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The establishment and ecological threat of the lizard, *Calotes versicolor* (Squamata: Agamidae), in Madhepura, Bihar, India

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Abstract: There is evidence that the *Calotes versicolor*, the lizard, is now established on Madhepura (Bihar), and it is reported to be dispersing away from its original point of introduction. Collected data on its habitats, feeding habits, predators and parasites show that this species is adaptable, prolific and omnivorous, and it is considered to be an invasive alien species that competes with or feeds on native biota in some parts of the Bihar state, such as Purnea and Saharsa. These population need to be studied to prevent their potential ecological threat.

Keywords: *C. versicolor*, Madhepura, feeding habit, invasive alien species, ecological threat.

INTRODUCTION

The lizard, *Calotes versicolor* is a strong candidate for the status of most widespread non-gekkonid lizard in the world. Gunther[1] (1864) noted: "This is one of the most common lizards, extending from Afghanistan over the whole continent of India to China; it is very common in Ceylon [Sri Lanka]" Its present distribution stretches from right across southern and south-east Asia to Indo-China to the east,[2] the Maldives,[3] Reunion,[4] Mauritius,[5] including Rodrigues,[6] Seychelles[7] and Florida in the United States.[8] With growing evidence that *C. versicolor* is an invasive species with potentially harmful ecological impacts in the areas where it is introduced[9-10] largely because of its omnivorous feeding habits, it is necessary to gather together the available, albeit limited, information on the status of its presence in Madhepura (Bihar) India. At the same time the opportunity is taken to review the existing literature on the ecology of the species with a view to summarizing the available data as a basis for further research on its status as a potential threat. It has various common English names used for this species garden lizard, bloodsucker, crested tree lizard etc.

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MATERIALS & METHODS

Video footage of specimens recorded with the help of handy cam in their natural habitat, was viewed. Photographs of the specimens were taken and analysed carefully. A literature search was undertaken to find all references to *C. versicolor* in Bihar, as well as references to the ecology of the species worldwide.

In general the specimen measured 38.6 cm long, including the tail. It was identified as *C. versicolor* by its dorso-nuchal crest, the two widely separated spines on either side of the head above the tympanum, and the absence of any fold or pit in front of the shoulder providing evidence that *C. versicolor* is now firmly established in Madhepura district of Bihar. There were both sexes there, including at least one male seen in breeding coloration (anterior part

of the body, including the head, orange-red with a black patch on each side of the throat) and a gravid female that had been crushed by a vehicle, with the eggs that it had been carrying very much in evidence. It is not certain how *C. versicolor* was introduced to Madhepura (Bihar).

Review of literature on ecology of *C. versicolor*:

Since the 1970s *C. versicolor* has gained importance as a laboratory animal, and researchers in Asia in particular have been using it as a subject for a broad spectrum of biological studies. This has resulted in a considerable output of literature on anatomy[11], morpho-metrics[12], endocrinology[13-14], embryology[15-17] and cytology[18]. However, there is relatively little published material on the ecology of *C. versicolor*. This is surprising in view of its recognized status as an invasive species that is extending its range and, in some colonized areas at least, is impacting negatively on native biodiversity[9-10]. The best general account of the species, based on original fieldwork in Singapore, is that of Diong *et al.* [10]. On the other hand, several of the laboratory-based studies referred to above have produced findings on the biology of *C. versicolor* that shed light on key aspects of its ecology.

Cytology: Ota *et al.*[18] have suggested the presence of cryptic taxonomic diversity in *C. versicolor*, i.e. that "*C. versicolor*" could in fact be a complex of different species, after the karyotype they worked out did not match those recorded by previous studies. It would be interesting to carry out a study of karyotypes from specimens caught in Madhepura and elsewhere in the Bihar to possibly elucidate the provenance of the Indian population.

