentiate it from *R. pseudomalabaricus*. *R. pseudomalabaricus* has been known to breed and build foam nests in artificial ponds (Vasudevan & Dutta, 2000). Our observations suggest that breeding continues into November and is not restricted to June – October as reported by Biju et al., (2013) and may occur throughout the year with peaks during monsoon and winter (Vasudevan & Dutta, 2000).

Previously, mating individuals/foam nests have been observed at a height of 2-6 m only on understorey vegetation overhanging pools of water (Vasudevan & Dutta, 2000; Biju, 2009; Biju et al., 2013). Our observations show that foam nesting can take place from the ground level up to 9 m suggesting that foam nest construction is adjusted according to the vegetation or substrate available around the breeding site as observed in *R. malabaricus* (Kadadevaru & Kanamadi, 2000). Not all foam nests were wrapped in leaves as reported by Biju (2009) and Biju et al. (2013), but were constructed in clumps of grass or on the sides of cement water tanks. The use of invasive plants, such as *Eupatorium sp*. and *Lantana sp*. for building nests is also an encouraging sign. Habitat restoration programs are undertaken in the species range and usually involve the complete removal of invasive plants as a standard. We urge that such programs be undertaken only after understanding the current habitat use and as well as, ideally only when the frogs are not breeding. Invasive species should also be ideally replaced with native ones, which provide similar habitat structure for the species. The species appears to utilise the same water-holes/sources as breeding sites over multiple years suggesting strong site fidelity. While the protection of breeding sites is important, it is also critical to protect non-breeding sites and home ranges of breeding populations. At present, the home range and habitat utilisation of *R. pseudomalabaricus* outside of the breeding season is unknown and requires further research. The IUCN Red List status for this species may need to be re-evaluated and the species down-listed from 'Critically Endangered B1ab(iii)' to 'Endangered B1ab(i,ii,iii)+2ab(i,ii,iii)' since the extent of occurrence (EOO) integrating all currently known locations is 1282km^2 and area of occurrence is 36km^2 (Appendix 1). Moreover, it is now known from nine locations across a highly fragmented region including at degraded habitats in agricultural

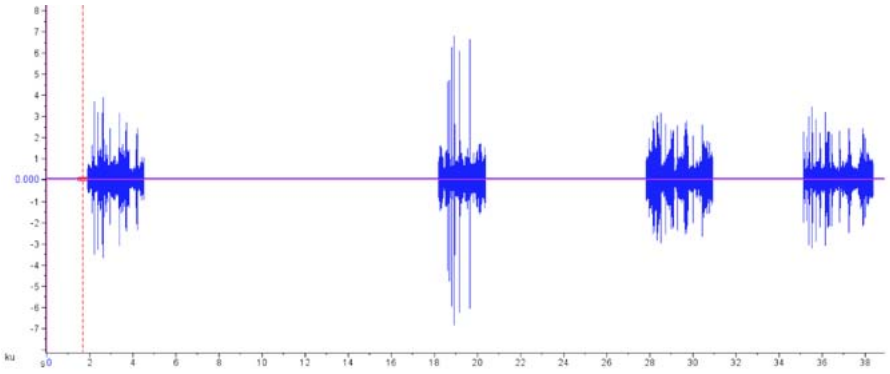

Figure 3. An oscillogram of four consecutive calls of a single, male *R. pseudomalabaricus*.

Figure 4. Road kill of *R. pseudomalabaricus* in a tea plantation in Munnar.

areas (Table 1, Appendix 1) unlike previously indicated (Biju et al., 2004), where it is also able to breed.

LOCAL ECOLOGICAL KNOWLEDGE AND DISUCSSION

Preliminary local ecological knowledge on *R. pseudomalabaricus* was gathered from the indigenous (Muduvar, Mannan) and non-indigenous local communities of Mankulam Forest Division in the Idukki District of Kerala in the Cardamom Hills. Morphologically, this species is similar to the widely distributed *R. malabaricus* (Biju et al., 2013) and local communities may not be able to distinguish between the two species. However, the distribution of the two species is not known to overlap and *R. malabaricus* is found at lower elevations (Vasudevan & Dutta, 2000; Biju et al., 2013). We have also not encountered *R. malabaricus* during our three years of field surveys at Munnar and to our knowledge, there are no published records of the species occurring at this site. The only other large Rhacophorid frog in the region is *R. calcadensis*, which is stark greyish-brown in colour and easily distinguishable from *R. pseudomalabaricus* (Biju et al., 2013). A total of 27 face-to-face questionnaires were conducted in the local languages (Tamil and Malayalam) with respondents being selected opportunistically from three settlements in Mankulam (Companykudi (n=10), Kandattikudi (n=6) and Viripara (n=11)) in January 2014. Most of the respondents either worked in cardamom plantations or as daily-wage labourers and were most likely to encounter frogs during their work, which involved de-weeding, digging, spraying pesticides/fertilizers, collecting cardamom or monitoring the estate. An unnamed colour photograph of *R. pseudomalabaricus* was shown and the respondents were asked whether they had seen the frog, the local name for the species and the habitat they had seen it in.

All the respondents confirmed the occurrence of *R. pseudomalabaricus* at the indicated habitats around their settlements at Mankulam. The respondents identified *R. pseudomalabaricus* with six names of which, Pacha tavala, Pacha tovaka and Pacha tera mean 'green frog', Mara tavala means 'tree frog', Ela thovaka means 'leaf frog' and Totturu whose meaning is not understood. The local names, which mean 'green frog' and 'leaf frog' were also used for bush frogs *Raorchestes jayarami* and *R. beddomii*. Only the indigenous individuals used the names Ela thovaka, Mara tavala and Totturu. Most of the respondents had seen the frog on leaves or trees (n=13), followed by cardamom plantations (n=11) and forest, bamboo and streams (n=5). Three respondents stated that they most often saw *R. pseudomalabaricus* during the monsoon while another had seen it inside his house. One respondent also stated that it 'flies' from one plant to another and that it vocalises all night during the monsoon. *R. pseudomalabaricus* was not consumed by the local communities and one individual from the Mannan community stated that pregnant woman should not touch it. One respondent also mentioned that the species consumed cardamom.

Indigenous communities may have a greater association with the species since they related it more with its habitat. The species may be considered as a bad omen among the Mannan community and could reflect the general dislike towards frogs among local communities, which was especially high among women (A. Kanagavel, unpublished data). The perception that *R. pseudomalabaricus* consumes cardamom has been documented in the region previously (Kanagavel & Parvathy, 2014) and whether they consume it in reality is not known. Local ecological knowledge surveys should be used prudently and in combination with other habitat/species characteristics for further surveys of *R. pseudomalabaricus* due to identical local names for smaller-sized bush frogs in the region. Since the size classes of these species are quite distinct we strongly suspect that the respondents did not make erroneous identifications, however, this cannot be completely ruled out. Local ecological knowledge surveys are not usually undertaken for amphibians and our preliminary findings suggest that such surveys would be beneficial for distinctive frogs with local names like *Nasikabatrachus sahyadrensis*, *Melanobatrachus indicus* and *Rhacophorus lateralis*, which are all threatened species (Biju, 2004; Biju et al., 2004b, c). These surveys would also be appropriate for amphibians that may not be encountered during routine herpetological surveys due to extremely seasonal or limited activity patterns. A case in point is *N. sahyadrensis*, a species with very seasonal activity period that was unknown to science until 2004 but was well known among indigenous communities (Aggarwal, 2004).

CONCLUSION

This report highlights the importance of agricultural habitats including cardamom and tea plantations for rare and threatened frogs and the role *R. pseudomalabaricus* may perform as a flagship for amphibian conservation in the region (Kanagavel et al., 2014). The species is easily identified by local communities and emblematic, including being featured on a postage stamp and similar to the culturally significant Mountain chicken frog *Leptodactylus fallax* in Dominica (Tapley et al., 2014), is a good candidate for conservation. The IUCN Red List status for this species would need to be re-evaluated and may need to be down-listed from 'Critically Endangered' to 'Endangered' based on the new distribution records and an increase in their range. A systematic field-based study supplemented by local ecological knowledge surveys needs to be undertaken to determine the actual distribution of this species. Home ranges should be determined to improve our understanding of breeding and non-breeding habitats so that appropriate conservation action can be implemented.

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Appendix 1. Proposed Red List Status for *Rhacophorus pseudomalabaricus*
Current Status: Critically Endangered B1ab(iii)
Proposed Status: Endangered (B1ab(i,ii,iii)+2ab(i,ii,iii))

Taxonomy
Scientific name: *Rhacophorus pseudomalabaricus* Vasudevan and Dutta, 2000
Common names: False Malabar tree frog, Anamalai flying frog, Parachuting frog, Anamalai gliding frog
Synonyms: None
Taxonomic notes: *Rhacophorus pseudomalabaricus* was described by Vasudevan and Dutta (2000) from the rainforests of Andiparai Shola in Anamalai Wildlife Sanctuary and Tiger Reserve, Valparai, Tamil Nadu State, India.

Assessment Information
Red List category and criteria:
Endangered (B1ab(i,ii,iii)+2ab(i,ii,iii))
Justification: *Rhacophorus pseudomalabaricus* is assessed as Endangered (B1ab(i,ii,iii)+2ab(i,ii,iii)) since it has a restricted distribution with an estimated extent of occurrence (EOO) of 1282 km^2 and area of occupancy (AOO) of 36 km^2 both of which are projected to decline due to increased anthropogenic stressors. The species is currently known from nine severely fragmented locations, where the area, extent and quality of species habitat is declining, due to development of large-scale tourism infrastructure and runoff of chemical effluents from plantations.

Geographic range
Range description: The species is endemic to the southern Western Ghats of India where it is currently known from the Anamalai Hills and Cardamom Hills in the states of Tamil Nadu and Kerala (Vasudevan & Dutta, 2000; Srinivas et al., 2009; Jobin & Nameer, 2012; Biju et al., 2013). Its occurrence in the Meghamalai Wildlife Sanctuary needs confirmation. It has an altitudinal range of 955–1640 m asl. The approximate current extent of occurrence (EOO) is 1282 km^2 (see Figure 1).
Countries: India (states of Kerala and Tamil Nadu)
Range Map: see Figure 1

Habitat and Ecology
It is an arboreal species, occurring in the understorey of high elevation tropical moist evergreen forests (Vasudevan & Dutta, 2000; Biju et al., 2013; current study). It is also present in highly degraded and disturbed secondary forests and habitats inside tea and cardamom plantations (Biju et al., 2013; current study). The species aggregate during the breeding season at stationary artificial and natural pools of water and on vegetation overhanging marshes, streams and ponds (Vasudevan & Dutta, 2000; Biju et al., 2013; current study). The species constructs foam nests in which eggs are deposited. These foam nests are constructed according to the vegetation or substrate available around the breeding site (current study). The eggs begin to develop into tadpoles in the foam nest and drop into the pools after attaining Gosner Stage 11, where they develop further (S. Varma, unpublished data; Gosner, 1960).
Systems: Terrestrial; Freshwater

Threats
Major Threat(s): The habitat of the species is greatly affected by fragmentation due to which 'potential habitat' has been reduced to small rainforest fragments among tea, coffee, cardamom, teak and eucalyptus plantations (Raman & Mudappa, 2003). Potential runoff of fertilisers, pesticides and other chemical effluents from the surrounding plantations degrades species habitats (Daniels, 2005). However, the species continues to occur in such landscapes and the actual effects of these threats are not well understood. The area and extent of habitat is also reducing due to development of large-scale tourism infrastructure in the species range. Road-kills of *R. pseudomalabaricus* have also been encountered (Vasudevan & Dutta, 2000; current study). The species used to be culled at cardamom plantations due to the perception that they consumed cardamom (Kanagavel & Parvathy, 2014), which is a highly valuable cash crop and one of the major livelihood sources in the region. *R. pseudomalabaricus*' range also coincides with the area where the probability of chytrid presence is high (Molur et al., 2015) but whether populations of this species are affected by the fungus is currently not known. Natural predators of foam nests and adults include Lion-tailed macaques *Macaca silenus* (Vasudevan & Dutta, 2000).

Population
Population: No reliable estimates of the status or trends in populations are available. The species is known to be common within its range (Vasudevan & Dutta, 2000; current study).
Population trend: Unknown

Conservation
Conservation action: No species specific conservation actions are currently in place. Except for the populations inside the Anamalai Wildlife Sanctuary and Tiger Reserve in Tamil Nadu and Parambikulam Wildlife Sanctuary and Tiger Reserve in Kerala, much of the range of this species (especially in the Cardamom Hills) is outside formal protected areas. The species is known to occur in privately-owned plantations including at areas owned by the Kanan Devan Hills Plantations Company Private Limited (KDHP), which have considerably high levels of protection. This plantation company has also recently been certified by Rainforest Alliance, which suggests that such certification could serve as a suitable incentive for integrating biodiversity conservation in cultivated landscapes. The project 'Cardamom plantations in the Western Ghats: Are these killing fields for amphibians justified?' implemented by Conservation Research Group, St. Albert's College, Kochi, India aims to understand the issue of amphibian (including *R. pseudomalabaricus*) culling in cardamom plantations and reduce culling through raising awareness among local communities. The species also has a high flagship potential (Kanagavel et al., 2014) and could be used as a symbol for promoting nature-friendly farming practices in the region. *R. pseudomalabaricus* use invasive plants such as *Eupatorium* and *Lantana* bushes for building nests and, caution needs to be exercised while removing them as a part of habitat restoration programs. A systematic field-based study supplemented by local ecological knowledge surveys needs to be undertaken to determine the actual distribution of this species including at Meghamalai Wildlife Sanctuary. The home range of the species should be determined to improve our understanding of breeding and non-breeding habitats, so that appropriate conservation action can be implemented.

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Erythrolamprus poecilogyrus (Wied-Neuwied, 1825) the Yellow-bellied Liophis: captive husbandry observation of amphigonia retardata (or sperm storage).

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INTRODUCTION

Erythrolamprus poecilogyrus (Wied-Neuwied, 1825), the Yellow - bellied Liophis, is a South America snake species belong to the family Dipsadidae. *Erythrolamprus* genus currently comprises 50 recognised species. *E. poecilogyrus* occurs in South America from South-Eastern Venezuela and Eastern Guyana to the Argentinian Pampas and Chaco. There are about four recognized subspecies due to the species great variability in colour patterns, and in meristic and morphological traits throughout its distribution (Alencar & Nascimento, 2014). Despite its widely distribution, the ecology and life history of this species are poorly known. In the literature there are a few natural history notes about reproduction (Pinto & Fernandes, 2004; Quintela, 2013) with the most comprehensive study by Alencar & Nascimento (2014). This species is active both during the day and night. It is partially terrestrial, but if necessary can be a skilled swimmer that looks for food in freshwater habitats. It is oviparous and feeds mainly on anurans of the family Bufonidae, Leptodactylidae and Hylidae, juveniles feed moostly on tadpoles and insects (Pinto & Fernandes, 2004; Prieto et al., 2012). This species is commonly kept in captivity and breeding events are apparently frequent. In this paper sperm storage in a captive female *E. poecilogyrus* is reported.

CAPTIVE HUSBANDRY

The observations in this study derive from a pair of captive breed *E. poecilogyrus*. Both were born in 2010 and the author acquired them from a German herpetoculturist in December 2013 when it is assumed they were already adults. The male measured 45 cm and weighed 47 g while the female (Fig.1) measured 70 cm and weighed 95 g. The couple was housed in a glass terrarium of 70×40×40cm. Half of the terrarium was heated to 28 °C by a heating plate with the other half mostly a large water tank where animals could swim and dive. The terrarium substrate had coconut fiber, branches, hiding places and a humid nest (hn) maintained at a moisture level higher than that of the rest of the terrarium by nebulising water every day. Individuals were fed with defrosted prey: *Atherina boyeri* every two or three days as freshwater fish and one or two time a month, pinky and fuzzy mice *Mus musculus*. During February 3 2014, about two months from the beginning of the observation period in the terrarium, the couple were observed mating for the first time during daylight hours with copulation lasting for about four hours. About one month later on March 5 2014, a clutch of 15 eggs were found in the hn. The eggs were removed from the terrarium and incubated at 27°C until hatching (the same treatment was followed for all successive clutches). The eggs were incubated in a plastic container within the incubator using Vermiculite mixed with water (ratio 2:1) as a substrate placing each egg in a small depression in the vermiculite (Radovanovic, 2011). A further and last mating was observed during March 7 2014. This event indicated that the female, only a few days after depositing eggs was already receptive to mating. In addition, the female never ceased to feed both before and after egg deposition. During April 4 2014, we found the male dead for unknown reason. However, the female

Figure 1. *E. poecilogyrus* adult female. This is the individual showing amphigonia retardata and reported in this note.

