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COMMUNICATION

A faunistic survey of tiger beetles (Coleoptera: Carabidae: Cicindelinae) in Chakrashila Wildlife Sanctuary and adjoining riverine ecosystem in Assam, India

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Abstract: A faunistic survey was made to assess the tiger beetle fauna from the Chakrashila Wildlife Sanctuary and adjacent rivers for the first time from the western part of Assam, India. A total of 15 species of tiger beetles (subfamily Cicindelinae) belonging to seven genera were recorded from forest, moist and dry riverine ecosystem using an occasional night trap. Eight species belonging to five genera were recorded from the riverine ecosystem. Two species, viz., *Cylindera spinolae* and *Calochroa assamensis*, were strictly restricted to the forest and *Cosmodela virgula* was recorded from both forest and riverine areas. *Cylindera (Eugrapha) minuta*, *Calochroa flavomaculata*, and *Lophyra (Spilodia) vittigera* were collected using a night trap from the forest area. The study revealed that habitat degradation due to human interference is the major threat to the tiger beetles in the study area.

Keywords: *Calochroa assamensis*, *Cylindera spinolae*, diversity, night trap, northeastern India, predatory insects, riverine, sandy, threats.

Abbreviations: BTAD—Bodoland Territorial Autonomous Districts | BTC—Bodoland Territorial Council | GPS—Global Positioning System | ZSI—Zoological Survey of India.

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Active contribution: KC conceptualised and supervised the study and also wrote the first draft. CD visited the field, collected the beetles and took images along with KC. ADS analysed the data, structured the manuscript and approved the final draft.

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INTRODUCTION

Tiger beetles are charismatic, fast running, and predatory insects under the subfamily Cicindelinae and family Carabidae. Cicindelinae is characterized by large compound eyes, filiform and 11-segmented antennae, long legs, and long sickle-shaped mandibles. The size of tiger beetles varies from 6–45 mm. They are adapted to different habitat types such as riverine sandy areas, stream and pond edges, hillsides, rocky areas near roads, trails, and forest openings. Though the tiger beetle is mainly distributed in the tropical region, it is also found in Greenland, Tasmania, and some small oceanic islands such as Hawaii (Pearson 1988; Cassola & Pearson 2000; Pearson & Vogler 2001).

All tiger beetles are highly habitat-specific (Knisley & Hill 1992; Adis et al. 1998; Cardoso & Vogler 2005; Pearson & Cassola 2007; Rafi et al. 2010). Each species prefer specific habitats such as riverine habitats (Ganeshaiah & Belavadi 1986; Satoh et al. 2006; Dangalle et al. 2011a,b), forests (Adis et al. 1998), agroecosystems (French et al. 2004; Sinu et al. 2006), parks, areas with human disturbances (Bhardwaj et al. 2008; Mosley 2009), open areas with sparse vegetation (Schiefer 2004) and grasslands (Acorn 2004). The association of tiger beetle species with habitat has been related to their preferences for mating and oviposition sites, food availability, seasonality, vegetation cover and physical, chemical and climatic qualities of the habitat (Pearson et al. 2006). Most of the tiger beetles are diurnal, some species are strictly nocturnal and many are cathemeral (Pearson 1988). Though several species living together is common, there is very little competition among them, particularly because of niche partitioning (Pearson & Carroll 1998).

There are around 2,300 species of tiger beetles recorded so far all over the world. India harbors 208 species of tiger beetles and ranks third among the countries inhabited by them. Of these, 51.9% species are endemic to India only (Cassola & Pearson 2000). Geographically, species richness of tiger beetles is comparatively high in the northeastern and southwestern parts of India (Pearson & Ghorpade 1989; Pearson & Juliano 1993). Since they are widespread, having specific habitat requirements and well-known taxonomy they serve as valuable indicators of the general state of the environment (Annemarie 1999; Cardoso & Vogler 2005; Satoh et al. 2006; Pearson & Cassola 2007). Besides, some species serve as important biological control agents in agroecosystems (Rodriguez et al. 1998).

