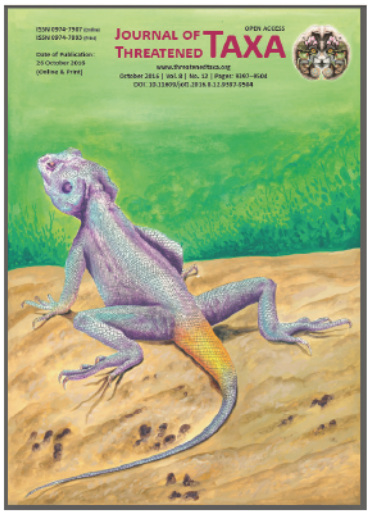

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SHORT COMMUNICATION

SPECIES DIVERSITY AND SPATIAL DISTRIBUTION OF SNAKES IN JIGME DORJI NATIONAL PARK AND ADJOINING AREAS, WESTERN BHUTAN

Bal Krisnna Koirala, Dhan Bdr Gurung, Phurba Lhendup & Sonam Phuntsho

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Species diversity and spatial distribution of snakes in Jigme Dorji National Park and adjoining areas, western Bhutan

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Abstract: This paper presents the results of a study conducted on the diversity and spatial distribution of snakes along the elevation gradients of Mochu River valley in Jigme Dorji National Park and its adjoining areas. The survey was conducted from July–September 2014 and May–July 2015. The study aimed to assess the diversity and distribution of snakes using opportunistic the visual encounter survey technique. A total of 17 species of snakes belonging to 15 genera and three families were documented during the study period. More than 53% of species were recorded in the lower sampling sites (between 1,200–500 m) indicating more favourable climatic conditions and habitat types for snakes assemblages at lower elevations indicating the importance of protecting low land forest areas for the conservation of snakes in the Bhutanese mountain ecosystem.

Keywords: Abundance, diversity, low land forest areas, Mochu River valley, mountain ecosystem, snake conservation, spatial organization.

Bhutan's diverse topography, different ecosystems ranging from sub-tropical forests to alpine meadows, altitudinal variations, and changing climatic conditions harbour a large variety of faunal elements. Snakes are important groups of reptiles to conquer the terrestrial ecosystem. Reptiles and amphibians sustain biodiversity by covering key roles in their ecosystems, utilizing both terrestrial and aquatic environments (Schneider et al. 2001; McCallum 2007). They play an important role in the ecosystem as links in food webs, as predators and prey, bio-monitors in controlling insect pests and also as excellent ecological indicators owing to their high degree of sensitivity to even a slight change in the environment (Lips 1998; Roy 2002; Daniels 2003).

Among vertebrates, amphibians and reptiles are of particular concern, as they are still poorly known and are highly threatened (Rodrigues et al. 2010). A decline in their population is a major concern (Wyman 1990; Dalton 2000; Stuart et al. 2004). The causes of catastrophic decline are habitat loss, environmental pollution, lethal diseases, unsustainable use of natural resources and global climate change (Stuart et al. 2004; Cushman, 2006; Rodrigues et al. 2010).

The reptiles of the kingdom of Bhutan have been poorly studied and few collections of Bhutanese reptiles have been made although it has long history of rich

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biodiversity and was identified by Myers (1998) as one of the 10 biodiversity hot spots in the world. Bauer & Günther (1992) reported 11 new species of snakes for Bhutan based on specimens collected by the 1972 expedition of the Basel Natural History Museum. Later, Mitra (2009) reported 16 species of snakes as new records for Bhutan. However, Wangyal (2014) claimed that at least two species were misidentified by Mitra (2009). Wangyal (2009) reported 38 snake species from Bumdeling Wildlife Sanctuary, Bhutan. Subsequently, Wangyal (2011) reported 30 new species of snakes from eastern Bhutan, of which six were mistakenly reported as new records (Wangyal 2014).

After a comprehensive review of the Bhutanese herpetological records, today 84 species of snakes are known to live in Bhutan (Wangyal 2014). However, there has been no single study conducted on the herpetofauna in Jigme Dorji National Park (JDNP) despite the park being recognized as an important embodiment of the eastern Himalayan ecosystem. In the present study, an attempt has been made to document the diversity and spatial organization of snakes in JDNP and its adjoining areas.