Habitats: Being a semi-arboreal, sun loving lizard that spends a lot of time on tree- trunks and rocks, *C. versicolor* has a predilection for open scrubland, wasteland, gardens, parks and other "man-made habitats" in Asia[9, 19]. Stuart[2] reports that it is found in low vegetation open forest or disturbed areas near human habitation. In a study of diurnal lizards in the city of Karachi in Pakistan, it was the second most numerous species[20]. In Reunion, Mauritius and Rodriguez it favours areas of "grassy savannah", such as that on the west coast of Reunion[6] as well as cemeteries and along roadsides[4]. In Florida, USA specimens have been collected in an area of grasses and weeds in the vicinity of a canal running along a dirt road[8]. The species appears not to favour dense forest with closed canopies[4,9,21]. Erdelen[19] found it to be most abundant in the driest parts of Sri Lanka. It is reported to occur from sea level to an altitude of 600m[2] or even 1,000 metres[9]. It has a sit-and-wait hunting strategy, usually watching for prey from a vantage point on a tree-trunk, but moving into the shade, including among high grasses, when it gets too hot; adult males stay in the open more often to exercise territoriality, while adult non-breeding females and, especially, juveniles tend to forage on the ground in grassy and shrubby vegetation [9,22]. In one study[22] an adult male was found on the same tree on 15 occasions. *C. versicolor* is reported to be able to swim in both fresh and sea water[4]. In Florida, USA[8] as well as in Mauritius, *C. versicolor* roosts on vegetation at night, up to 9m from the ground, usually at the tips of twigs, shoots and inflorescences.

Feeding: Records of prey and other food items of *C. versicolor*, most of them based on observations in India, are summarised in Table-1. It would seem that the crested tree lizard is predominantly insectivorous. According to Diong *et al.,*[9] "analysis of stomach contents [in Singapore] reveals a diet comprising mainly ants, larval and adult insects, and other small invertebrates, but it is clearly an opportunistic omnivore that can prey on small vertebrates and feed on plant material as well. One particularly interesting observation[23] is of a crested tree lizard charging and attempting to bite an Oriental magpie robin (*Copsychussaularis*) in a fight over a centipede (*Scolopendra* sp.).

Table 1: Recorded food items of *C. versicolor*

Food item	Locality	Source
Earthworms (Oligochaeta)	India	Sharma 2002[24]
Millipedes (Diplopoda), including *Proterosperhormage* sp.	India	Ahmed 1984[25]
Centipedes (Chilopoda), including (1) *Rhysida* sp. & (2) *Scolopenda* sp.	India	Ahmed 1984[25]; Kalita 2000[23]
Dragonflies (Odonata)	India	Mitra 1996[26]
Orthoptera, including grasshopper *Chrotogonus* sp. (Acridoidea: Pyrgomorphidae)	India	Chandra 1983[27]; Bhanotar & Srivastava 1985[28]

Termites (Isoptera), including *Microtermes*	India	Parihar 1978[29]; Manakadan 1993[30]
Wasps (Hymenoptera: Vespoidea)	India	Bhatti 1988[31]
Ants (Hymenoptera: Formicidae)	Singapore	Diong *et al.* 1994[9]
Frogs	India	Daniel 1983[32]
Small birds	India	Daniel 1983[32]
Eggs of weaver birds (Aves: Passeridae): Baya weaver (*Ploceus philippinus*), black- throated weaver (*P. benghalensis),* streaked weaver (*P. manyar*)	India	Dhindsa & Toor 1983[33]
Adult house sparrow (Passer domesticus) (Aves: Passeriformes: Passeridae)	India	Paralkar 1995[34]
Brook's gecko (*Hemidactylus brooki*) (Squamata: Gekkonidae)	India	Sharma 1992b[35]
Young Indian wolf snake (*Lycodon aulicus* (Squamata: Colubridae)	India	Sharma 1999[36]
Hatchlings of flying dragons (*Draco volans*) (Squamata: Agamidae)	Singapore	Diong *et al.* 1994[9]
Hatchlings/juveniles of *C. versicolor* (i.e. cannibalism)	India; Singapore	Sharma 1992a[37]; Diong 1994[9]
Plant material, including (1) unripe pods with soft seeds of Lima bean (Phaseoluslunatus, Papilionaceae); (2) buds & flowers of *Tabernaemontana* sp. (Apocynaceae); (3) germinating seeds of *Feronia limonia* (Rutaceae); (4) dry leaves of mango (*Mangifera indica*) (Anacardiaceae); (5) flowers of *Cassia marginata* (Caesalpiniaceae) and *Morinda tinctoria* (Rubiaceae); and (6) young shoots of cow- pea (*Vigna sinensis*) (*Vigna unguiculata*) (Papilionaceae) chewed but not swallowed, possibly as a source of water	India	Bhatti, Batti & Batti 1988[38]; (1)Daniel & Shull 1963[39]; (2) Sekar 1988[40]; (3) Sharma 1994[41]; (4) Sharma 1998[42]; (5) Aengals 2000[43] (6) Devasahayan & Devasahayan 1989[44]
Faeces of iguana (Squamata: Agamidae)	India	Rajarathinam & Kalaiarasan 1999[45]

Predators: *C. versicolor* is in turn preyed upon by a number of carnivorous reptiles, birds and mammals. Published records of predators are summarised in **Table 2**.