Indian tiger beetles were first documented by Schaum (1863), Atkinson (1889), and Horn (1905a,b), though the first comprehensive list of all genera of tiger beetles of the Indian subcontinent was published by Fowler (1912). After independence, Pajni & Bedi (1973) reported a preliminary survey of the cicindelid fauna of Chandigarh. Pearson & Ghorpade (1987) studied the geographical distribution and ecological history of tiger beetles of the Siliguri-Darjeeling area of eastern India. Later, Bhargav & Uniyal (2008) studied tiger beetles in the Shivalik Landscape. In 2008, Werner & Wiesner first recorded *Neocollyris* (*Leptocollyris*) *parvula* (Chaudoir, 1848), *Calochroa bicolor haemorrhoidalis* (Wiedemann, 1823) and *Cylindera* (*Ifasina*) *severini* (Horn, 1892) from the state of Maharashtra, Rajasthan, and Madhya Pradesh. Bhardwaj et al. (2008) reported the occurrence of tiger beetles from Uttarakhand. Tiger beetles of Meghalaya were exclusively reported by Sawada & Wiesner in 1997. Recently, Harit (2013) studied the diversity of tiger beetles in Mizoram of northeastern India. Invertebrates are understudied overall, and for even some of the taxonomically better studied groups like tiger beetles (Cicindelidae), knowledge is scanty from this part of the land. Keeping these aspects in view, an investigation of the occurrences and preferences of habitats along with their present threats in Chakrashila Wildlife Sanctuary and the adjoining riverine ecosystem in western Assam of India was conducted.

MATERIALS AND METHODS

Study area

Chakrashila Wildlife Sanctuary (26.250–26.433 ^{0}N and 90.250–90.333 ^{0}E 4,500ha) is located in the districts of Kokrajhar and Dhubri in the state of Assam, India. The sanctuary is the only protected area for the Golden Langur *Trachypithecus geei* in India. The hilly terrain is covered with dense forest which is mostly semi-evergreen and moist deciduous, with patches of grassland and scattered bushes (scrubland). The dominant trees found are *Tectona grandis*, *Shoresa robusta*, *Eleocarpus* sp., *Oroxylum indicum*, *Castanopsis purpurea*, and *Dillenia pentagyna*. The forest type falls in the category 3C/C.1.a(ii) following Champion & Seth (1968).

There are several small streams, of which the major ones are Howhowi Jhora and Bamuni Jhora, which help maintain humidity of the environment. Two major wetlands, viz., Diplai and Dhir 'beel' (water bodies) are also adjacent to its boundary. The sanctuary harbours about 154 species of butterflies (Choudhury & Ghosh