Figure 2. *E. poecilogyrus* newborn with the typical colour pattern of the juveniles of this species.

Date	Event	Eggs Clutch
03.02.14	Breed 1	
05.03.14	Eggs deposition 1	15
07.03.14	Breed 2	
04.04.14	Male death	
12.04.14	Eggs deposition 2	14
02.05.14	Born 1	
16.05.14	Eggs deposition 3	14
03.06.14	Born 2	
11.06.14	Eggs deposition 4	15
04.07.14	Born 3	
26.07.14	Eggs deposition 5	15
04.08.14	Born 4	
07.08.14	Eggs deposition 6	12
26.09.14	Born 5	
12.10.14	Eggs deposition 7	10
29.10.14	Born 6	
29.11.14	Born 7	

Table 1. Date, type of biological event and number of eggs in each deposition from the *E. poecilogyrus* couple.

continued to lays eggs, more or less once a month (Table I), to the last deposition on October 12 2014 without any contact with a male. From the first deposition on the March 5 to the last, in October, the female laid a total of 95 fertile eggs. The progeny were housed in small plastic containers (5-6 snakes to a single container) with coconut fiber as substrate, hiding place, a little water tank and they were fed with small pieces of *A. boyeri*. The new born (Fig.2) were up to 10 cm in length but with different colouration and body patterns from the adults. While the latter are uniformly black on the back and pale yellow on the ventral scales (Fig.1), the juveniles had a dorsal colouration of black and brown, marked with black spots that gradually fade towards the terminal part of the body with the ventral scales white/pale yellow. After a few months newborn have been gradually distributed to the Italian and European herpetoculturist community. It is suggested that this captive breeding observation is a case of amphigonia retardata. Also called sperm storage or delayed fertilization, this phenomenon has been described frequently in reptiles, in turtles and snakes in particular. This adaptation allows a female to produce several clutches from a single mating in one season. The viability of the stored sperm is not indefinite and varies with the species, ranging from several months to six years (Ballard & Cheek, 2013). The females of many types of reptiles have specialized structures for storing sperm suggesting that selection for sperm storage has operated on females (Birkhead & Møller, 1993). In snakes, this kind of mechanism is quite common and it has been observed in many species: pythons and boas (Ross & Marzec, 1990); rattlesnake (Matison, 1998); several rat snakes species (Radovanovic, 2011); European grass snake (Kabisch, 1999) and has been studied in wild populations of vipers (Luiselli, 1993; Höggren & Tegelström, 1996).

CONCLUSIONS

A total of 95 eggs were obtained from a single female of *E. poecilogyrus* from just two breeding events, in a time period of only ten months. As indicated in Table 1, the number of eggs remained reasonably constant for the first five events of eggs deposition (15 and 14 eggs), but then there was a slight decrease (10 and 12 eggs) in the last two clutch deposition events. Interestingly, all eggs were fertile and hatched and the female never ceased to feed during this time period, except during the moult. These observations might suggest that *E. poecilogyrus* is also an "income breeder", fueling reproductive expenditure by simultaneous feeding (Bonnet et al., 1998; Stephens et al., 2009). The ecological conditions that this species experiences throughout its geographic range, for example an abundance of fish and amphibians in its habitat (Pinto & Fernandes, 2004), could support the income breeding adaptation. Amphigonia retardata could be an ecological adaptation for particular habitat conditions where male–female encounters are infrequent. However it is recognised that captive observations do not necessarily reflect those in natural conditions and behaviour may be distorted in captive environments. For example, optimal temperatures in captivity and regular food source could explain the large number of fertilized eggs produced by the female from two breeding events.

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Does habitat structure affect foraging success in the Mediterranean house gecko, *Hemidactylus turcicus?*

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ABSTRACT - The effects of structural habitat complexity on predator foraging success has been seldom investigated in lizards. We studied a population of the gecko *Hemidactylus turcicus* in Northern Cyprus to examine how structural habitat complexity can alter the behavioural patterns of foraging geckos. In Northern Cyprus *H.turcicus* are found in both urban and natural environments, however urbanised areas provide a simple habitat structure which could benefit foraging success. Although light levels and prey density are factors in their success, foraging success could also be a factor as to why these geckos are often found in urbanised areas. We hypothesised that increased structural complexity of the habitat will have a negative influence on *H.turcicus* foraging success because of visual impairment. The results support our hypothesis that in a simple habitat foraging will be more successful with a significantly lower number of strike attempts, fewer failed feeding bouts and a significantly larger strike distance in a simple habitat compared to a more complex one. However the time taken to start hunting prey showed no significant difference, which was not predicted. The results from this study show that the foraging success of *H.turcicus* is increased in simple habitats, therefore we propose that foraging success could be a part of the driver for the successful colonisation into urbanised areas.

INTRODUCTION

The gecko, *Hemidactylus turcicus*, commonly occurs in built up areas, often associated with human-mediated dispersal events. It is often thought that the main cause of the dispersal is a result of human introduction (Carrenza & Arnold, 2006), a claim that is supported by the distribution being associated with the US highway network (Davis, 1974). However in North Cyprus it is not known how or when *H. turcicus* arrived but the species is nonetheless more commonly found in urbanised areas but also occurs in natural habitats. *H. turcicus* utilises adapted toes that enable them to climb walls (Hennig & Dunlap, 1977; Carrenza & Arnold, 2006) and other flat surfaces. Climbing walls is beneficial because geckos can move to high places where most forms of disturbance can be avoided, such as predation. (Carrenza & Arnold, 2006). *H. turcicus* often perches on walls near lights, presumably to prey on insects attracted to the lights in human habitations, providing a higher prey density. (Carrenza & Arnold, 2006; Williams & McBrayer, 2007; Rato et al., 2011).

The walls of buildings are often simple compared to natural rock habitats. In a structurally more complex environment, prey location may be more difficult because objects can break the line of sight (Petren & Case, 1998), whereas in a simple habitat there should be greater opportunities for a gecko to observe and catch prey, and to procure prey more quickly (Short & Petren, 2007). The line of sight between predator and prey is important for predators to locate prey, which is another advantage of a high perch as it often removes visual impairment (Andersson et al., 2009).

In this study we compared the foraging success of *H. turcicus* in simple and complex environments. We hypothesised that simple habitats could yield higher foraging success and could alter how the gecko procures prey. Behavioural observations were used to test these hypothesises, by recording the strike success, distance and time of each strike.

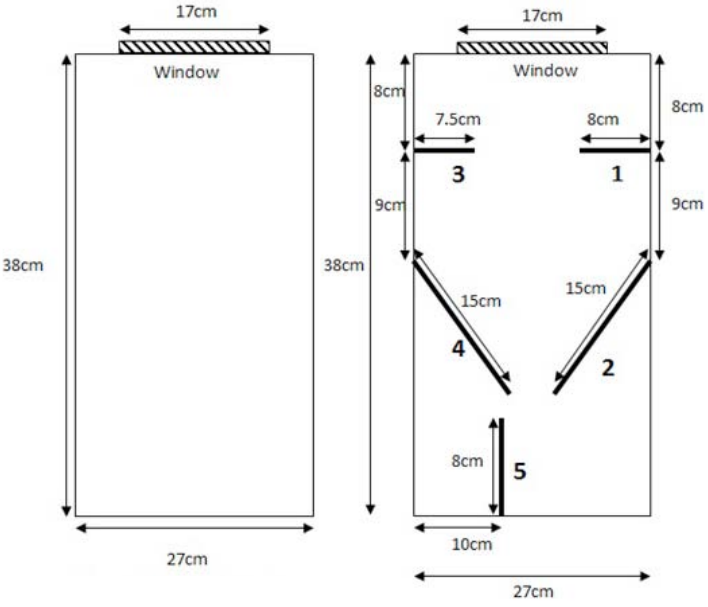

Figure 1. Layout of simple habitat enclosure. Open plan area with no internal walls to impair visibility providing simple habitat. Window at the front used as insertion point for prey.

Figure 2. Layout of complex habitat enclosure. A more complex area containing 5 walls at variable sizes to obscure vision. Window at the front used as insertion point for prey.

MATERIALS AND METHODS

The study was carried out on a population of *H.turcicus* geckos in Northern Cyprus between 29th June and 27th July 2010. Comparative observations were made on the predation behaviour of individual geckos in simple and complex chambers within a basic field laboratory on a work bench (Fig.1 and Fig.2). The simple structured habitat was an empty grey plastic box arranged horizontally 38 cm long, 27 cm wide and 15 cm high, providing an open space to represent the simple habitat found in human habitations (Fig. 1). Hardboard partitions were used to create the complexity of the second habitat type, acting as barriers to reduce the geckos' visual range (Fig. 2). Partitions one and five were 8 cm x 8 cm at a 90∫angle from the wall and were elevated off the floor by 7 cm. Partitions two and four were 15 cm x 7.5 cm lying long ways on the floor at a 45∫angle from the wall. The final partition (partition number three) was 15 cm x 7.5 cm standing up against the left wall at a 90∫angle from the wall.

Both of the habitat types were divided into a three dimensional grid with each grid section being 7.6 cm deep x 5.4 cm across x 5 cm high. The grid was used to record the exact location of the gecko when the first sign of hunting was observed and where the gecko captured the prey.

All caught geckos were sexed and any gravid females were immediately released back where they were caught; no experimentation was conducted on them because in many reptilian species gravid females are known to have a reduced consumption rate (Johnson et al., 2010). Only geckos with a snout to vent length of 44 mm or greater were used because this is the average size of an adult *H. turcicus* gecko (Selcer, 1986). Fifteen adult *H. turcicus* geckos in total were caught from the wild and randomly placed into either a complex or simple enclosure for a 7 day period regardless of sex or size.

Following Hitchcock & McBrayer (2006), each gecko was left undisturbed for 20 hours to acclimatise after being placed into the test enclosures. Observations were made under a red light to minimise disturbance between 20:00 and 00:00 (Hennig & Dunlap, 1977). On each occasion an adult flour moth (*Ephestia kuehniella*) was released into the enclosure at the same location (the front window) for each assay and the time was recorded. The time of each strike was recorded as well as the grid reference (the central point of the grid section) of the gecko when it first started to hunt. The grid reference of where the prey was situated when the gecko struck was also recorded. Since a failed first strike would shorten the distance between hunting initiation and a successful strike, only data from first strikes were used to compare distances travelled to strike at prey. The success of each strike was recorded and if successful the observation was concluded for that night. If the strike was unsuccessful the gecko observations continued and all other attempts recorded in the same way until a successful strike was made. After 60 minutes, if the gecko had not made a successful strike the moth was removed and observation was concluded for the night.

Observations were repeated for seven consecutive days, after which the gecko was moved into the other habitat type and left for another 20 hour acclimatisation period before repeating the study. Therefore, each gecko had the opportunity to feed for 7 consecutive days with a 20 hour acclimatisation period before another 7 consecutive days in the opposite habitat type.

We used Pearson's chi-squared analysis to assess whether there was a difference in the amount of successful feeding bouts compared to unsuccessful feeding bouts in both simple and complex habitats. While a Paired t-test was used to test the null hypotheses that there is no difference between the distance to strike, the number of attempts, and time to strike in both habitat types.

RESULTS

The Pearson's chi-squared analysis showed that there is a significant difference between a successful feeding bout and an unsuccessful feeding bout in simple and complex habitats (χ^2 = 5.1079, df = 1, p = 0.024). The results show that in a simple habitat foraging is more successful as there were fewer failed attempts than in the complex habitat.

The time taken to initiate hunting did not differ significantly between the two habitats (t (71)= -0.845; P = 0.401). The average number of grid squares travelled to make a successful strike was greater in a simple (mean number of grid squares=2.79, SD= 1.66) compared to a complex (mean number of grid squares=2.18, SD=1.35) habitat (t (61) = -2.537; P = 0.013). Similarly the distance travelled to make a strike, whether successful or not, was also greater in the simple (mean number of grid squares=3.08, SD=1.55) compared to a complex (mean number of grid squares=2.51, SD1.31) habitat (t (71) = -2.524; P = 0.014). Fewer attempts were needed to make a successful strike in the simple (mean=1.40, SD=0.69) compared with the complex (mean =1.71, SD=0.91) habitats (t (69) = 2.036; P = 0.046).

DISCUSSION

We have shown that *H. turcicus* is more successful at catching prey in a simple habitat than in a more complex one, with fewer strikes before capturing a live food item and the small number of unsuccessful feeding bouts in simple habitats. The ability to catch prey from a longer distance in comparison to a more complex habitat also shows how habitat complexity alters foraging. However the time that is taken to initiate a response to the prey showed no significant difference between simple and complex habitats. Overall, simple habitats provide a more suitable area for a more efficient feeding bout. Combined with the increased prey density from lights in anthropogenic environments, it is reasonable to suggest that a simple habitat is an extra benefit for foraging.

Any feeding bout can be divided into four stages: prey search, subjugation (handling), ingestion and digestion. However the energetic cost of prey handling and ingestion has been shown to be trivial in lizards (Cruz-Neto et al., 2001). Generally speaking the time taken to find the prey will be longer than the time taken to procure and ingest prey. Strike success then becomes more important to avoid having to find and procure another prey item, therefore a higher capture efficiency would minimise energetic costs. *H. turcicus* is more successful at capturing prey in a structurally simple habitat as

shown by a significantly lower number of attempts needed to catch the prey. Having a higher capture efficiency in simple habitats will reduce the energetic costs and decrease handling time of the prey; this could be a reason for *H. turcicus* being more common in urbanised areas, which is simpler than a natural habitat.

The strike range of *H. turcicus* is another important factor to be considered when comparing how successful the species is in either simple or complex habitats. The results show that the distance travelled between the gecko and prey for both the first strike and for a successful strike in a simple habitat is greater than in a complex habitat. A possible reason for this might be that the simple habitat is providing *H.turcicus* with a greater line of sight and it is therefore able to stalk prey over a longer distance (Fernandez-Juricic et al., 2011). However, when the gecko fails to capture the prey on the first attempt the gecko will quickly have a second attempt while the prey is close, meaning that this could bias the distance of the successful strike (if all strikes are measured) as geckos in complex habitats require more attempts to catch prey. Despite this, the results from the first strike show that habitat structure does affect the strike distance of *H.turcicus*. Although travelling a greater distance to capture prey has a higher energetic cost, the higher success rate balances the cost/benefits from travelling a longer distance. A simple habitat structure could lead to a higher foraging efficiency, which would increase fitness in a structurally simple habitats such as that used in this experiment. Although it has been shown in *H. frenatus* that increased prey density resulting from the presence of artificial lights is a driver for success in urban areas, the results from this study suggest that an increased foraging success has an extra impact on the success of urbanised geckos.

There was no significant difference between the time taken for a gecko to initialise hunting between simple and complex habitats. A possible reason for this could be that geckos in complex habitats can safely position themselves closer to the entry point, therefore negating the advantage of an open vantage point. However the number of failed feeding bouts is greater in complex habitats suggesting that visual obstructions do prevent the geckos locating their prey.