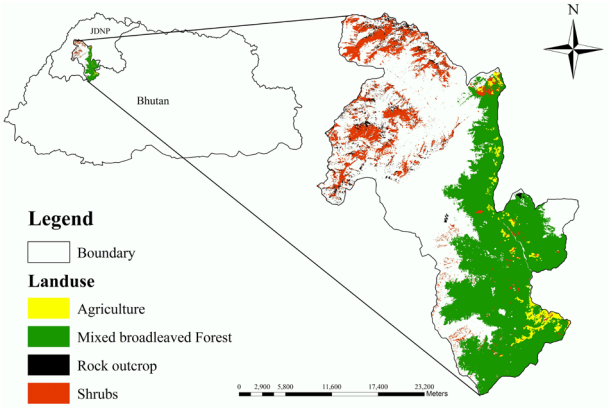

Figure 1 . Map of study site

Study area

Jigme Dorji National Park, one of the 10 protected areas in Bhutan was gazetted in the year 1995. It is located at 27^{0}49'09.4"N & 89^{0}43'49.3"E and altitude ranges from 1,200–7,000 m with corresponding vegetation types of warm broadleaved, mixed conifer and alpine meadows (Fig. 1; Image 1). Precipitation in the high altitude is mainly in the form of snow and rainfall in the lower region.

The dry subtropical zone of the park experiences a hot summer with moderate rainfall, whereas in the warm temperate and cool temperate zones at higher altitudes, the climatic conditions are characterized by warm summers and cold winters. In 2013, the annual total rain fall of Punakha (which falls under the dry subtropical zone) and Gasa (temperate zone) was 715.6mm and 1,842.1mm respectively (National Statistics Bureau 2014). It is covered by perennial snow rendering it as a home of glacial rivers which serve as an important source of water for household use, agriculture and hydropower generation in the downstream valleys.

JDNP is a vital watershed covering almost half of northern Bhutan, and is an important natural conservatory of glaciers, alpine meadows and scrublands, sub-alpine and temperate conifer forests, warm and cool temperate broadleaf forests, major rivers and streams, and the flora and fauna that inhabit these ecosystems. The study area adjoining JDNP is characterized by conifer and warm broad leaved forests and agricultural farm lands. Scrub vegetation and rocky outcrops are prominent geophysical features found along the rivers, which provides ideal habitats for various reptile species.

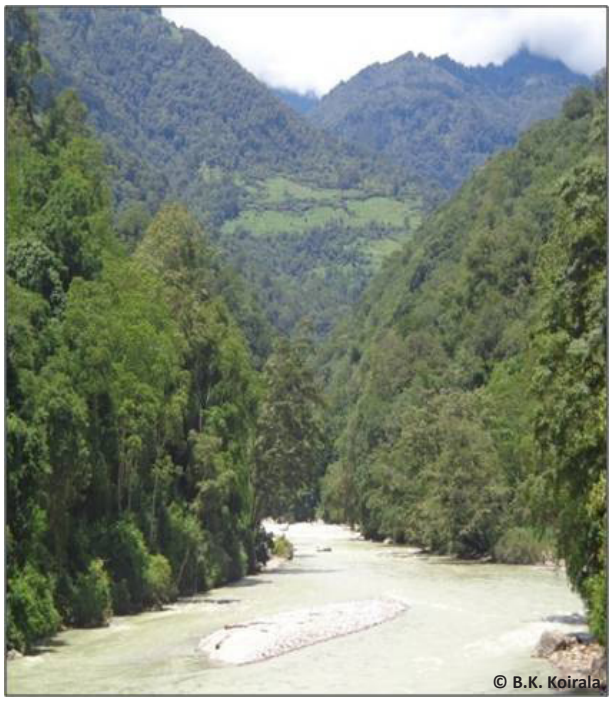

Image 1. River Mochu (Jigme Dorji National Park)

Methods

The survey was conducted from July–September, 2014 and May–July, 2015 in JDNP and adjoining areas,

Bhutan. Although the valley covered up to 5800 m, the survey was restricted to 3000 m.

The survey was conducted using the opportunistic visual encounter survey methodology. The survey was conducted from 08:00–11:00 hrs in the morning and 17:00–20:00 hrs in the evening. Every individual specimen was noted and identified to the most specific taxonomic level possible. Identification of species was done using standard field guides books Daniel (2002), Vasudevan (2010), and Ahmed et al. (2009). Digital photographs taken during the field survey were sent to experts to confirm species identity. Locality data were collected for all specimens encountered, live or dead. Wherever possible, the digital photographs were taken for specimens, elevation and geospatial location of each species was recorded using GPS.