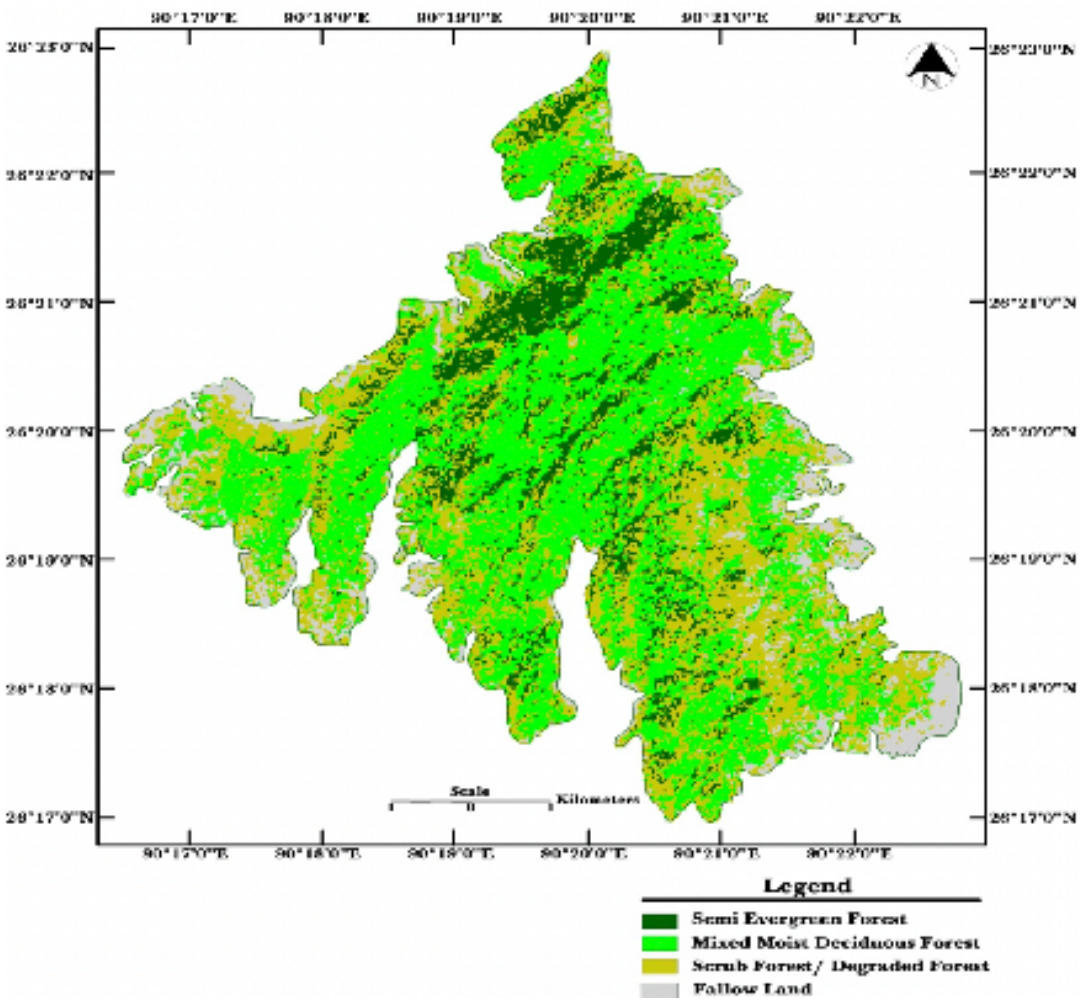

Figure 1. GIS image of Chakrashila Wildlife Sanctuary, western Assam, India.

2009) and the endemic Golden Langur (Gee 1961). Besides, a survey was also carried out along the river banks of Gaurang, Champawati, Saralbhanga, and Bahalpur, which are the major tributaries of the river Brahmaputra and originate from the Bhutan Himalayas.

The present study was conducted from October 2018 to October 2019. Surveys were carried out between 10.00 and 16.00 h on sunny days by walking on dry river beds and along the banks of the rivers Gaurang, Champawati, Saralbhanga, and Bahalpur. Visual encounter survey is the most effective method for tiger beetle study. Species recorded in moist sandy soils and dry sandy soils were recorded. For forest species, active search was made along all approachable areas of different habitats such as stream bank, grassland and forest trails of Chakrashila Wildlife Sanctuary. All the GPS locations were recorded with the help of Garmin GPS-60. Specimens were collected by hand picking and a standard-sized insect net. Besides, an opportunistic light trap was also carried along during the survey along the road side of the Chakrashila Wildlife Sanctuary to find out the alpha-diversity of tiger beetles. Collected specimens were preserved in 96% ethanol in the laboratory of P.G. Department of Zoology, Science College, Kokrajhar and Zoological Survey of India (ZSI), Kolkata for further reference. Identification was carried out following Fowler (1912) and with the assistance of an insect taxonomist.

RESULTS

A total of 15 species of tiger beetles belonging to seven genera were recorded in Chakrashila Wildlife Sanctuary and riverine ecosystem of Gaurang, Champawati, Saralbhanga, and Bahalpur during the sampling period (Table 1). Maximum number of species was recorded from the genus *Calomera* (27%)

Table 1. Tiger beetle fauna of Chakrashila Wildlife Sanctuary, and adjacent riverine ecosystems with their associated habitat.