This study has been able to provide some understanding of the foraging behaviour of *H.turcicus*. It showed that habitat structure can influence foraging success and that the gecko is able to benefit from simple structures increasing foraging efficiency. The research has suggested that the availability of foraging areas that are unimpeded by physical barriers could be a possible factor in the species' successful establishment in an urbanised area. Higher prey density caused by insects being attracted to artificial lights and high foraging success work simultaneously to further increase their successful integration into urban areas.

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New records and search for contact zones among parapatric vipers in the genus *Vipera* (*barani*, *kaznakovi*, *darevskii*, *eriwanensis*), *Montivipera* (*wagneri*, *raddei*), and *Macrovipera* (*lebetina*) in northeastern Anatolia

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ABSTRACT - North-eastern Anatolia harbours a high diversity of viperid snakes with only a limited knowledge about their distribution and with relationships among these vipers not yet fully resolved. Moreover, information on habitat attributes for most of these vipers is scarce. We initiated a multi-year project to improve our knowledge on their distribution and habitat preferences, especially by searching contact zones of closely related and ecologically similar species and evaluate potential gene flow and species integrity. In this context and as an intermittent step, we report new localities nearby putative contact zones. Thus, herein we present new information on the distribution of *Vipera barani*, *V. kaznakovi*, *V. darevskii*, *V. eriwanensis*, *Montivipera wagneri*, *M. raddei* and *Macrovipera lebetina* based on our field work and third sources provided to us. With these data, we were able to reduce the distribution gaps between three pairs of "parapatric", related or ecologically similar, viper species (genus *Vipera*) by mostly 50%, and detected a putative contact zone in a fourth species pair (genus *Montivipera*). All putative contact zones are discussed in an ecological context. In addition, we add new sites of *M. lebetina* in the Province Artvin and discuss its northern limit in Turkey.

INTRODUCTION

The Anatolian Peninsula, the Asian part of Turkey, is a melting pot for palearctic species originating from Europe, Asia, and northern Africa. For example, its north-eastern quarter is considered as a global diversity hotspot for vipers with at least 10 species occurring within a radius of 200 km from the city of Erzurum (Nilson & Andren, 1986; Joger et al., 1997, 2005, 2007; Avci et al., 2010; pers. data), thus rivalling the species richness of most tropical sites in viperids. The diversity is resulting from a great variety of habitats, including zones of subtropical climate along the Black Sea coast, mixed deciduous forests, alpine meadows, and semi-arid steppes on the Central Anatolian plateau. Unfortunately, flooding of valleys associated to dam constructions, intensive agronomic practices, such as tea plantations along the Black Sea coast, and overgrazing by domestic livestock (goats, sheep, cattle) have drastically reduced the habitat quality for many animal species including vipers. Furthermore, illegal collecting of these rather attractively coloured vipers for the commercial trade, as well as intentional and accidental killing by locals, are considered to harm populations as well (IUCN Red List of Threatened Species, 2014.3; Ettling et al., 2014). However, the impact of illegal collecting appears to be reduced today and current threats relate rather to increased habitat destruction, and thus, conservation statuses need to be reassessed accordingly (Mebert, 2014).

Nonetheless, the lack of knowledge on Turkish vipers, from simple distribution data to taxon and population biology, is preventing any reasonable assessment of species statuses. It is therefore paramount to identify not only the environmental key factors that are relevant for their habitat, but also to elucidate which species really represent valid taxa (independent evolutionary entities) and deserve further conservation efforts, as well as the role of interspecific relationship among them. This can be achieved most efficiently through a multi-faceted approach by studying characters of habitat selection, genetics, and morphology in contact zones or contiguous populations of two or more viper species (e.g., Mebert et al., 2015). Finally all these elements will provide relevant tools for their conservation management.

Consequently, we outlined an ambitious project to search for contact zones, contiguous, and proximate populations of pairs of closely related or ecologically similar viper species in an area of approximately 200 km diameter in north-eastern Turkey (Ardeşen-Hopa-Camili-Posof-Çildir-Tuzluca-Kağizman-Horasan-Uzundere-Çamlihemşin). Eight confirmed species occur in this area, excluding the dubious *Vipera pontica*, which is known from only three specimens, all from one valley (Mebert et al., 2014), but represents a hybrid

between *V. kaznakovi* and *V. (ammodytes) transcaucasiana* (Zinenko et al., 2013). The results of range extensions from the 2013 season including new records of *V. (ammodytes) transcaucasiana* have already been published (Göçmen et al., 2014; Mebert et al., 2014). The following reports focuses on new locality findings during the 2014 season of the other seven viper species from north-eastern Turkey, supplemented by previously unpublished records from third party sources. We update information on range distances between "parapatric" vipers of the genus *Vipera* and take a critical look at a possible contact zone between two rock viper species (*Montivipera* spp.) and its habitat-linked position.

Six out of seven viper species were assigned a conservation status according to the International Union for Conservation of Nature (IUCN Red List of Threatened Species, 2013.1). Their threat level and current population assessments with a focus on Turkey are listed below. The seventh species, *Macrovipera lebetina*, is not threatened and receives no conservation status by IUCN standards, but is added here due to its rarity in our study area and our new information on its range limit. In parentheses are recent suggestions for taxonomic name changes or affinities, that require more research or peer-reviews before the new taxonomy can be approved or disproved (see Stümpel, 2012; Joger & Zinenko 2013, Joger et al., 2010; Zinenko et al., 2013, 2015; Mebert et al. 2014; Göçmen et al., 2014):

1. *Vipera (berus) barani* (Baran's adder): Near Threatened; Turkish endemite, significant decline due pet-trade-harvesting, probably will qualify for Vulnerable status, known by ca. 25 specimens
2. *Vipera (olguni) darevskii* (Darevsky's viper): Critically Endangered; known in Turkey by approximately 20 adult wild specimens and a range < 100km^2 with all sites > 2000 m asl. and a similar situation in Armenia
3. *Vipera eriwanensis* (Armenian steppe viper): Vulnerable; known by approximately 25 sites in Turkey alone, few more sites in Armenia, Azerbaijan (Nachitschewan), extent of distribution < 20,000 km^2
4. *Vipera kaznakovi* (Caucasian viper): Endangered; populations severely fragmented, coastal range < 500km^2, in Turkey known from < 10 sites, exposed to the international pet trade and severe habitat degradation
5. *Montivipera raddei* (Radde's rock viper): Near Threatened; threat by pet-trade-overcollection, known from at least 10 sites in Turkey alone, few more in Armenia and Azerbaijan (Nachitschewan)
6. *Montivipera wagneri* (Wagner's rock viper): Critically Endangered Turkish endemite; very restricted range, known by approximately 15 sites, heavily collected for pet trade
7. *Macrovipera lebetina* (Levantine or Blunt-nosed biper): no IUCN status as it is not threatened, but appears to be very rare in Province Artvin

APPLIED FIELD METHODS

Three field expeditions, in May and July 2013 and June 2014, were conducted to sample vipers in north-eastern Turkey. We selected five geographic regions, four related to potential contact zones and one to a northern range limit. The five regions and the reasoning for their selection are:

1. A potential contact zone of *Vipera (berus) barani* and *V. kaznakovi* between Ardeşen and Findikli, Rize Province. These are two medium-sized and possibly parapatric species that both inhabit open patches of deciduous forest along the subtropical Black Sea coast.
2. A potential contact zone of *V. kaznakovi* and *V. darevskii* north of the Karçal Mountains between Camili and Maden, Artvin Province; these two viper taxa are ecologically and morphologically extremely different, as *V. darevskii* is a dwarf form of rock slides in alpine grassland, whereas *V. kaznakovi* is a medium-sized viper of subtropical light forest. But recent research found confounding results of mixed genotypes among several Caucasian vipers, including some closely related haplotypes between *V. darevskii* and *V. kaznakovi* (Zinenko et al., 2013), possibly indicating introgression. *V. kaznakovi* is known from the Camili area (Afsar & Afasr, 2009), and apparently suitable alpine habitat exists only a few km south in the Karçal Mountains from where no vipers have been confirmed, though.
3. Both vipers, *V. darevskii* and *V. eriwanensis*, occur in eastern Hanak District, Ardahan Province. These vipers are small forms that similarly inhabit rocky areas in alpine grassland. However, no contact zone or proximate populations have been reported so far, but can be expected in eastern Ardahan Province.
4. Both rock vipers, *Montivipera wagneri* and *M. raddei*, occur in Aras Valley, Kars Province. These two similar species inhabit rocky slopes in a montane environment west and east of Kağizman, respectively. As their preferred habitat is abound near Kağizman, a contact zone could be expected in that area.
5. The Coruh Valley in Artvin Province, as the north-eastern range limit of *Macrovipera lebetina* in Turkey, is based on a single record only (Basoglu & Baran, 1980). We add several unpublished records from various sources.

We accessed the different regions by all means possible, such as cars, tractors and on foot. Each region was searched for contact zones and/or proximate populations of pairs of viper species during about 40 days (4 weeks in 2013 and 2 weeks in 2014). Vipers have been located by visual encounter survey of suitable microstructures, usually with one area well exposed to solar radiation (rock slides, dry stone walls, edges of forest and bushes, river borders) that provides shelter, basking sites, and hunting ground. Our sampling effort focused on south-facing slopes, the preferred exposition for reptiles in the northern hemisphere, followed by east- and west-faced slopes, but eventually complemented by a few north-facing slopes. Furthermore, to accelerate the finding of new viper sites, we interrogated local residents about the regional viper species by showing them comparative photographs of various viper species from north-eastern Turkey, but without indicating them, which species is supposed to occur in their region. The locals mostly pointed to the photograph of the viper species, we expected to occur at their site, and thus encouraging our search efforts.

For each found viper, we recorded a few structural habitat factors (25 m radius around the exact capture point) for future analyses. Exact locality coordinates were taken with a GPS device for subsequent landscape and GIS analyses. Each specimen was sexed, photographed to assess colour pattern variation, a few body proportions measured, and some pholidosis characters recorded. Vipers aimed for release were scale-clipped (cutting off a dead part of the projecting outer edge of 1-2 ventral scales) and mouth-swabbed for future DNA analysis. Most specimens were released back to their habitat/capture site, while a few others were maintained for other projects or deposited as vouchers in the Zoology Museum of Adiyaman University (ZMADYU) in Adiyaman, Turkey.

RESULTS AND DISCUSSION

We successfully sampled all 7 focus-species within a radius of 100 km around the point where three provinces meet (Ardahan, Erzurum, Artvin). Information on habitat and distribution for each region and its viper species considered herein is summarised and discussed sequentially to facilitate reading and comprehension. In the following, we applied the current taxonomic affiliations of Turkish vipers as utilised by the IUCN in the remainder of this report.

Region 1: *Vipera barani-V. kaznakovi* transition zone (Fig. 1)
For these species, our field inspections were focused along the coastal versant of the Black Sea Mountains from the environs of Hopa, Province Artvin, to Ardeşen, Province Rize, in particular within the districts of Arhavi, Findikli and Ardeşen. These districts lie between the previously known westernmost records of *V. kaznakovi* near Hopa (e.g., Nilson et al., 1988) and the easternmost coastal records of *V. barani* in Firtina Valley near Çamlihemşin (Franzen & Heckes, 2000; Baran et al., 2001, 2005a).

In all, we acquired information on eight *V. kaznakovi* (sampled n=7, observed n=1) and six *V. barani* (sampled n=5, unpublished record n=1 by J. Mulder pers. comm.). Six *V. kaznakovi* were sampled at known sites east of Hopa (Nilson et al., 1988; Afsar & Afsar, 2009), whereas two *V. kaznakovi* were found above Güzelyali near Kiyicik, Findikli District (one sampled, one observed; see Fig. 1). Latter two vipers represent currently the westernmost site and the first documentation for this species from Rize Province (Fig. 2C and D). *V. barani* were sampled in Firtina Valley mostly within five kilometres south of its confluence with Zigem River (Figs. 1, 2A and B). They represent minor extensions of up to 2.5 km north from a previously reported site (Franzen & Heckes, 2000).

With the new findings, the known distance between *V. barani* and *V. kaznakovi* vipers was reduced from 40 to 25 km, and even to 14 km when considering local reports. We presume that Işikli Valley constitutes the most likely area for a contact between *V. kaznakovi* and *V. barani*, but we only reached that valley during one rainy day without any sampling success. Future excursions should focus on the Işikli Valley and the area around Findikli and Zigem Valley south-east of Ardeşen.

We perceive that the Black Sea costal belt is the most threatened bio zone in north-eastern Turkey in regard to the survival of its indigenous viper populations. The habitat for

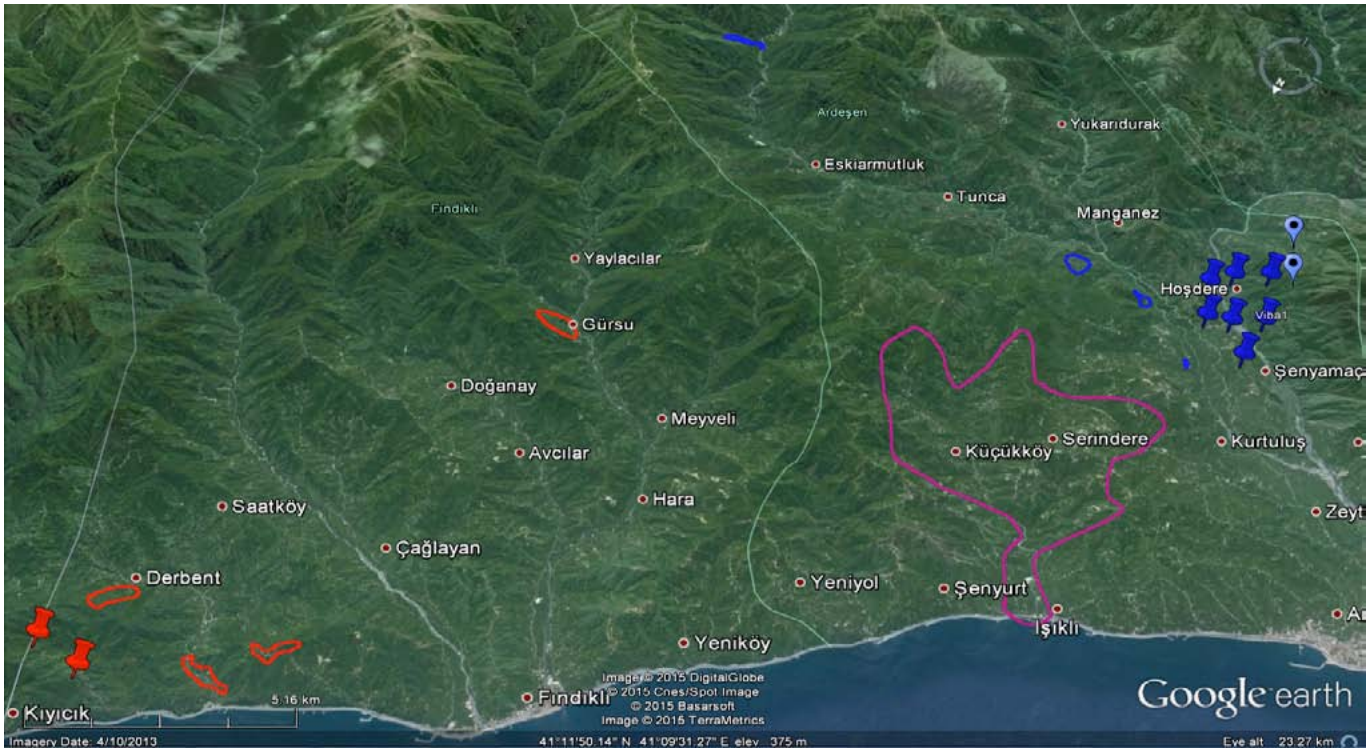


Figure 1. Approximate sampling area for Region 1, a *Vipera barani-V. kaznakovi* transition zone with the centre of the map at 41°11'50.14"N, 41°09'31.27"E. The pin markers/area-circles in red (*V. kaznakovi*) and blue (*V. barani*) represent new records/verbal reports from this study (see text). The new *V. barani* records have been displaced relative to each other to visibly fit into the map. The two "blue drop-markers with black centres" to the right refer to previous records of *V. barani* from Firtina Valley (Baran et al. 2001; Franzen & Heckes 2000). Purplish area-circle designates the potential contact zone between these viper species in Işikli Valley.