Table 2: Recorded predators of *C. Versicolor*

Predator	Locality	Source
Indian wolf snake (*Lycodon aulicum*) (Squamata: Colubridae)	Reunion	Guillermet 2004
Rat snake (*Ptyas mucosas*) (Squamata: Colubridae)	India	Mundkur 1986[46]
Keeled grass skink (*Mabuya carinata*) (Squamata: Scincidae)	India	Vyas 1988[47]
Pariah kite (*Milvus migrans*) (Aves: Accipitridae)	India	Pittie 1998
Jungle crow (*Corvus macrorhynchus*) (Aves: Corvidae)	India	Kalaiarasan & Rajarathinam 1997[48]
Mynahs (Aves: Sturnidae)	Singapore	Diong *et al.* 1994[9]
Jungle babbler *Turdoides striatus* (Aves: Sylviidae)	India	Parasharya & Mathew 1994[49]

Parasites: The literature on the parasites of *C. versicolor* is extensive[9, 50-52]. The range of identified ecto- and endoparasites is shown in Table- 3, but this is far from an exhaustive list. There may be interactions between parasites: for example, mites have been shown to transmit a species of Schellackia (Apicomplexa) to other lizards[53].

Table 3: A selection of parasites recorded from *C. versicolor*

Parasite	Site of infection in host	Source
Tongue worm Raillietiellagehyrae (Pentastomida: Cephalobaenida)	Lungs	Dutta & Manna 1995[54]
Scale mite Pterygosomaneumanni (Acarina: Pterygosomidae)	Beneath imbricating scales of body tegument & tympana	Diong & Ho 2001[55]
Fluke Paradistomumorientalis (Trematoda: Dicrocoelidae)	Gall bladder	MADHAVI *et al.* 1998[56]
Protozoan (Apicomplexa) Isosporalacertae (Coccidia: Eimeriidae)	Intestine? (Oocysts found in faeces)	Saum *et al.* 1997[57]
Protozoan (Apicomplexa) Schellackiacalotesi (Coccidia: Lankesterellidae)	Intestine? (Sporozoites found in blood & liver)	Finkelman & Paperna 1998[58]
Flagellate protozoan Proteromonaskrishnamurtyi (Slopalinida: Proteromonadidae)	Rectum	Saratchandra & Ramesh Babu 1982[59]

Discussion of status as an ecological threat

The continuing extension of the range of *C. versicolor* in Bihar particularly in Madhepura district, to the Purnea and Saharsa, is due to a combination of intentional and unintentional transport and introduction by humans. At the same time, the alteration of natural habitats through anthropogenic factors, including deforestation, must have created suitable habitats for the species where there were none before. Surprisingly, although it is an adaptable, prolific and omnivorous species, its impact on native biodiversity does not appear to have been scrutinized very closely in the localities where it has become established. *C. versicolor* in their list of introduced vertebrates thought to have a significant impact on native biodiversity in Madhepura as it competes with native geckos and consumes native invertebrates. If *C. versicolor* were to disperse to other place this could represent a serious new threat to native biodiversity, with prey records from India and elsewhere. Table-1 shows the wide range of groups of organisms that could be threatened. The smaller, rat-free islands with extensive seabird colonies and populations of endemic terrestrial birds, invertebrates, amphibians (Caecilidae on Fregate) and reptiles[60] would seem particularly vulnerable. It is not clear to what extent the parasites harboured by *C. versicolor* are host- specific, i.e. whether some of them, at least, can infect native lizards like skinks (Mabuya spp.) and geckos (e.g. Phelsuma spp.) as well.

Further research is urgently required to elucidate the status and ecology of the established population of *C. Versicolor* in Madhepura. Captured specimens could be sexed, measured, weighed and dissected for stomach contents and, possibly, parasites. Managing the spread of invasive alien species involves (1) prevention, preferably, to keep potential invaders from entering a new ecosystem; (2) early detection, if prevention is not successful, to locate the alien before it has the chance to become established and spread; (3) eradication, mostly possible when the alien is detected early; and (4) control as a long-term process to limit the population size and distribution of the alien if eradication is not possible[61]. In the present context, to manage the spread of the lizard would involve all of these going on at the same time on different place.

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