	Genus	Species	Habitat
1	*Calomera*	*Calomera angulata* (Fabricius, 1798)	Moist sandy soil
2		*Calomera (Lophyridia) chloris* (Hope, 1831)	Moist sandy soil
3		*Calomera plumigera macrograptina* (Acciavatti & Pearson, 1989)	Moist sandy soil
4	*Myriochila*	*Myriochila undulata* (Dejean, 1825)	Moist sandy soil
5	*Cylindera*	*Cylindera (Eugrapha) minuta* (Olivier, 1790)	Moist sandy soil
6		*Cylindera* (*Eugrapha*) *venosa* (Kollar, 1836)	Moist sandy soil
7		*Cylindera spinolae* (Gestro, 1889)	Forest area
8		*Cylindera bigemina* (Klug, 1834)	Moist sandy soil
9	*Cosmodela*	*Cosmodela virgula* (Fleutiaux, 1893)	Moist sandy soil and forest area
10	*Chaetodera*	*Chaetodera albina* (Wiedemann, 1819)	Dry sandy soil
11	*Lophyra*	*Lophyra cancellata intemperata* (Dejen, 1825)	Moist sandy soil with sparse vegetation
12		*Lophyra (Spilodia) vittigera* (Dejean, 1825)	Forest area
13	*Calochroa*	*Calochroa octonotata* (Wiedemann, 1819)	Moist sandy soil
14		*Calochroa flavomaculata* (Fabricious, 1775)	Forest area
15		*Calochroa assamensis* (Parry, 1844)	Forest area

Table 2. Geographical locations of different survey areas during the study period.

Survey area	Latitude (N)	Longitude (E)	Altitude (m)
Gaurang River	26.713	90.444	57
	26.722	90.443	57
	26.426	90.262	57
	26.429	90.265	56
	26.713	90.444	56
	26.691	90.445	56
	26.710	90.459	56
	26.429	90.265	57
	26.417	90.271	57
	26.722	90.448	57
	26.710	90.459	57
	26.692	90.717	57
	26.724	90.429	57
	26.670	90.434	57
	26.667	90.430	57
	26.687	90.447	57
Champawati River	27.120	90.620	45
Bahalpur River	26.533	90.798	82
Saralbhanga River	26.568	90.211	82
Malbhog River	26.540	90.082	73

Image 1. Survival threats to tiger beetle: A—extraction of sand | B—extraction of gravel and boulder | C—forest fire. © K. Choudhury.

followed by *Calochroa* (20%) and *Cylindera* (20%). *Lophyra* presented 13% of the total species. The least number of species was recorded from the genus *Chaetodera* and *Cosmodela* (7%) (Figure 2A). In the study, maximum number of species was recorded from the moist riverine sandy soil (53%) which was followed by forest area (33%) while the least number of species was recorded from the dry, riverine sandy soil, while only 7% species share both forest and moist riverine sandy soil (Figure 2B). *Cylindera* (*Eugrapha*) *venosa* and *Myriochila undulata* were the most common species in moist riverine sandy soil while *Cylindera spinolae and Calochroa assamensis* were restricted to the forest area only. *Cosmodela virgula* was recorded from both the moist sandy soil and forest area. *Chaetodera albina* was the only species recorded from dry sandy soil during the study period (Table 1). Three species were encountered using a light trap of which *Cylindera (Eugrapha) minuta* and *Calochroa flavomaculata* occurred frequently but *Lophyra (Spilodia) vittigera* was rare. All the survey sites along with their GPS locations during the survey period are depicted in Table 2.