V. kaznakovi and *V. barani* is extremely degraded, as the once lightly-wooded hazelnut plantations, that were rich in rodent prey for vipers, have been cut and concomitantly replaced with structure-poor and canopy-closed tea plantations. Natural stretches of the coastal region consists mostly of densely shading forests, leaving suitable semi-open areas for vipers only along the margins of agricultural fields, tea plantations, and forests, as well as in meadows and along river-and roadside structures. Furthermore, future dam building will lead to the disappearance of many suitable valley habitats. Consequently, the survival of any viper populations in this region is uncertain. Action plans for both viper species, as well as studies to investigate the extend of their ranges, ecological niches, and the impact of tea plantations are urgently needed.

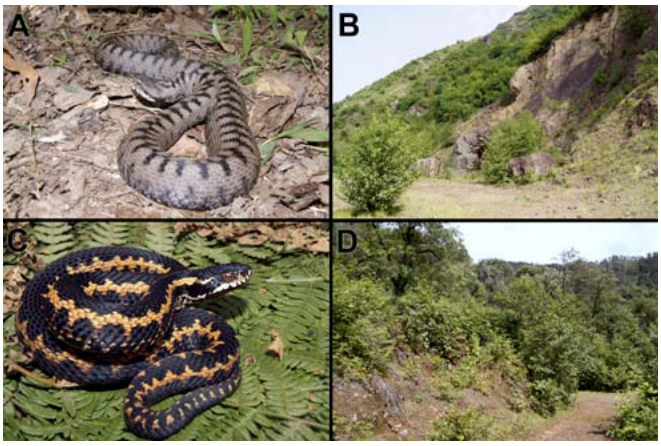


Figure 2. Region 1, transition zone between *Vipera barani* and *V. kaznakovi* in Province Rize, Turkey, along the Black Sea coast: (A) *V. barani* and (B) its habitat south of Ardeşen; (C) *V. kaznakovi* and (D) its habitat from Güzelyali, District Findikli. Habitat sites B and D are 27 km straight line apart.

Region 2: *Vipera kaznakovi-V. darevskii* transition zone (Fig. 3)
The currently known gap between *V. kaznakovi* from Borçka to *V. darevskii* near Zekeriyaköy is at least 60 km straight distance (Baran et al., 2005b; Geniez & Teynié, 2005), or approximately 90 km distance between *V. kaznakovi* from Maral Valley, Camili, Artvin Province, to *V. darevskii* near Posof, Ardahan Province (Afsar & Afsar, 2009; Avci et al., 2010). These stretches are accompanied by a significant change of elevation and vegetation cover, reflecting a corresponding change from temperate-humid to montane-arid climate. In the search for a high-alpine zone (> 2000 m asl.) suitable for *V. darevskii* but closer to *V. kaznakovi*, we located the Karçal Mountains just south of the Maral Valley. Both areas, the Maral Valley and Karçal Mountains, were visited each on single days in 2013 and 2014.

We sampled, and thus confirmed, *V. kaznakovi* around Düzenli, Maral Valley, at 600 m asl. (n=4, Mebert et al., 2014; Fig. 4A and B) in 2013. For *V. darevskii*, we briefly searched vipers in the high mountain valleys, the Lekoban and Çikunet Plateaus (Fig. 4D). We could not confirm the occurrence of *V. darevskii* in the Karçal Mountains, but locals on the Çikunet Plateau have shown us two sites (slopes), where small light greyish venomous snakes (vipers!) with a blackish dorsal

Figure 3. Sampling area for Region 2, a potential *Vipera kaznakovi-V. darevskii* transition zone in the Province Artvin, Turkey, with the centre of the map at 41°23'8.52"N, 42° 0'21.25"E. Red pin-markers represent our sampled *V. kaznakovi* individuals and the red drop-markers with black centres refer to previously published individuals (Afsar & Afsar 2009). The new records of *V. kaznakovi* have been displaced relative to each other to visibly fit into the map. The black area-circles indicate where small grey-black vipers have been observed by locals or were anticipated by us, suggesting the potential occurrence of *V. darevskii*, albeit this requires verification (see text for explanation).

pattern occur. These sites are only 10-15 km distance from the nearest *V. kaznakovi* site at Baltacik, Maral Valley, around 1050 m asl. (Afsar & Afsar, 2009).

Even though the description of vipers by locals from the Çikunet Plateau would fit *V. darevskii* (or *V. eriwanensis*), it might also be related to the locally common Smooth Snake (*Coronella austriaca* in Fig. 4C). If no *V. darevskii* can be located in the Karçal Mountains, we suggest to expand the search to the next high mountain range east along the Turkish-Georgian border, which is closer to known populations of *V. darevskii* (Tuniyev et al., 2012, 2014). Any find of *V. darevskii* in either mountain range would greatly expand the known distribution for this critically endangered and geographically limited species. While the lightly wooded habitat for *V. kaznakovi* in the forest belt of the Maral Valley is protected, heavy cattle grazing of alpine meadows might pose a threat to potential viper populations in the Karçal Mountains (see also Region 3).

Region 3: *Vipera eriwanensis-V. darevskii* transition zone (Fig. 5).

V. eriwanensis and *V. darevskii* are externally similar small viper species that both inhabit high altitude rocky grassland (Fig. 6B), but are phylogenetically not close relatives (Joger et al., 2010; Zinenko et al., 2013). Recent publications show that *V. darevskii* occurs at two sites around Posof in the eastern Province Ardahan, Turkey (Avci et al., 2010; Tuniyev et al., 2012), whereas we reported new sites of *V. darevskii* 20 km farther south-east at Sulakçayir, Hanak District, Ardahan Province (n=4, Göçmen et al., 2014). The *V. darevskii*-site south of Posof is ca. 30-35 km distant to the nearest known site of *V. eriwanensis* south of Çamlibel, Ardahan District (Baran et al., 2005b) or Ölçek, Hanak District (Geniez & Teynié, 2005).

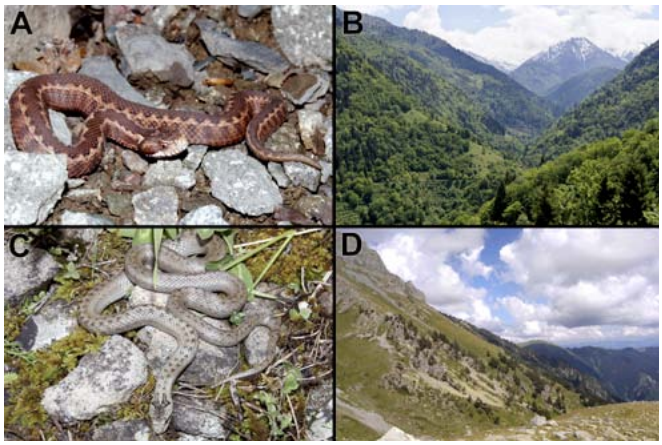
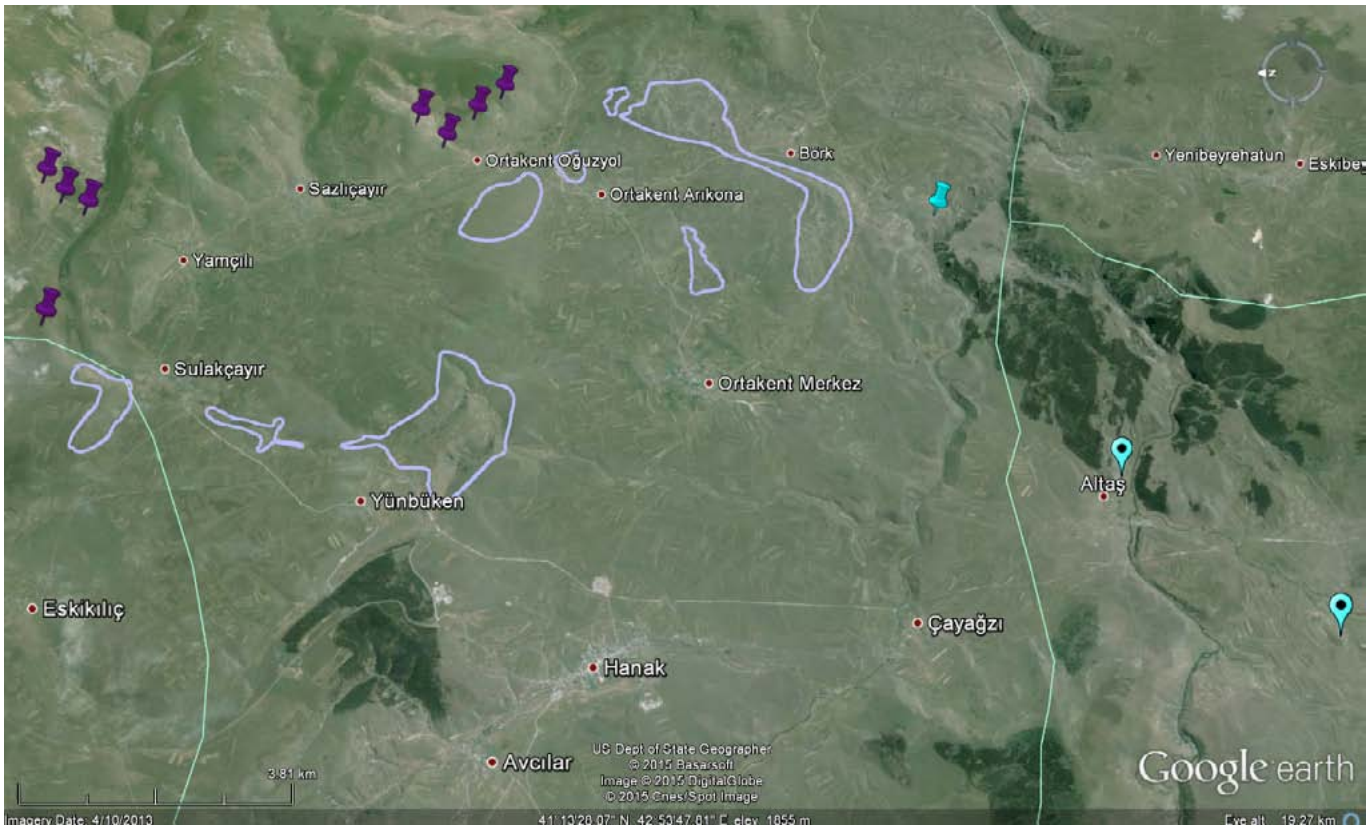


Figure 4. Region 2, with the potential (not confirmed) transition zone between *Vipera kaznakovi* and *V. darevskii* in the Province Artvin, Turkey: (A) juvenile *V. kaznakovi* and (B) its habitat in the Camili area, Artvin, with the Karçal Mountains visible in the background; (D) the Smooth Snake (*Coronella austriaca* from Province Ardahan), inhabiting high altitude site up to 2000 m asl., as the Çikunet Plateau in Artvin Province where small vipers were reported by locals, but which might be confused with the Smooth Snake.

Figure 5. Sampling area for Region 3, the *Vipera darevskii-V. eriwanensis* transition zone with the centre of the map at 41°13'28.07"N, 42°53'47.81"E. Violet pin-markers on the left represent our *V. darevskii* records, the light blue one represents the new *V. eriwanensis* from Dilekdere. The new records of *V. darevskii* have been displaced relative to each other to visibly fit into the map. The two light blue drop-markers with black centres refer to published records; the upper one from Geniez & Teynié (2005) and the lower one by Mulder (1995). The exact positions of the latter two records were personally confirmed by the respective authors. The light purplish area-circles designate potential contact zones between these two viper species.



In 2014, we detected four *V. darevskii* near Oğuzyolu, approximately 7 km south of the Sulakçayir site (Fig. 5). Individuals were found in rockslides and natural stone piles in alpine grassland > 2000 m asl. Recently reported sites of *V. darevskii* in Georgia (Tuniyev et al., 2014), along its border with Turkey, are only 10-15 km distant from our sites. A look at the topography in north-eastern Ardahan Province suggests that all currently known sites of *V. darevskii* in that region, from Posof along the Turkish-Georgian border to Oğuzyolu and Dirsekkaya, are connected via mountains and slopes with sufficient rock slides and piles to provide an almost continuous habitat at an elevation > 2000 m over more than 40 km in this province alone. In regards to *V. eriwanensis*, we found only two specimens outside of Region 3 near Kağizman in Kars Province. But we were able to confirm its presence in eastern Hanak District via a photo-ID from Dilekdere (Fig. 6C). This record substantially shortens the distance between *V. eriwanensis* and *V. darevskii* from ca. 30 km to 8 km (Dilekdere to Oğuzyolu).

During two days in the field, we have unsuccessfully searched a putative contact zone in the area between the two viper species, which lies around 2000 m asl. and appears superficially suitable for either species, as it provides plenty of rocks/stones on alpine meadows. We recognised that the visibly heavy grazing by cattle and horses drastically reduced the diversity of dry meadow plants, and thus, the abundance of grasshoppers and crickets, an important food source for both species (Höggren et al., 1993; Aghasyan et al., 2009). Furthermore, the grazing reduces herbaceous cover, which is important for safe thermoregulation, as the cover obstructs against visual predators and provides increased humidity and moderate temperatures in hot summer days. Nonetheless, the few kilometres of rocky/grassy habitat between these

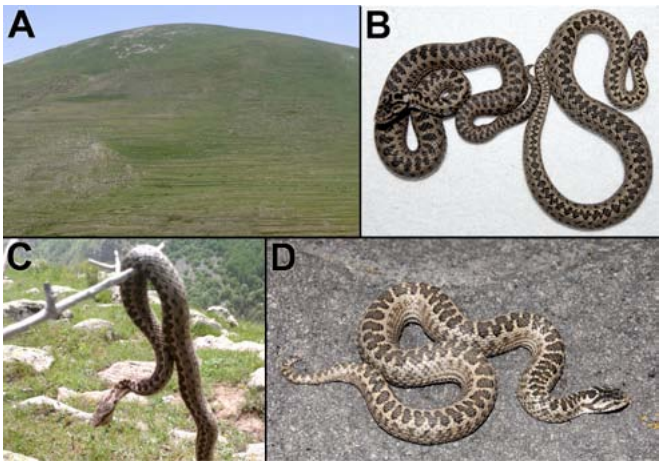
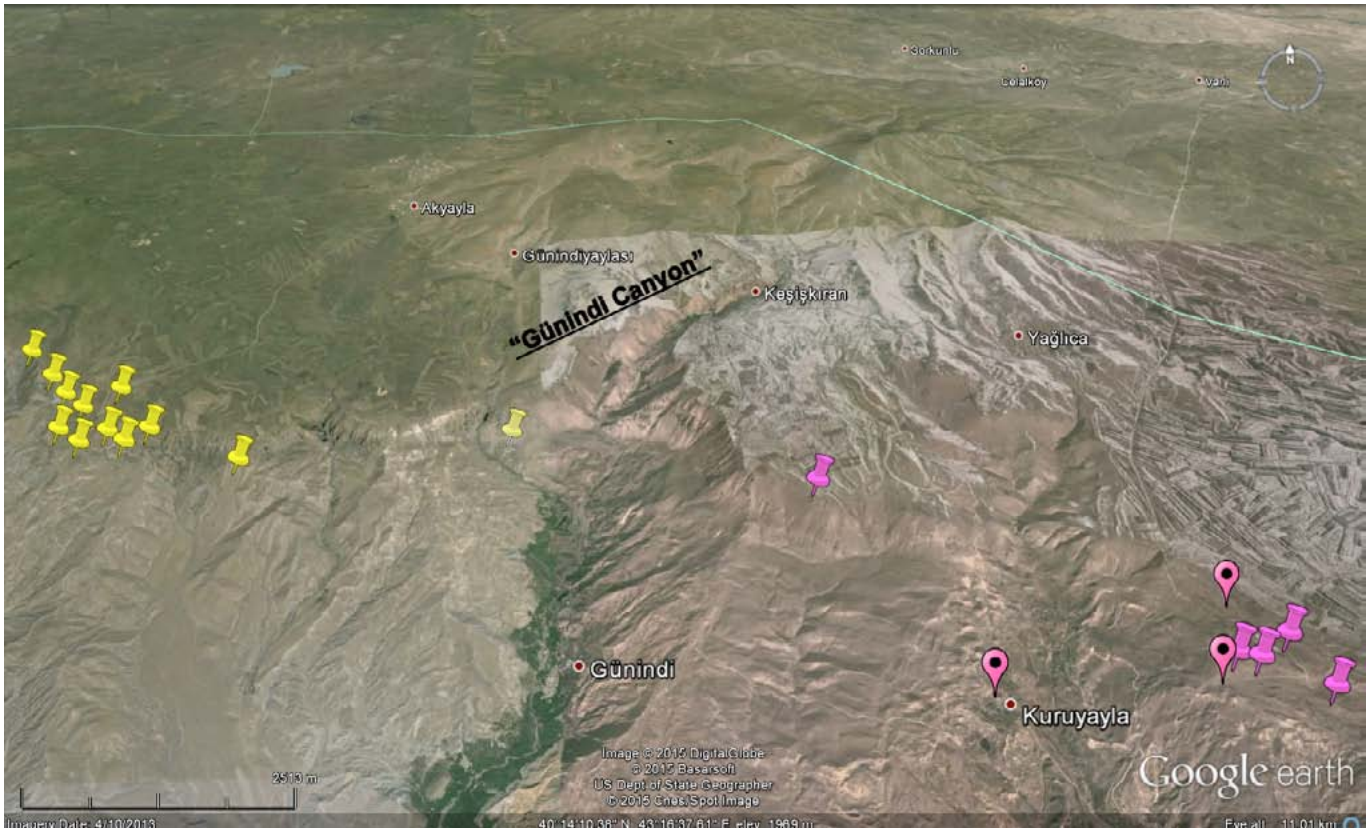