Results and Discussion

Diversity

In total, 60-day field trips or 260 man-hours were spent searching for snakes in JDNP, of which 36 man-hours for standardized road survey at night.

A total of 17 species of snakes belonging to 15 genera, distributed among three families were documented from the various altitudinal zones of JDNP and adjoining areas (Table 1). The most species-rich family was the Colubridae (10 genera and 11 species), followed by the Viperidae (3 genera and 3 species), and the Elapidae (2 genera and 3 species). The family Colubridae was found to be the most diverse in terms of species richness, generic richness and abundance.

Abundance

A total of 69 individuals were recorded during the entire study period. The species belonging to the Colubridae family were found to be the most abundant with 38 individuals contributing (55%), followed by 20 individuals (29%) belonging to the family Viperidae and species belonging to Elapidae were found to be the least abundant with 11 individuals contributing (16%) of the total count.

At species level, the abundance of snakes varied from 1–11 individuals. Relative abundance data indicated that *Protobothrops himalayanus* (Image 2) was found to be the most abundant species contributing 15.94%. This was followed by *Ptyas nigromarginata* (Image 3) (14.50%), *Naja kaouthia* and *Ovophis monticola* (Image 4), each contributed (10.14%), *Amphiesma platyceps* (Image 5) with (8.70%), *Boiga multifasciata* (7.24%), and other 11 species all together contributed about (33.33%) of the total abundance (Fig. 2).

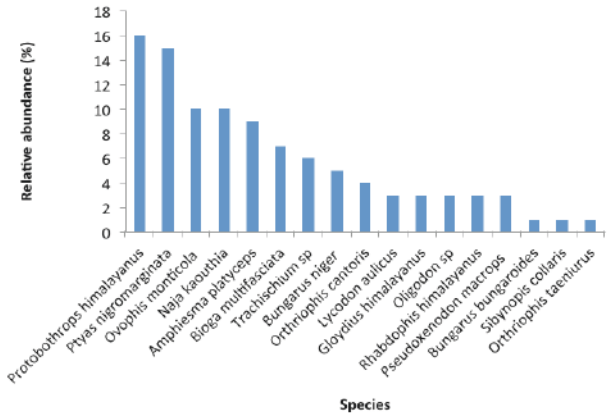

Figure 2. Relative abundance of individual species recorded in Jigme Dorji National Park and its vicinity

Table 1. List of snake species documented in Jigme Dorji National Park and adjoining areas during July 2014–July 2015.

Family / Scientific name	Common name	Individuals
Colubridae		
Ptyas nigromarginata (Blyth, 1854)	Green Rat Snake	10
Rhabdophis himalayanus (Günther, 1865)	Himalayan Keelbeck	2
Boiga multifasciata (Blyth, 1861)	Many-banded Cat Snake	5
Trachischium sp.		4
Orthriophis cantoris (Boulenger, 1894)	Mountain Racer	3
Orthriophis taeniurus (Cope, 1861)	Striped Trinket	1
Amphiesma platyceps (Blyth, 1854)	Mountain Keelbeck	6
Pseudoxenodon macrops (Blyth, 1855)	False Cobra	2
Lycodon aulicus (Linnaeus, 1758)	Wolf Snake	2
Oligodon sp.	Kukri Snake	2
Sibynopis collaris (Gray, 1853)	Collared Black-headed Snake	1
Viperidae		
Gloydius himalayanus (Günther, 1864)	Himalayan Pit Viper	2
Ovophis monticola (Günther, 1864)	Mountain Pit Viper	7
Protobothrops himalayanus (Pan et al., 2013)	Habu Himalayan Pit Viper	11
Elapidae		
Naja kaouthia (Lesson, 1831)	Monocled Cobra	7
Bungarus niger (Wall, 1908)	Black Krait	3
Bungarus bungaroides (Cantor, 1839)	Himalayan Krait	1
	Total	69

Spatial organization

Most of the reptiles about (53%) showed narrow distribution range and were concentrated in the lower elevation, particularly between 1,200–1,500 m. The species such as *Naja kaoutha* (Image 6), *Boiga*

Table 2. Geographical coordinates indicate the location where maximum numbers of individuals were sighted. Elevation range indicates the highest and lowest altitudinal boundaries within which individuals were sighted.