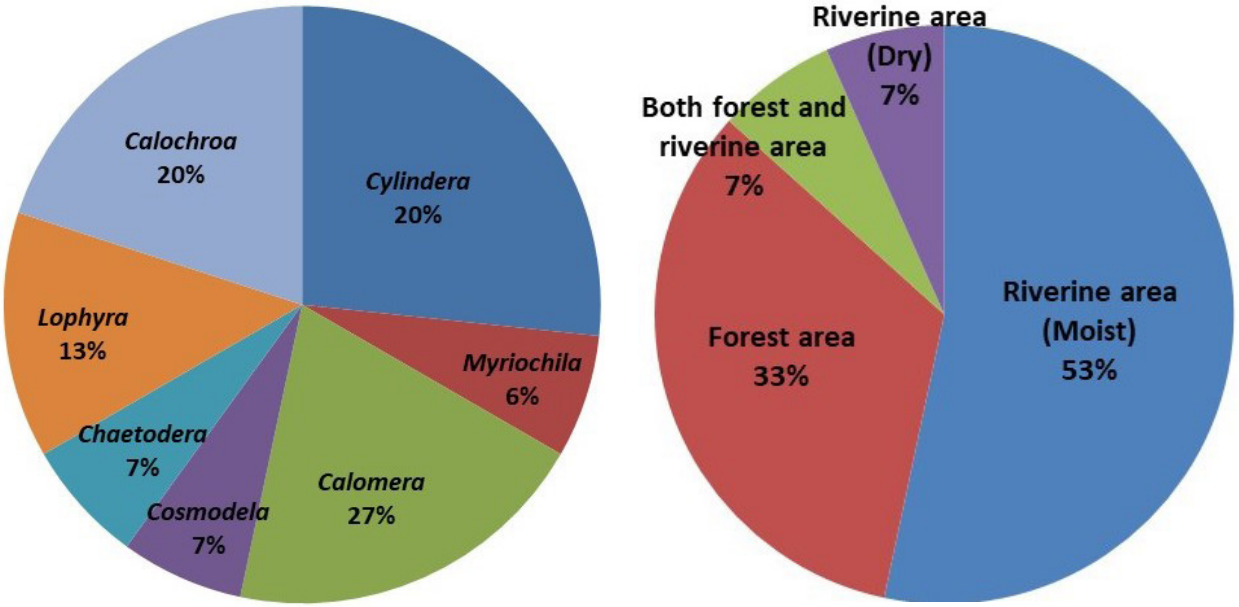

Figure 2. A—Different genera of tiger beetles in percentage recorded during the survey | B—Habitat utilization of tiger beetles in the study sites during the survey.

DISCUSSION

The sandy bank formed along the margin of the water level attracts many invertebrates due to accumulated organic matter and high food supply. Such riparian habitats are known to be preferred by tiger beetles not only because of adequate food resources but also due to safety from predators and low human disturbance (Bhargav & Uniyal 2008; Dangalle et al. 2012). Among the species, nine—*Calomera plumigera macrograptina, Cylindera bigemina*, *Lophyra cancellata intemperata, Myriochila undulata, Chaetodera albina, Calochroa octonotata, Cylindera* (*Eugrapha*) *venosa, Cylindera (Eugrapha) minuta*, and *Calomera chloris* (Image 3)—were recorded in moist riverine sandy areas of rivers Gaurang, Sarlbhanga, and Champawati. Tiger beetles usually prefer low moisture containing sandy soil with sparse vegetation where females' oviposition becomes easier (Ganeshaiah & Belavadi 1986; Hoback et al. 2000; Satoh et al. 2006; Dangalle et al. 2011a,b). Among the moist riverine sandy species, *Cylindera* (*Eugrapha*) *venosa* and *Myriochila undulata* were the most common species and dominated all other species in terms of occurrence. *Calochroa octonotata* is the largest tiger beetle in terms of body size and has a powerful flyer and usually occurs individually in the margin of the water level. When disturbed, it flies for long distances and perches in areas of sparse vegetation. Some species like *Cylindera* (*Eugrapha*) *venosa, Myriochila undulata, Cylindera (Eugrapha) minuta, Calomera plumigera macrograptina*, and *Lophyra cancellata intemperata* co-occurred but they could have the least competition amongst themselves probably due to niche separation (Pearson 1998). *Lophyra cancellata intemperata* was less abundant and prefers moist sandy area with sparse vegetation (Schiefer 2004). It has been noticed that this species, when disturbed or threatened, moves to sparse vegetation areas at once and obscures itself. They usually co-occurred with *Cylindera (Eugrapha) venosa* and *Myriochila undulata* but were found to be scanty in number. During the survey, *Chaetodera albina* was recorded only from a few locations of the river Gaurang specifically during hot sunny days when sand temperatures were about 45^{0}C (mid-day). It was recorded in a characteristic dry sandy soil (white) about 20m away from any water source. *Chaetodera albina* is a conspicuous species and is difficult to locate unless or until it moves. The expanded white maculations on the elytra may have functioned in lowering the body temperature making them able to forage longer without overheating (Dangalle et al. 2012). Besides, it is an apparent adaptation for remaining inconspicuous to natural enemies reliant on visual cues (Seago et al. 2009).