Figure 6. Region 3, transition zone between *Vipera eriwanensis* and *V. darevskii* in Province Ardahan, Turkey: (A) habitat of *V. darevskii* in eastern Hanak district with a cattle herd on the upper left slope; (B) two highland meadow vipers, with *V. darevskii* from the Province Ardahan on the left and *V. eriwanensis* from the Province Kars on the right; (C) *V. eriwanensis* from Dilekdere, Ardahan (photo by Uygun Akpinar); (D) a female *V. darevskii* from eastern Hanak at a distance of ca. 8 km from the *V. eriwanensis* depicted on the left image.

Figure 7. Sampling area for Region 4, the *Montivipera wagneri-M. raddei* transition zone with the centre of the map at 40°14'10.38"N, 43°16'37.61"E. Yellow pin-markers represent *M. wagneri* (the single pale yellow marker on the right is a unverified sighting of *M. wagneri* by a local, all saturated yellow markers were sampled by us), and the pink pin-markers is for *M. raddei.* Pink drop-markers with black centres represent *raddei*-markers from literature records (lower right composite for Nilson et al. 1988; Schätti 1991) and pers. comm. (drop-marker at Kuruyayla by M. Schweiger; upper right drop marker by M. Corboz and V. Ruffieux). The new records of *M. wagneri* to the left have been displaced relative to each other to visibly fit into the map.



two vipers will need to be searched more intensively to eventually find the zone of contact and evaluate differences in microhabitat. The impact of heavy grazing by cows, goats, sheep, and horses, should urgently be evaluated for its potentially detrimental effects to most small, alpine, and insectivorous vipers.

Region 4: *Montivipera wagneri-M. raddei* transition zone (Fig. 7)

The Aras Valley is home to both rock vipers (Fig. 8A and B). *M. wagneri* occurs predominantly west of Kağizman and *M. raddei* east of it with about 40 km distance between their closest officially known populations (Nilson et al., 1988; Schätti et al., 1991; Mulder, 1995; Baran et al., 2004; Stümpel, 2012). However, no proximate populations or area of contact have ever been published, and the occurrence of these taxa around Kağizman is not documented to our knowledge.

We searched and found vipers (*M. wagneri*: n=20, *M. raddei*: n=5) along the cliffs and their stone slides, as well as in patches of rock/alpine grass, near Karakurt and within 20 km of Kağizman. Both species were detected virtually in the same habitat along the south-exposed slopes north-east of Kağizman, but separated by a 6.7 km straight-line distance at Günindi (Fig. 7). The gap declined to only 3.5 km with the inclusion of one reliable observation of *M. wagneri* by a local shepherd (positive photo identification on our questionnaire sheet). This area constitutes the potential contact zone between these rock vipers on the northern side of the Aras Valley. The upper stretch of Günindi Valley contains a small stream, which divides the 40 km long continuous slope/cliff between the village Şabanköy and the Armenian border into an eastern (*raddei*) and western (*wagneri*) segment. Locals on either side of the "Günindi Stream" have corroborated this division by pointing on our questionnaire sheet only to the rock viper species occurring on their side of the stream. The eastern (*raddei*) and western (*wagneri*) cliffs come close to each other near Günindi, where the interjacent valley and both cliffs deviate north, forming a 3 km long canyon as far as to the village Keşişkiran (Fig. 7). At that village, the large cliffs/slopes end and change into less steep slopes and a plateau > 2200 m asl., a habitat less suitable for either *Montivipera* species. Already the cliffs/slopes in "Günindi canyon" are rarely south-exposed, and thus, will receive less direct solar radiation compared to the principal slopes of the Aras Valley, where both *Montivipera* spp. yield strong populations in essentially the same habitat. In particular the *raddei*-cliff in "Günindi canyon" is mostly north-exposed, and thus, maintains a cooler climate for a longer period in the winter through spring, which is well visible by the snow covered slopes on GE-satellite images taken on 21 December 2010 and 17 March 2009, whereas the *wagneri*-side in Günindi canyon is mostly snow free.

Even though, the "Günindi canyon" may lack optimal habitat for *Montivipera* spp., there are sufficient rock slides and piles to provide at least temporarily (e.g., during summer and fall months) some habitat. The shallow stream at the entrance of the canyon is only 1-5 m wide, and thus, unlikely poses a barrier for any exchange between these taxa. On the contrary, the confirmed distance down to a few kilometres between both *Montivipera* spp. is likely within the reach of moving/migrating specimens during the period of a single generation. However, other landscape factors possibly decrease the habitat quality in this area. For example, the slopes below the cliffs consist predominantly of finely eroded mineral soil (e.g., sand and gravel) across a straight distance of approximately 8.7 km between Kuruyayla and Günindi, and thus includes the potential contact zone. In addition, important rockslides are less frequent in that zone than in adjacent areas (Fig. 8C). The finding of the boid *Eryx jaculus* (Fig. 8D), a sand specialist, in this habitat corroborates the significant mineral soil component. The sandy slopes provide less stability to important subterranean burrow systems (for daily shelter, hibernation, prey) and decreases vegetation growth than the more stable organic soil, which can be found adjacent to this putative contact zone at Günindi-Kuruyayla, and where the two viper species are common.

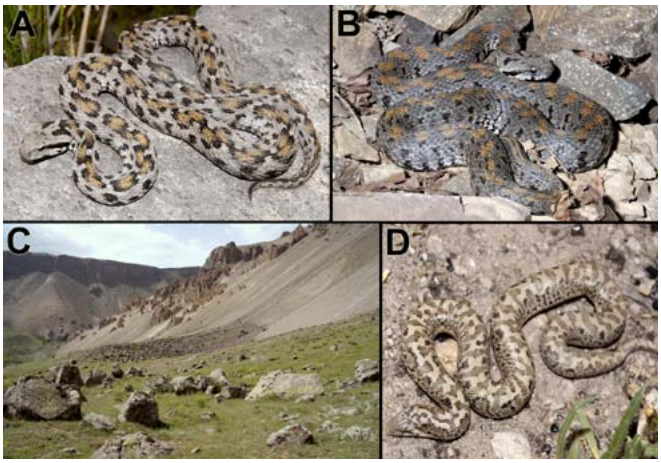


Figure 8. Rock vipers from sites near the putative *Montivipera* contact zone at Günindi, Kars Province; (A) *M. wagneri* and (B) *M. raddei*, (C) habitat at the contact zone with sandy slopes (see text), and (D) Sand Boa *Eryx jaculus* from this site, an indicator species for loose, sandy soil.

It needs further on-site investigations to evaluate how significant the perceived correlation "soil type-viper presence" is, and whether the mineral (sandy) soil poses an incomplete barrier for individuals of both species to migrate between their respective populations. Even though the putative contact zone may not be impossible to inhabit by either species, the entire zone of mineral soil of 8–9 km length may represents a density trough, i.e., that specimens of either species may migrate into that zone and live in sympatry and syntopy, but density is so low that neither species can build up a large population that would promote individuals to migrate into adjacent areas where only the other *Montivipera* species is present (on opposite sides of the potential contact zone). Hence, migration of any *Montivipera* species into the range/population of its related species would be countered by the neighbouring species' dominance (higher number of individuals), and provoke a competitive scenario or genetic swamping, if hybridization occurs.

Region 5: *Macrovipera lebetina* from its northern periphery in Turkey (Fig. 9)

The Blunt-nosed Viper is known only from a single record in Artvin Province, the most north-eastern province in Turkey (Ardanuç; Basoglu & Baran, 1980, see approximate location C in Fig. 9). We have compiled information on four new observations of *M. lebetina* in Artvin Province, which are:

1. We collected one exuvia of *M. lebetina* and observed one specimen (escaped) at 270 m asl. across Serender Tatil Köyü on the right hand slope downstream of Coruh River on 4. July 2013 (location B in Fig. 9; 41°14'33.96"N, 41°47'8.97"E).
2. Approximately 4 km north of our record, a video document by Ömer Altuntas (http://www.youtube.com/watch?v=uYkEmWQWKRo) clearly shows a *M. lebetina*. This observation was recorded in 2009 above the Coruh River near Irsa (Erenler) according to the author. We provisionally set the location at ca. 340 m asl. along a paved curve 11 km north of the city Artvin, fitting the scenes in the video clip. This record currently represents the most northern for this species in Turkey (approximate location A in Fig. 9).
3. An independent Dutch team found a killed *M. lebetina* on 30.05.2013 along Berta River ca. 12 km north of the town Ardanuç (location D in Fig. 9; 41°13'50.17"N, 42° 5'35.10"E).
4. One previously unpublished record of *M. lebetina* (DOR) at Yusufeli, Artvin by Göran Nilson, on 28.05.1989 (pers. comm. and location E in Fig. 9; 40°48'37.50"N, 41°34'9.90"E)

These observations indicate, that *M. lebetina* likely expanded via the Coruh Valley to its current northern limit near Borçka. The most northern extent of *M. lebetina* in Turkey is not known precisely, but they are likely to be found along the slopes of the Coruh Valley within 10 km south of Borçka. Whereas the construction of the hydropower plant at Borçka and the subsequent flooding of the Coruh River presumably has killed a large number of specimens of *M. lebetina*, the subsequent construction of the shore road generated new rock slides and large dry walls supporting the road. These structures probably produced new habitat along the river and so provide a potential corridor for *M. lebetina* to expand north toward Borçka. According to satellite images, the small ridge villages Ibrikil and Adagül south of Borçka appear to provide the last arid patches and south-exposed rocky outcrops, viewed as a suitable habitat for local *M. lebetina*. The area around Borçka is in the midst of a habitat transition with a humidity gradient across a few km only, and correspondingly, different viper species associated with it, ranging from dry (*M. lebetina*) to moderate humid (*V. ammodytes*) to humid (*V. kaznakovi*).

CONCLUSIONS

During three field expeditions, we have substantially reduced the distances between closely related viper species by mostly more than 50%, and in the case of *M. raddei* and *M. wagneri* determined one putative contact zone. However, in order to verify contact and mixed populations between closely related

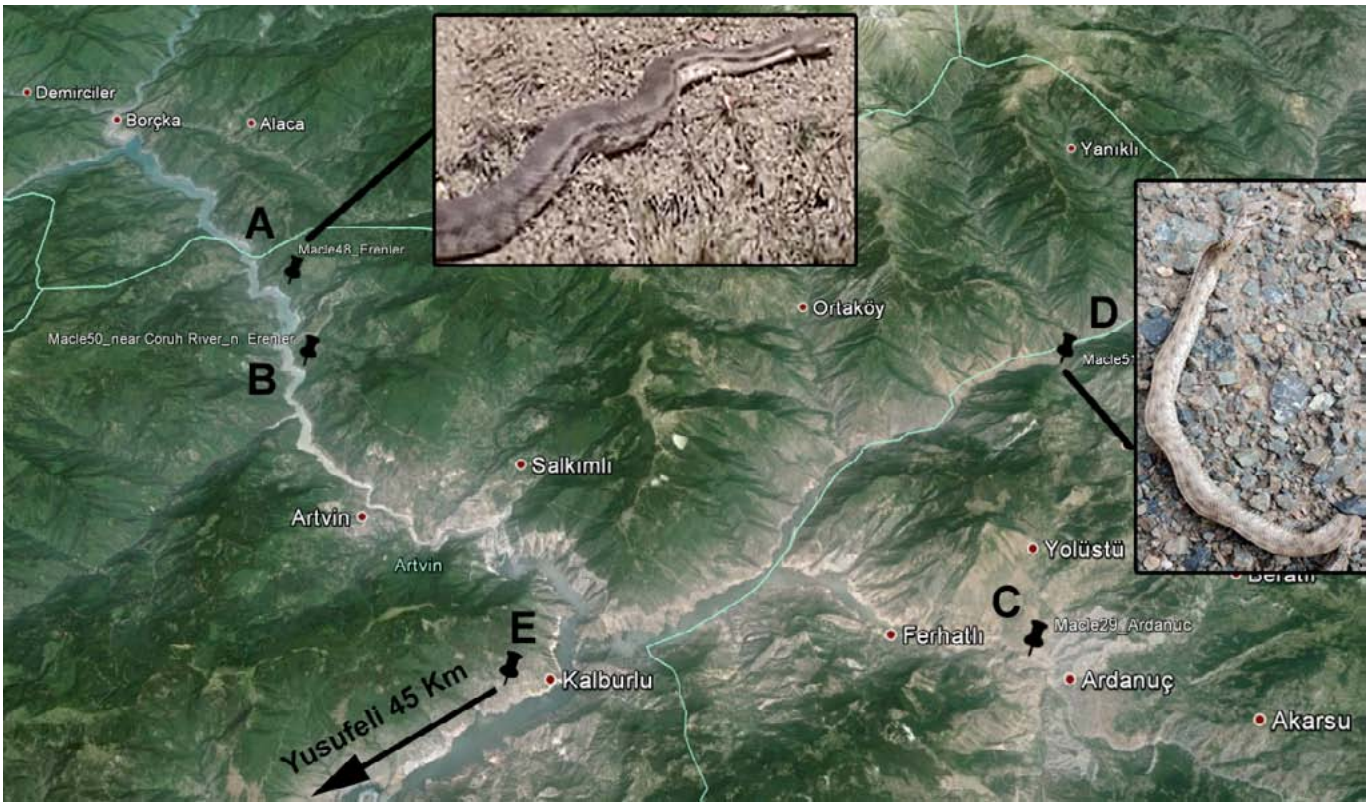


Figure 9. *Macrovipera lebetina* records from Province Artvin (see text for available coordinates and more information on the sources): (A) with an image of a specimen crossing a road near Eneler, District Artvin, by Ömer Altuntas; (B) our observations above Coruh River, District Artvin; (C) Ardanuç (Basoglu & Baran 1980); (D) killed specimen, Berta River, District Ardanuç, coordinate and photo provided by Ronald Laan, Klooiplek; (E) DOR from Yusufeli (not on map) by Göran Nilson (pers. comm.).

taxa, all defined regions should be visited again, possibly partitioned into regional and local study sites of a few square kilometres, in order to evaluate habitat segregation and/or potential hybridization.