Species	Geospatial location		
	N	E	Elevation range (m)
Ptyas nigromarginata	27°49'11.0"	089°43'45.1"	1500–2400
Rhabdophis himalayanus	27°43'59.6"	089°44'53.6"	1500–1800
Boiga multifasciata	27°33'42.3"	089°46'42.3"	1200–1400
Trachischium sp.	27°49'08.6"	089°43'42.9"	2100–2400
Orthriophis cantoris	27°41'40.1"	089°46'09.1"	1500–1800
Orthriophis taeniurus	27°30'17.1"	089°52'14.1"	1370
Amphiesma platyceps	27°49'03.9"	089°46'24.5"	1500–2400
Pseudoxenodon macrops	27° 53'58.3"	089°43'20.7"	2750–3000
Lycodon aulicus	27°31'32.9"	089°52'12.1"	1200–1500
Oligodon sp.	27°41'16.6"	089°46'19.4"	1200–1500
Sibynopis collaris	27°32'11.5"	089°52'17.7"	1380
Gloydius himalayanus	27°54'22.3"	089°43'37.8"	2750–3000
Ovophis monticola	27°49'09.0"	089°43'41.4"	1500–2400
Protobothrops himalayanus	27°53'32.3"	089°44'25.6"	1500–2100
Naja kaouthia	27°30'58.5"	089°52'00.3"	1200–1300
Bungarus niger	27°30'34.0"	089°52'29.7"	1200–1400
Bungarus bungaroides	27°40'08.2"	089°46'24.5"	1400

multifasciata (Image 7), *Bungarus niger*, *Oligodon* sp. (Image 8), *Sibynosis collaris*, *Orthriophis taeniurus* and *Lycodon aulicus*, were restricted to a range below 1,500m while the two species *Pseudoxenodon macrops* (Image 9) and *Gloydius himalayanus* were restricted to their range profile above 2,700m (Table 2). Some of the snake species such as Green Rat Snake *Ptyas nigromarginata,* Himalayan Mountain Keelback *Amphiesma platyceps*, Mountain Pit Viper *Ovophis monticola* and Habu Pit Viper *Protobothrops himalayanus* observed at a higher altitude extended their range towards lower elevation.

It was interesting to observe that *Protobothrops himalayanus* was found mostly in undisturbed areas and very selective in its hunting period. This species was encountered at night mostly between 18:00–21:00 hr in open areas adjoining dense undisturbed forest habitat, and away from human habitation. Very limited information, however, is available about its ecology. In Sikkim, *Protobothrops himalayanus* was commonly observed on the roads and moist litter of cardamom plantations at night from May–July, and is rarely seen after mid-September (Pan et al. 2013). Our investigation found that this species is mostly active from August–September as most of the specimens were detected during this period and the last specimen was recorded on 23 September 2014 at an altitude of 2,000m in JDNP.

Image 2. *Protobothrops himalayanus*

Image 3. *Ptyas nigromarginata*

Image 4. *Ovophis monticola*

Discussion

The present study revealed that diversity, observed species richness and abundance were

Image 5. *Amphiesma platyceps*

Image 6. *Naja kaouthia*

Image 7. *Boiga multifasciata*

found comparatively higher in lower altitudinal region particularly below 1,500m than subsequent zones towards higher elevations. This implies that forest habitats below 1,500m altitudinal boundary are significantly important for conservation of herpetofauna diversity in JDNP.

The area below 1,500m is characterized by diverse habitats which comprised of chirpine forest, cool broadleaved forest, agro-ecosystem and numerous perennial streams providing potential habitats for herpetofauna assemblages. The warm chirpine forest, cool broadleaved forest, agro-ecosystem and numerous perennial streams providing climatic condition and habitat heterogeneity may be the possible cause of aggregation of species in this area. More species at lower region in this study agrees with patterns reported for a wide range of taxonomic groups, such as small mammals (Heaney 2001) and tree frogs (Smith et al. 2007). Chettri et al. (2010), for instance, noticed a seven-fold decline in reptile species richness along an elevation gradient in the eastern Himalaya.

Although a large part of this area falls under JDNP the lower region is subjected to human disturbance from people living along the valley. Taking into account the global concern on declining herpetofauna population, the protection of forest habitat of this area could be an important conservation approach.

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Image 8. *Oligodon* sp.

Image 9. *Pseudoxenodon macrops*

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