Moreover, tissues from all sampled vipers are currently stored and await further additions before a genetic analysis will be conducted. Based on the new observations and further sampling, habitat distribution models could be considered in order to improve the distribution knowledge and ecological divergence of the different viper species. Although we are not at this level yet, we have steadily worked to approach this goal by sampling distributional, genetic, morphological, and ecological data. We have planed to continue this research and hope to acquire sufficient data in the near future to provide ample means for concrete and effective conservation purposes and specific action plans, i.e., such as the range limits of threatened taxa, their population densities, a clarification which taxa do constitute clear independent species (and deserve preferred conservation assessment), and which are their relevant environmental correlates. Finally, we look forward to further collaborative research with Turkish and international researchers. Once accomplished, the results will be available to conservation entities, including Turkish national park authorities, NGOs, academics, to generate public awareness and improve tools for the conservation of these valuable species.

ACKNOWLEDGEMENTS

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Statement on Conservation Issues: Publishing new viper locations in Turkey has been a contentious issue, as such information could facilitate the search for vipers by potential animal smugglers and dealers in order to supply the illegal pet trade. Furthermore, wildlife tourism for trophies (mainly photographs) has been increasing for years, but with negligible impact on local populations. However, the recent discussion held during the "The 4th Biology of the Vipers" conference in Athens on Oct. 2014 organised by the VSG (Viper Specialist Group of the SSC-IUCN) suggested that the threat status for Turkish vipers, as stated in the current IUCN Red Lists, is exaggerated and not justified and thus requires a complete update. Indeed, our expanded data set shows that most viper species are significantly more common and widespread in Turkey than stated in the Red Lists. After several years of research on vipers in Turkey by us, combined with our extensive field experience and knowledge of the biology of vipers from other countries, we have no grounds to consider densities of Turkish vipers being any different from other "healthy" viper populations in comparable mountain ranges (e.g., Alps, Balkan Peninsula). Numerous requests among persons with extended knowledge on Turkish vipers in the pet trade have not uncovered any explicit and recent commercial offers of wild caught vipers from Turkey, and by far most, if not all Turkish vipers in the market originated from the breeding of captive specimens. The occasional report of viper smuggling out of Turkey is either erroneous or relates to very few specimens, irrelevant for the conservation of Turkish viper populations. Nonetheless, we would like to promote the respect of Turkey's natural assets and state that collecting Turkish vipers is strictly forbidden and such illegal action will be prosecuted. In the context of publishing new locations, we perceive this as not problematic, as sampling at sites with low viper densities is non-profitable (large search effort for little success), a sufficient deterrent for illegal collectors, whereas sites with extensive habitats and large populations of vipers are robust enough to sustain limited impact by man. Yet we encourage projects to prevent biosmuggling with the participation of authorities and local people wherever such actions are required.

Based on our experience and studies with vipers in Western and Central Europe, we conclude that the biggest threat for Turkish vipers results mainly from man-made habitat degradation, including dam construction, overgrazing, plantation and intensive agriculture. We therefore suggest to conduct, publish and promote studies of wild Turkish viper populations after taking necessary permissions from The General Directorate of Nature Conservation and Natural Parks of Turkey. Such studies should result in relevant information on the species habitat requirements. By so, we hope to provide with our studies essential knowledge for the development of specific conservation plans for Turkish vipers and public education.

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Dietary habits of *Varanus salvator salvator* in Sri Lanka with a new record of predation on an introduced clown knifefish, *Chitala ornata*

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INTRODUCTION

Two species of monitor lizard (*Varanus*) occur in Sri Lanka: *V. salvator salvator* (water monitor) and *V. bengalensis* (land monitor). The nominotypic form *V. s. salvator* is endemic (Koch et al., 2007) and the largest species of lizard in Sri Lanka with the longest individual recorded being 321 cm in total length (Bennett, 1998). *V. s. salvator* are generally found in aquatic habitats including freshwater swamps, ditches, tanks, streams, reservoirs, ponds, rivers, mangroves and coastal marshes areas. They also live in urban areas (in Kandy Lake, a lake located in an urban center of Sri Lanka, they frequently forage around the city and flea markets), suburban storm-water discharge canals and man-made storage ponds (personal observations, Karunarathna et al., 2008a, b). Previous studies have indicated that *V. s. salvator* is an opportunistic generalist carnivore that scavenges and predates on a wide variety of prey including fish, amphibians, rodents, birds, reptiles, and large invertebrates such as crustaceans (e.g. Daniel, 2002; Somaweera & Somaweera, 2009). In this paper we present a short detailed review of the known dietary habitats of *V. s. salvator* in Sri Lanka, including new observations made by ourselves that includes a new record of a predation event on an introduced species of fish previously not recorded as a prey species of *V. s. salvator*.

METHODS

Our results are based on our field observations in various regions of Sri Lanka, observations made by other herpetologists, interviews conducted with local communities regarding their opportunistic observations and published peer-reviewed literature. Our field observations of the new prey type were made at a distance of 2-20 m from the focal individual between 0600 and 1700 hrs with 8×40 binoculars.

In this review we define non-natives as long-term resident species - i.e. domestic dogs and cats, as distinct from aliens, which are more recent introductions - see Hegan (2014) for an alternative definition.

RESULTS AND DISCUSSION

Our study indicates that prey selection of *V. s. salvator* is much broader than previously reported in the literature. We found a total of 102 food items that have been observed predated/consumed by *V. s. salvator* in Sri Lanka (Table 1). Among these, 86 (84.3%) were vertebrates, and 16 (15.7%) invertebrates. Vertebrate prey included four species of amphibian (3.9%), 18 species of reptile (17.7%) including highly toxic snakes, for example *Daboia russelii* and *Naja naja*, 11 species of birds (10.8%), 24 species of mammals (23.5%) and 29 fish species of fish (28.4%). Among these, 15 are considered introduced species in Sri Lanka (9 freshwater fish, 4 mammals, 1 bird and one land snail). In addition, we recorded predation on a captive population of *Aix galericulata* (Mandarin ducks) in the National Zoological Gardens of Sri Lanka. Our research confirms the importance of scavenging behaviour in *V. s. salvator* including foraging on discarded fish remains (10 species of marine fish) around fishing harbours and marine fish markets in the coastal areas. We also noted that *V. s. salvator* consumed household trash (personal observations).

Our field observations also indicate that (n>20 observations) water monitors when hunting are able to dive deep and actively hunt large fish (25-40 cm long). For instance, we observed lizards ingest about 2-3 large-sized introduced fish at a single feeding (e.g. *Piaractus mesopotamicus* [30 cm] and *Pangasianodon hypophthalmus* [30 cm]). We also documented predation on newborns and juveniles of domestic cat (Fig. 1a), domestic dog, and Indian hog deer (*Axis porcinus*). Further, both fully-grown and subadult lizards excavate below-ground nests of terrapins (*Melanochelys trijuga*) (Fig. 1b), *V. bengalensis*, rats, mice, burrowing frogs (*Uperodon systoma*), and birds (Fig. 1c), invasive fish including their benthic nests (Fig. 1d), and buried animal carcasses (e.g. domestic cats, domestic dogs and domestic buffalos). *V. s. salvator* is apparently able to detect prey items 20 – 70 cm deep in the ground, and dig continuously for at least two hours and are capable of breaking the carapace of terrapins (*M. trijuga*) using their jaws (personal observations;

Figure 1. Examples of predation by adult *V. s. salvator*: (a) attempting to predate a domestic cat *F. catus*; (b) consuming black terrapin (*M. strijuga*) eggs; (c) predating a little cormorant *Phalacrocorax niger* and (e) predating an invasive catfish *Hypostomus plecostomus* .

Deraniyagala, 1953). More recently, we observed *V. s. salvator* feeding on the remains of human meals e.g. cooked rice and other prepared food as has Karunarathna et al., (2012).

New record of predation. On 24th January 2015 in Kuda Waskaduwa old clay excavation site (altitude: 3 m; 6°37'30.85'' N and 79°57'17.26 E) in Kalutara district of Western Province, Sri Lanka a mature male water monitor (*V. s. salvator* ~80 cm SVL) was observed from a distance of ca. 5 m from 0915hrs (local standard time) until 0948hrs moving in an abandoned, "naturalized" clay pit. The pit was rain-fed, with dimensions 25 m wide, 40 m long, and from 0.5m (in the littoral zone) to 4m (in the center) deep. At 0920 hrs the monitor suddenly submerged and ~5 minutes later we noted that it was actively pursuing something. The monitor emerged from middle of the pool and hid in the littoral vegetation. After ~3 minutes it re-emerged from the littoral zone with a large live Clown knifefish (*Chitala ornata*). The fish was nearly 40 cm long from head to tail and although struggled to break free was consumed after 15 minutes.

Given these observations it is likely that *V. s. salvator*, an abundant, widely-distributed reptile in Sri Lanka, may play an important role in regulating the population size of invasive species (see Karunarathna et al., 2008a, b). There are 15 species of vertebrates and 5 invertebrates that are well-established invasive species in the lowland wet zone of Sri Lanka (Marambe et al., 2011) and our data indicate that *V. s. salvator* predates at least 8 of the invasive vertebrates (Table 1 & Fig. 1d). Future detailed investigations based on both field observations and experimental studies on the predator-prey interactions of *V. s. salvator*, especially in relation to invasive fauna, could potentially yield important information for our understanding of natural history, community ecology and conservation biology in Sri Lanka.

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Table 1. Current known prey items of *V. s. salvator*, in Sri Lanka

Prey taxa	Prey species	Prey condition at the time of ingestion	Location	Reference and remarks
Mammalia	*Axis axis*	Carcasses	Polonnaruwa, Udawalawe Lowland dry zone	L. Dayarathne and S. Weerathunga pers. com.
	Axis porcinus	Live juveniles	Baddegama Lowland wet zone	S. Akmeemana pers. com.
	Bandicota indica	Adults killed by people and carrion	Nugegoda Lowland wet zone	Current study
	Bubalus bubalis[1,3]	Offal scavenged from slaughter houses and other carcasses	Homagama, Beruwala, Udawalawe Lowland wet zone, lowland dry zone	Current study; S. Weerathunga pers. com.
	Canis aureus	Carcasses	Udawalawe Lowland dry zone	S. Weerathunga pers. com.
	Canis familiaris[1]	Live pups, road kill carcasses and buried carrion	Ganemulla, Galle, Panadura, Kesbewa, Kirulapone Lowland wet zone	Current study; S. Akmeemana pers. com.
	Capra hircus	Offal scavenged from slaughter houses	Aluthgama, Kandy Lowland wet zone, highland wet zone	Current study
	Elephas maximus	Carcasses	Polonnaruwa, Udawalawe Lowland dry zone	L. Dayarathne and S. Weerathunga pers. com.
	Fanambulus palmarum	Adult road kill carcasses	Piliyandala Lowland wet zone	Current study
	Felis catus[1]	Live juveniles, road kill carcass, buried carrions	Dehiwala,Galle, Hirana, Matugama, Nugegoda,Udawalawe Lowland wet zone, lowland dry zone	Current study; A. Nanayakkaraand S. Weerathunga pers. Com.
	Felis chaus	Live juveniles and dead carcasses	Udawalawe Lowland dry zone	S. Weerathunga pers. com.
	Hystrix indica	Adult carcasses that were killed by humans	Polonnaruwa Lowland dry zone	L. Dayarathne pers. com.
	Homo sapiens sapiens	Corpses or body parts floating on river	Kelaniya, Matara, Panadura, Kalutara Lowland wet zone	P. Mendis and P. Atapattu pers. com.
	Lepus nigricollis	Live juveniles	Udawalawe Lowland dry zone	S. Weerathunga pers. com.
	Macaca sinica	Carcasses	Matara Lowland wet zone	Current study

Prey taxa	Prey species	Prey condition at the time of ingestion	Location	Reference and remarks
	Moschiola meminna	Adult that had been killed by domestic dogs	Bandaragama Lowland wet zone	T. Pieris pers. com.
	Paradoxurus hermaphoditus	Adult road kill	Nugegoda Lowland wet zone	Current study
	Pteropus giganteus	Adults killed by electrocution	Homagama, Moratuwa Lowland wet zone	Current study
	Rattus rattus[1,3]	Adults and sub adults killed by people and as carrion	Maharagama Lowland wet zone	Current study
	Rusa unicolor	Dead adults and juvenile carcasses	Polonnaruwa, Giritale Lowland dry zone	Current study; T. Priyadarshana pers. com.
	Semnopithecus vetulus	Adults killed by electrocution	Avissawella Lowland wet zone	Current study
	Suncus sp.	Live adults and juveniles	Puttalam, Rajagiriya Lowland dry/intermediate zone, lowland wet zone	Karunarathna et al. 2012; K. Manamendra-Arachchi pers. com.
	Sus domesticus	Body parts scavenged from slaughter houses	Kuruwita, Moratuwa, Kandana Lowland wet zone	Current study
	Sus scrofa	Dead adults	Polonnaruwa Lowland dry zone	Current study
Aves	*Aix galericulata*[1]	Captive live adults	Dehiwala Lowland wet zone	S. Kiriwaththuduwa pers. com.
	Amaurornis phoenicurus	Live chicks	Ganemulla Lowland wet zone	Current study
	Ardea purpurea	Carcasses	Malambe Lowland wet zone	Current study
	Bubulcus ibis	Live adult	Udawalawe Lowland dry zone	S. Weerathunga pers. com.
	Corvus splendens	Carcass	Puttalam, Rajagiriya Lowland dry zone/wet zone	Karunarathna et al. 2012; Current study
	Gallus domesticus	Live juveniles, eggs and body parts scavenged from slaughter houses	Moratuwa, Homagama, Kandana Lowland wet zone	Current study
	Gallus lafayetii	Carcasses	Sinharaja Lowland wet zone	Current study
	Mesophoyx intermedia	Carcasses	Panadura Lowland wet zone	Current study
	Pavo cristatus	Carcasses, chicks and eggs	Thissamaharama, Puttalam Lowlan dry zone/arid zone	Karunarathna et al. 2012; Current study
	Phalacrocorax niger	Live juveniles and carcasses	Puttalam, Bellanwila-Attidiya, Kandy Lowland dry zone, lowland wet zone, highland wet zone	Karunarathna et al. 2012; Current study
	Vanellus indicus	Eggs	Boralesgamuwa Lowland wet zone	Current study
Reptilia	*Caretta caretta*	Live hatchlings and eggs	Weligama, Kahawa, Balapiyiya Lowland wet zone	Current study; T. Kapurusinghe pers. com.
	Chelonia mydas	Live hatchlings and eggs	Kosgoda, Rekawa, Seenigama Lowland wet zone	Current study; T. Kapurusinghe pers. com.
	Crocodylus palustris	Live hatchlings and eggs	Bibila, Thanamalwila Intermediate zone	Current study; C. Dissanayake pers. com.
	Crocodylus porosus	Live hatchlings and eggs	Beruwala, Borupana Lowland wet zone	Amarasinghe et al. 2015; Current study
	Daboia russelii	Live adults, sub adults and road kill carcass	Dambulla, Thissamaharama Lowland dry zone	Current study; S. Velaratne pers. com.
	Dermochelys coriacea	Live hatchlings and eggs	Hikkaduwa, Balapitiya, Rekawa Lowland wet zone	Current study; T. Kapurusinghe pers. com.
	Eretmochelys imbricata	Live hatchlings and eggs	Matara, Dikwella, Rekawa, Moratuwa Lowland wet zone	Current study; T. Kapurusinghe pers. com.
	Geochelone elegans	Buried eggs of captive tortoises	Angulana Lowland wet zone	C. Jayaweera pers. com.
	Lepidochelys olivacea	Live hatchlings and eggs	Kosgoda, Hikkaduwa, Wellawatta Lowland wet zone	Current study; T. Kapurusinghe pers. com.
	Lissemys ceylonensis	Live juveniles and adult road kill carcasses	Meegoda Lowland wet zone	Karunarathna et al. 2012; Current study

Prey taxa	Prey species	Prey condition at the time of ingestion	Location	Reference and remarks
	Melanochelys trijuga	Live juveniles, eggs and adult road kill carcasses	Puttalam, Ampara Lowland dry zone/intermediate zone	Deraniyagala, 1953; Karunarathnaet al. 2012; Current study
	Naja naja	Live sub adults and road kill carcasses	Puttalam, Kalutara Lowland wet zone, lowland dry zone//intermediate zone	Karunarathna et al. 2012; Current study
	Oligodon arnensis	Live sub adult	Horana Lowland wet zone	Current study
	Oligodon taeniolata	Live adult and road kill carcasses	Puttalam, Kegalle Lowland dry zone/intermediate zone, lowland wet zone	Karunarathna et al. 2012; S. Basnayake pers. com.
	Ptyas mucosa	Live sub adults, juveniles and adult road kill carcasses	Nugegoda, Puttalam, Nilgala lowland dry zone/intermediate zone, lowland wet zone	Karunarathna et al. 2012; Current study
	Varanus bengalensis	Road kill carcasses, juveniles and eggs	Dehiwala, Ambalangoda Lowland wet zone	Karunarathna et al. 2008b; V. Silva pers. com.
	Varanus salvator	Carcasses	Rathgama, Kandawala Lowland wet zone	Amarasinghe et al. 2009; Current study
	Xenochrophis piscator	Live adults, sub adults, juveniles and road kill carcasses	Maharagama, Ganemulla, Puttalam Lowland wet zone, lowland dry zone/intermediate zone	Karunarathna et al. 2012; Current study
Amphibia	*Duttaphrynus melanostictus*	Live adults, sub adults, juveniles and road kill carcasses	Jaela, Ratmalana, Panadura Lowland wet zone	Current study
	Hoplobatrachus crassus	Live adults and road kill carcasses	Anuradapura, Mahiyanganaya Lowland dry zone	Current study
	Pseudophilautus sp.	Contents of regurgitation	Kandy Highland wet zone	K. Ukuwela pers. com.
	Uperodon systoma	Live adults, sub adults and road kill carcasses	Hambegamuwa, Dambulla Lowland dry zone /intermediate zone	Current study
Pisces	*Aetobatus narinari*[2]	Discarded body parts from fishermen	Homagama, Boralesgamuwa Lowland wet zone	Current study
	Anabas testudineus	Live adults	Lahugala Lowland dry zone	Wickramasinghe et al. 2010
	Anguilla nebulosa	Dead adult	Gampaha Lowland wet zone	Current study
	Auxis thazard[2]	Discarded body parts from fishermen	Boralesgamuwa, Moratuwa Lowland wet zone	Current study
	Catla catla[1]	Discarded body parts from fishermen	Udawalawe Lowland dry zone	S. Weerathunga pers. com.
	Channa gachua	Live adults	Nugegoda Lowland wet zone	D. Geekiyanage pers. com.
	Channa striata	Individuals strangled in fishing nets	Udawalawe Lowland dry zone	S. Weerathunga pers. com.
	Chitala ornata[1,3]	Live adults	Waskaduwa Lowland wet zone	Current study
	Cirrhinus mrigala[1]	Discarded body parts from fishermen	Udawalawe Lowland dry zone	S. Weerathunga pers. com.
	Clarias brachysoma	Live adults	Nugegoda Lowland wet zone	Current study
	Cyprinus carpio[1,3]	Captive live adults and sub adults	Galle Lowland wet zone	S. Akmeemana pers. com.
	Euthynnus affinis[2]	Discarded body parts from fishermen	Angulana, Lunawa Lowland wet zone	Current study
	Heteropneustes fossilis	Live adults	Lahugala, Nugegoda Lowland dry zone, lowland wet zone	Wickramasinghe et al. 2010; Current study
	Hypostomus plecostomus[1,3]	Live adults and trash carcass	Bellanwila-Attidiya, Bolgoda Lowland wet zone	Karunarathna et al. 2008a; Current study
	Istiophorus platypterus[2]	Discarded body parts from fishermen	Ratmalana, Borupana Lowland wet zone	Current study
	Katsuwonus pelamis[2]	Discarded body parts from fishermen	Boralesgamuwa, Homagama Lowland wet zone	Current study
	Labeo rohita[1]	Discarded body parts from fishermen	Udawalawe Lowland dry zone	S. Weerathunga pers. com.

Prey taxa	Prey species	Prey condition at the time of ingestion	Location	Reference and remarks
	Oreochromis mossambicus[1,3]	Dead individuals and individuals asphyxiated in fishing nets	Dehiwala, Udawalawe Lowland wet zone, Lowland dry zone	Karunarathna et al. 2008b; Current study; S. Weerathunga pers. com.
	Oreochromis niloticus[1]	Dead individuals and individuals asphyxiated in fishing nets	Dehiwala, Udawalawe Lowland wet zone, Lowland dry zone	Karunarathna et al. 2008b; Current study; S. Weerathunga pers. com.
	Osphronemus goramy[1]	Discarded carcasses and other dead individuals	Dehiwala Lowland wet zone	Karunarathna et al. 2008b; Current study
	Pangasianodon hypophthalmus	Captive live sub adults	Moratuwa Lowland wet zone	Current study
	Piaractus mesopotamicus	Captive live adults and sub adults	Galle Lowland wet zone	S. Akmeemana pers. com.
	Prionace gluaca[2]	Discarded body parts from fishermen	Kuruwita Lowland wet zone	Current study
	Puntius sp.	Live adults	Lahugala, Bandanagala Lowland dry zone	Wickramasinghe et al. 2010; Current study
	Rastrelliger kanagurta[2]	Discarded body parts from fishermen	Lunawa, Moratuwa, Panadura Lowland wet zone	Current study
	Scomberomorus commersoni[2]	Discarded body parts from fishermen	Ratmalana, Angulana Lowland wet zone	Current study
	Selar crumenophtthalamus[2]	Discarded body parts from fishermen	Wellawatte, Ratmalana, Beruwala Lowland wet zone	Current study
	Systomus sp.	Live adults	Udawalawe Lowland dry zone	S. Weerathunga pers. com.
	Thunnus albacares[2]	Discarded body parts from fishermen	Boralesgamuwa, Maharagama Lowland wet zone	Current study
Arachnida	*Isometrus sp.*	Live hunting	Matugama Lowland wet zone	Current study; S. Akmeemana pers. com.
	Lychas sp.	Live hunting	Kanneliya Lowland wetzone	Current study
Chilopoda	*Solopendra sp.*	Live hunting and eggs	Baduraliya Lowland wet zone	Current study; S. Akmeemana pers. com.
	Rhysida sp	Live hunting	Kurunegala Lowland dry zone	Current study
Gastropoda	*Acavus phoenix*	Live adults	Kitulgala Lowland wet zone	Current study
	Acavus haemastoma	Live adults and juveniles	Balapitiya Lowland wet zone	Current study
	Cryptozona bistrialis	Live adults	Maduganga, Kalutara Lowland wet zone	Current study
	Lissachatina fulica[1,3]	Live adults and juveniles	Ambalangoda Lowland wet zone	Current study
	Oligospira polei	Live adults	Atweltota Lowland wet zone	Current study
Malacostraca	*Ceylonthelphusa sp.*	Live adults and juveniles	Ratnapura Lowland wet zone	Current study; M. Bahir pers. com.
	Macrobrachium rosenbergii	Live adults	Nilgala Intermediate zone	Current study
	Panulirus sp.	Discarded body parts from fishermen	Angulana, Moratuwa Lowland wet zone	Current study
	Penaeus semesulsctus	Discarded body parts from fishermen	Kandana, Jaela Lowland wet zone	Current study
	Perbrinckia sp.	Live adults and juveniles	Elpitiya Lowland wet zone	Current study; M. Bahir pers. com.
	Portunus pelagicus	Discarded body parts from fishermen	Thalapathpitiya, Aluthgama Lowland wet zone	Current study
	Scylla serrata	Discarded body parts from fishermen	Beruwala, Balapitiya Lowland wet zone	Current study

[1]non-native species, [2]Marine fish, [3]Invasive species (see Hegan, (2014).

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Captive breeding of the Montane trinket snake (*Coelognathus helena monticollaris*) at Pilikula Biological Park, Mangalore, Karnataka, India.

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ABSTRACT - The Trinket snake *Coelognathus helena monticollaris* is a non venomous, semi-arboreal, constrictor, endemic to Western Ghats. Courtship and mating was observed in the month of July and eggs deposited after 61 and 68 days by two females respectively. The eggs hatched after 68 days with 100% hatching rate.

INTRODUCTION

The Montane trinket snake *Coelognathus helena monticollaris* (Fig.1) is native to South Central Asia. In India, it is endemic to the Western Ghats and found in Tamil Nadu, Kerala, Karnataka and Maharashtra states (Whitaker & Captain 2008). The Western Ghats region is cooler and with higher rainfall and humidity in comparison to the regions where the other subspecies of *C. helena* occur. Females (total length 120cm - 150cm) grow larger than males (90cm - 120cm) while males have a proportionately longer tail. During the hot weather this species lives deep in termite moulds, rock piles and crevices. In the cool season they emerge and are found in leafy trees, bushes and branches. They are found in the scrub zones of rain forest edges, rice fields, plantations and meadows and may frequently venture towards human habitation, occasionally enter human dwellings. *C. h. monticollaris* is a generalist feeder on a variety of prey (Daniel, 1983) and deposits between 8 to 12 eggs. In this paper we describe the first captive breeding of this little known subspecies at the Pilikula Biological Park, in India.

MATERIALS AND METHODS

Two pairs of adult *C. h. monticollaris* were housed together for one year in the same enclosure in Pilikula Biological Park. The snakes were wild caught in the Mangalore, Karnataka region and housed in a 2×2m enclosure maintained at an ambient temperature of 22-28ºC and relative humidity from 80-90% (Fig. 2). The enclosure was provided with a heating source (a 60W incandescent lamp covered with a inverted clay pot) in a corner during winter and monsoon season and at cool spots throughout the year. The enclosure was enriched with plant growth, dead wood, a water pit, stones etc. Soil and leaf litter were used as a substrate which was regularly cleaned and maintained hygienically. The roof of the enclosure was covered with a mesh to provide natural light and also aeration. During the monsoon season the roof was covered with mangalore tiles to avoid rain-water entering the enclosure but at this time 25% of the roof of the enclosure was covered by transparent sheets to allow sunlight to penetrate.

Figure 1. Adult *C. h. monticollaris*.

Figure 2. Enclosure used to house *C. h. monticollaris* at Pilikula Biological Park.

RESULTS & DISCUSSION

Courtship behaviour was observed during July. After successful mating the two females deposited eggs after 61

Figure 3. *C. h. monticollaris* eggs began to hatch after 68 days.

Figure 4. Group of one day old *C. h. monticollaris* – see Fig. 1 for comparison of body pattern with an adult.

and 68 days on the soil substrate. Clutch size was 8 and 12 respectively with an overall average egg weight of 4.2g. The eggs were removed from the enclosure and incubated in a plastic box provided with soil as a substrate. The box was kept in a cool and well ventilated area at a temperature range of 25-28˚C with a relative humidity of 80-90%. Hatching began after 68 days (Fig. 3) with 100% hatching rate. The average weight of the hatchlings was 8.3gm and average total length 17.3 cm (Fig.4). During the present study courtship was observed only during July in both the breeding pairs. Normally, in natural conditions, *C. h. monticollaris* breed once a year, whereas *C. h. helena* normally produce more than one clutch annually with the first hatchlings appearing before June.

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Trogloxeny in the Caucasian parsley frog (*Pelodytes caucasicus*)

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ABSTRACT - The Caucasian parsley frog (*Pelodytes caucasicus*) is a patchily distributed endemic of Turkey and the Caucasus. What is known about its habitat preferences mostly refers to the breeding sites; unlike other *Pelodytes* species it has never been reported to occur in caves. This paper presents observations showing that caves, particularly those with bat colonies, are an important habitat for this obscure species.

INTRODUCTION

The Caucasian parsley frog (*Pelodytes caucasicus* Boulenger 1896) is a little-known species with localised and fragmented distribution. It occurs in western Republic of Georgia, Krasnodar Region of Russia, and extreme northeastern Turkey, with isolated populations in the central part of Turkey's northern coast and in Georgia-Azerbaijan border area (Kaya et al., 2009). Published information about its habitat preferences mostly refers to its breeding sites, with non-breeding habitats characterised very broadly as moist forests with dense undergrowth near water (Chubinishvili et al., 1995 and bibliography therein; Tarkhnishvili & Gokhelashvili, 1999; Kuzmin, 2001; Gül, 2014). The only known wintering sites are in the layer of leaf litter on the forest floor (Kuzmin, 2001). The closely related common parsley frog (*P. punctatus*) is known to use caves as wintering sites and summer shelters (Thomas & Triolet, 1994; Salvidio et al., 2004); it is also known from Pleistocene cave deposits (Delfino, 2004; Blain et al., 2014). However, although most (possibly all) of *P. caucasicus* range lies in areas of extensive limestone karst (Adamia et al., 2011), this species has never been reported to occur in caves.

MATERIALS AND METHODS

The study was conducted in summer months (July-August) in the vicinity of Khosta, Russia (43°33-34' N, 39°49-56' E), in the area later included in Sochinsky National Park, at elevations 94-444 m a. s. l. All explored caves (N=8) were located on steep slopes covered with deciduous forests, sometimes with limestone cliffs. All caves were simple horizontal or near-horizontal shafts with no visible water and a deep layer of mud mixed with rocks of varying size on the floor. The caves ranged in length from 8 to ~500 m, and the entrances were located 2-400 m from the nearest stream. Three of the caves had colonies of horseshoe bats (*Rhinolophus* spp.).

Parsley frogs were located during daytime by flipping rocks on the floor of the caves and hand-digging through underlying soft sediment. Each cave was searched for approximately half an hour by moving from the entrance inwards and flipping rocks nearest to the path, so only a small portion of such habitat was searched in each cave and it was unlikely that any frog would be caught twice. The cave where the largest number of frogs (N=3) was found was later visited at night for spotlighting search (its results were excluded from statistical analysis to avoid counting the same frogs twice). The length of each cave was estimated visually. The coordinates of each cave, its elevation above the sea level, and the distance from the entrance to the nearest stream were determined post-hoc from Google Earth. The same methods were used to search for frogs in the forest outside the caves, with approximately four hours spent looking under rocks during the day and more than twenty hours spent spotlighting at night.

The numbers of frogs found in each cave were tested for correlation with elevation above the sea level, length of the cave, and distance to the nearest stream using Spearman's Rank test; and for differences between caves with presence vs. absence of limestone cliffs near the entrance and with presence vs. absence of bat colonies inside using two-tailed randomization test with each cave as a single data point. In all cases, significance level was set at 0.05.

RESULTS AND DISCUSSION

No parsley frogs were ever found outside of caves; all following information refers to frogs found inside. A total of 8 parsley frogs were found in caves during daytime, and 4 more during a night-time visit. During the day, one frog was found approximately 50 m from the entrance, and others 5-20 m from the entrance. At night all frogs were found 5-15 m from the entrance (that cave was only 15 m long). All were found in places where daylight from the entrance was still visible, 5-10 cm deep in soft sediment under rocks 20-40 cm in size (very few larger rocks were flipped).

There was no significant correlation with elevation above the sea level, length of the cave, distance to the nearest stream, or presence/absence of limestone cliffs near the entrance ($P > 0.1$ in all cases), but the effect of presence of bat colonies was significant ($P = 0.0357$).

Finding parsley frogs in cave habitats is difficult, and there is no doubt that only a small fraction of them was found. It can be concluded that caves, particularly those with bat colonies, are important for this species as summer shelters. The fact

that frogs were also found there at night and the correlation of their numbers with bat presence suggests that they also use caves for foraging on invertebrates feeding on bat guano. Invertebrate numbers are known to be much higher in caves inhabited by bats (see for example Howarth, 1983). The frogs might also stay in the caves for hibernation, as the closely related common parsley frogs often do (Thomas & Triolet, 1994; Salvidio et al., 2004), and leave them only for breeding. The absence of significant correlation with other parameters of the caves is probably due to small sample size.

P. caucasicus is listed as near-threatened by the IUCN, and as Category 2 (declining) in Russia, Georgia and Azerbaijan (Kuzmin, 2001; Kaya et al., 2009). It is protected in dedicated nature reserves, and there were attempts at captive breeding (Kuzmin, 2001). If its decline reaches the stage when captive breeding and reintroduction would be necessary, knowledge of the importance of caves in its behavioural ecology will help in choosing reintroduction sites and in monitoring populations; the decline might also be slowed down by protecting caves. This finding also underlines the importance of protecting bat colonies in small caves, where they frequently experience catastrophic declines due to human disturbance. Many bat colonies in the study area have recently disappeared (Dinets & Rotshild, 1998).

Finding that a significant part of the population might be trogloxenic outside the mating season doesn't mean that the species' population densities have been underestimated or its conservation status needs to be re-evaluated, since all previous counts and estimates used data from breeding ponds (Chubinishvili et al., 1995; Tarkhnishvili & Gokhelashvili, 1999; Kuzmin, 2001).

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Boa constrictor (Common Boa) feeds on and regurgitates alive a lizard *Iguana iguana* (Green Iguana)

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The Neotropical common boa (*Boa constrictor*) is a large boid snake that feeds on small and medium vertebrates (Martins & Oliveira 1998). Its diet consists primarily of mammals but may also feed on birds and small lizards (Martins & Oliveira, 1998; Duellman, 2005; Pizzato et al., 2009; Rocha & Bernarde, 2012).

During a herpetofauna monitoring at Porto Trombetas in central Amazonia, Pará state, Brazil, conducted in January, 2010, we captured an adult female of *B. constrictor* (1,97 m rostral-anal length; weight = 7,0 kg) at the edge of a forested area. The snake was found wrapped under a tree trunk at around 10:00 a.m., when the air temperature was near 32˚C. Immediately after capture, the snake regurgitated an adult male green iguana *(Iguana iguana*) (0,35 m rostral-anal length; weight = 2,75 kg) which it appeared to have swallowed headfirst. The lizard's weight was about 39% of the mass of the *B. constrictor*, and possibly the predation event had occurred a few minutes earlier, given the apparent integrity of the iguana. On initial discovery we were not aware that the snake had recently fed, because there was no external evidence of prey in the stomach position. We do not rule out the possibility that the iguana was still in the esophagus region at the time, but the snake had fully swallowed the lizard.

The snake was subsequently submitted to veterinary treatment for dehydration, perhaps due to the regurgitation. We assumed the iguana was dead, since *B. constrictor* kills its preys by constriction before consumption. However, the iguana started to walk five minutes after regurgitated. We submitted the lizard to a veterinary evaluation and no injuries were detected. Both specimens were kept for observations and were released one week later at the same locality where they were found.

Reptiles are known to highly reduce their metabolism and certain some physiological processes under extreme conditions such as low temperatures or dehydration (Toledo et al., 2008). In the present case, the green iguana´s cardiac rhythm had probably drastically reduced under the absence of oxygen imposed by snake´s constriction giving the appearance of being dead. Although large iguanid lizards might be occasional prey of *B. constrictor*, endothermic vertebrates organisms and/or small lizards are more common prey species. Therefore, the senses of a snake may be less adapted to the recognition of iguana´s physiological condition. In theory this could represent a problem to the predator, since large lizards could impose injuries to the digestive system, due to movements after been swallowed. Further research is necessary to understand physiological aspects of predation on ectothermic organisms by boid snakes.

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Thanatosis (feigning death) in the frog *Ischnocnema aff. henselii* (Peters, 1870)

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The evolution of defensive behaviours in amphibians has been attributed to selective pressures related to predator-prey interaction (Wells, 2007). These pressures involve the morphological and physiological costs of predation (Gans, 1986), which promote evolution and diversification of defensive strategies in anurans (Toledo et al., 2010). Feigning death or thanatosis is a strategy found in some *Ischnocnema* species (Toledo et al., 2010); however, the behaviour has not been reported for *Ischnocnema aff. henselii*.

I. aff. henselii is a nocturnal anuran endemic to the subtropical rain forests on the border from the Araucaria plateau in southern Brazil (Kwet & Solé, 2005). During field surveys in the municipality of Campo Largo, Paraná state, Brazil (-25.39725ºS, -49.530964ºW, SAD 69, 937 m a.s.l.), we observed two events of death-feigning behaviour in *I. aff. henselii* (Collection permit ICMBIO 46393-3). At the first event, on May 15 2014 at 2130 h, we captured three males calling in a wetland near a stream within remnant of Araucaria moist forest. When handled by the researcher, they turned their belly up, with eyes closed, arms upward and the legs away from the body, exhibiting yellowish colour on the ventral region (Fig. 1). After being manipulated, the individuals remained motionless even when touched. The frogs remained in this position for about two minutes, before slowly returning to normal position. On June 11, 2014, a young male and a female were captured at same locality presenting the same behaviour. Voucher specimens are housed at the Zoological Collection of the Federal University of Goiás (ZUFG), Goiás State, Brazil (ZUFG 9004; ZUFG 9005).

Anurans are an important component for the diet of a large number of vertebrates and invertebrates in natural ecosystems, despite having evolved several defensive strategies (Duellman & Trueb, 1994). Thanatosis is a strategy mostly displayed by non-toxic anuran species to avoid or minimise the risk of predation, in part at least because movement increases predation risk (Toledo et al., 2010). Species of *Ischnocnema* have cryptic colour and are very polymorphic (Hoffman & Blouin, 2000; Gehara et al., 2013), which can efficiently minimise the risk of predation. When performing thanatosis behaviour *I. aff. henselii* exhibit a yellowish colour on the ventral region, which may be a different form of crypsis (resembling a dead leaf). Previous records of thanatosis in species of *Ischnocnema* are scarce. Of the 33 species currently known (Frost, 2015), thanatosis was recorded in three species of the genera: *I. guentheri*, *I. juipoca* and *I. parva* (Toledo et al. 2010).

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Figure 1. Adult males I. aff. henselii exhibiting death-feigning behaviour in a remnant of Araucaria moist forest, Campo Largo Municipality, Paraná State, Brazil.

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First record of limb abnormalities in the Near Eastern fire salamander (*Salamandra infraimmaculata*)

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Polyphalangy (extra bones in a digit), together with ectrodactyly (missing toe) and brachydactyly (dwarfed toe) are among the more frequent skeletal malformations found in urodeles (Diego-Rasilla et al., 2007; Williams et al., 2008). On the contrary, syndactyly (fused digits), as well as polymelia (excessive number of limbs) and phocomelia (absence of the proximal portion of a limb) are rare (Escoriza & García-Cardenete, 2005; Diego-Rasilla et al., 2007; Villanueva, 2007; Williams et al., 2008). Skeletal malformations can be attributed to both anthropogenic and natural changes in the abiotic and biotic factors in the environment. Suggested causes for these abnormalities include parasites and pathogens, UV radiation, regeneration following trauma, high levels of anthropogenic pollution, or synergistic interactions of these factors (Blaustein et al., 1997; Reaser & Johnson, 1997; Gillilland & Muzzall, 2002; Johnson et al., 2002; Diego-Rasilla et al., 2007; Williams et al., 2008).

In the course of our fieldwork in the Tel Dan Nature Reserve (northern Israel, 33.248288ºN 35.651375ºE, 200 m alt.) we observed three cases of limb abnormality. All salamanders seemed to have a good body condition with around average weight for their size. An adult salamander with a partial polymelia next to its left hind limb was observed on 25 February 2014 (Fig. 1). There was an extra limb lacking any real digits. It had just two dwarf fingers. On 1 December 2014, another adult was found with a complete polymelia (Fig. 2), consisting in a complete fifth, non-functional leg that protruded from the upper right hind leg. A third adult salamander was observed on 20 November 2014 near the Tel Dan Nature Reserve with a case of ectrodactyly. The individual was lacking one finger of its right hind limb (Fig. 3).

Given the presence of many predators (fish, crabs, dragonfly nymphs, etc.) in the streams where the larvae develop, it is possible that these malformations are due to incorrect regeneration after bite injuries made by predators (Ballenge & Sessions, 2009) or conspecifics. Larvae of *S. infraimmaculata* are very likely to harm or cannibalise on conspecifics if raised in the same container, although such behaviour was not common in *S. salamandra* larvae when raised under similar conditions (personal observations). Thompson et al., (2014) reported that only 43% of Ambystoma mexicanum larvae would present four anatomically normal looking adult limbs after incurring a bite injury, so salamanders from a high density predator environment like the Tel Dan Nature Reserve are expected to experience many limb malformations.

Figure 1. *S. infraimmaculata* with a partial polymelia.

Figure 2. *S. infraimmaculata* with polymelia.

Figure 3. *S. infraimmaculata* with ectrodactyly.

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Intellagama lesueurii Eastern water dragon: Cannibalism.

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The presence of cannibalism across the animal kingdom is well known (e.g. Polis 1981) and may evolve under intense competition for food (e.g. Ribeiro et al., 2015) crowding of conspecifics (e.g. Cooper et al., 2015) and increased predation risk (Huang, 2008). In recent years there has been increased documentation of cannibalism in lizards which includes full (e.g. *Podarcis siculu*; Capula & Aloise 2011) and partial (e.g. tails) cannibalism (e.g. *Podarcis gaigeae*; Cooper et al., 2015), as well as siblicide (e.g. *Sceloporus undulatus*; Robbins et al., 2013).

Here we report the first evidence of cannibalism in the eastern water dragon (*Intellagama [Physignathus] lesueurii*) within an urban city park, Roma Street Parkland (RSP), located in the central business' district of Brisbane, Australia (27°27.046'S, 153°1.011'E). Previous observations on this species, for example at the Australian Botanical Gardens in Canberra ACT (Meek et al., 2001) found no evidence of cannibalistic behaviour in *I. lesueurii* during a 2 month study period (Meek & Avery, 2008). This was despite a high density of *I. lesueurii* that included the close proximity of all age classes (Meek et al. 2001). The RSP population of *I. lesueurii* have similar population characteristics to the Australian Botanical Gardens population, in that they occur in a human-made curated landscape at high density. The RSP population density is unusual when compared with non-urban populations, with more than 650 individuals recorded to date and a mark-recapture population estimate of 311 animals (Gardiner et al. 2014). The social and mating behaviour of *I. lesueurii* has been studied in populations living in high densities (Baird et al. 2012, Strickland et al. 2014, Frère et al. 2015), but this is the first recording of cannibalistic behaviour in *I. lesueurii*.

The observations were made during a longitudinal behavioural and genetic study of the *I. lesueurii* population at RSP, which commenced in 2010. During the 5 year study period several cannibalistic events, which resulted in the ingestion of hatchlings were made. One of these was photographed (Fig. 1) at 4 pm on the 18th December 2014. The image and coordinates of the encounter were recorded using a Canon EOS 60D digital SLR Camera equipped with a EF 75-300mm f4-5.6 lens and a GARMIN eTrex10 handheld global positioning system respectively. The lizard (Fig. 1) was identified as a sub-adult male carrying a conspecific hatchling in its mouth through a section of the rainforest themed gardens (27° 27.740'S, 153° 1.027'E). It was assumed the dragon had cannibalised the hatchling. Unfortunately, ingestion of the hatchling was not observed as the lizard retreated with prey into an inaccessible area of the park.

Figure 1. Young adult *I. lesueurii* during the cannibalism act. Photograph taken by Daniel R. Nugent.

City-park populations of eastern water dragons in South East Queensland resemble in many ways island like communities which experience lower predation risk and relaxed interspecific competition (Losos and Ricklefs 2009). Unlike island populations, however, *I. lesueurii* may experience reduced intraspecific competition given the abundance of food these city parks offer (e.g. substantial food subsidies from public feeding and worm exposure by mechanical disturbance of flower beds by gardeners). However, it is possible that while food may be plentiful, the increase in population density would retain a high level of food competition, which may include cannibalism.

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Amphibian Biology, Volume 11: Status of Conservation and Decline of Amphibians: Eastern Hemisphere, Part 4: Southern Europe and Turkey

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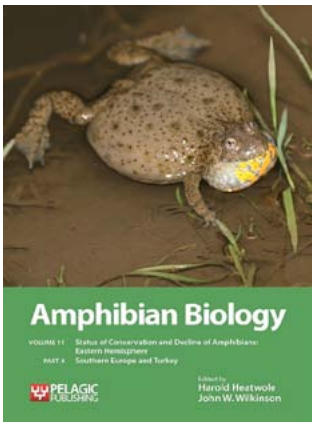

The Amphibian Biology series has had a long and slightly chequered history. Originally conceived in the mould of the classic Biology of the Reptilia series, with different volumes covering different subjects, new volumes have appeared at irregular intervals since the first publication on The Integument in 1994. Although there has been a change in both publisher and format over the years, Harold Heatwole has steered the series as the editor since the outset, and this has ensured consistency in style, direction and philosophy. In recent years the series has responded to the growing concern in amphibian declines and conservation through the publication of a number of detailed treatises covering different conservation issues and geographical areas. With John Wilkinson enrolled as co-editor of these volumes since 2009, the editorial team have ensured that the series maintains a truly international perspective on the issues that the volumes cover.

This slim, but very comprehensive volume, comprises part 4 of volume 11 of the series, and covers a region of high amphibian diversity within the eastern hemisphere. Amphibian taxonomy and systematics for species in this region remains in a state of flux and debate, so the editors point out at the outset that they have made no attempt to standardise the names used in this volume. This is probably a wise decision. The book comprises 15 chapters (chapters 39-53 of the wider volume 11), each covering a different country within the region (or perhaps more accurately, a different politically delimited area within the region).

Although the chapters vary in structure and content, each contains a species list for the country concerned together with information on Red List status and/or Bern Convention listings. This is complemented by more detailed narratives concerning threats, protection, research and monitoring, and – in some chapters – individual species accounts. Some common themes emerge. Nine of the 15 countries covered are EU member states and therefore subject to EU legal instruments. These include the 'Habitats Directive' and Natura 2000 network, which (theoretically) place obligations on member states to carry out conservation and monitoring. Although most countries covered within the book have implemented legal protection for many of their species, it is clear that the effectiveness – and enforcement – of such legislation varies widely. The overarching messages for the region are that – perhaps not surprisingly – habitat loss and fragmentation remain the most important threats to amphibians, and coordinated, long-term monitoring programmes are needed to provide the evidence needed to underpin conservation action. Many monitoring programmes are instigated on short-term grants provided to NGOs, and after a flurry of productive activity struggle to maintain their impact when the funds run out or are channelled towards other priorities.

The coverage is of the book is well-balanced. Even small countries with few species (e.g. Malta – one species; Cyprus – three species), get their own brief but informative chapters. At the other end of the spectrum, the most comprehensive chapter is that dealing with Hungary, which contains population monitoring information on several species, maps and a very extensive bibliography. This chapter is a fitting epitaph to one of the co-authors – Miklos Puky – who very sadly died shortly after this book was published and made very substantial contributions to herpetological conservation in Hungary.

All of the chapters are well-referenced, and the tables and figures (mainly graphs and maps) generally clearly laid out. Pelagic publishing have a growing portfolio of herpetological publications, and the production quality is high. However, I can't imagine many readers shelling out £69.99 for the paperback version when the e-book or PDF is £19.99. Overall, this book very usefully compiles under a single cover a large body of information that would otherwise be widely dispersed between specialist journals and regional literature. In this respect it serves as a very useful starting point for anyone seeking information on the conservation of amphibians in the countries within the region.

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