Likewise, three species namely *Cylindera spinolae, Calochroa assamensis*, and *Cosmodela virgula* were recorded from the forest of Chakrashila Wildlife Sanctuary. *Cylindera spinolae* and *Calochroa assamensis*

Image 2. Different habitats of tiger beetles: a—forest | b—moist sandy soil | c—dry sandy soil | d—moist soil. © K. Choudhury

are both forest dwellers and observed while perching on leaf surfaces. The presence of tiger beetles in forest and thick undergrowth vegetations were also reported by Pearson & Ghorpade (1987) and Adis et al. (1998). The black coloration of both the species seems to give them an advantage of not being easily recognized by predators as they seem to camouflage in the dark and shady environments and dark substrates. In general, tiger beetles' general coloration tends to match their substrate as a tool to evade and confuse predators (Morgan et al. 2000; Dangalle et al. 2014). On the other hand, *Cosmodela virgula* occurs in both river banks as well as forest paths. This indicates that this species is a habitat generalist. Among the forest dwellers, *Cosmodela virgula* is the most abundant species. During the study period, *Lophyra (Spilodia) vittigera* and *Calochroa flavomaculata* were collected by incidental catch by night trap near the Forest Bungalow of Chakrashila Wildlife Sanctuary. Among the night trap species, *Cylindera (Eugrapha) minuta* and *Calochroa flavomaculata* occurred frequently but *Lophyra (Spilodia) vittigera* was sighted only once. Harit (2013), however, recorded *Calochroa flavomaculata* and *Calomera chloris* from riverine sandy soil, while *Cylindera (Eugrapha) minuta* was reported to prefer riverine sandy soil as well as agricultural land in the Mizoram State of northeastern India.

The present study reveals that due to rapid urbanization, demand of sand and gravel has increased manifold. These materials are extracted legally or illegally in large and small scale from the river bed by traders as well as villagers from almost all the rivers. The extraction pressure however is comparatively more on the Champawati River than the others because of its good sand quality. The raw materials for rock crushing industries are also extracted from these rivers. Since, most tiger beetles are habitat specific, such activities definitely impact on their survival which may lead to their local extinction (Image 1). Presently, the unscientific use of fertilizers in the paddy fields around the vicinity of riverine sides may degrade the soil quality, which in turn hampers the development of the tiger beetles' larvae. Besides, illegal tree-felling, encroachment, silvicultural practices, conversion of cultivated land into tea gardens and illegal forest fire can cause the diversity of tiger beetles in the area to decline. The study indicates the presence of pristine habitat condition of tiger beetles in this region. Therefore, conservation of these local poorly known taxa is of utmost importance along with other flora and fauna of this region.

Image 3. Microphotographs of different species of tiger beetles: a—*Cylindera spinolae* | b—*Calochroa assamensis* | c—*Calochroa flavomaculata* | d—*Calomera plumigera macrograptina* | e—*Cylindera (Eugrapha) minuta* | f—*Calomera angulata* | g—*Lophyra cancellata intemperata* | h—*Lophyra (Spilodia) vittigera* | i—*Calomera (Lophyridia) chloris* | j—*Chaetodera albina* | k—*Cylindera (Eugrapha) venosa* | l—*Cosmodela virgula* | m—*Calochroa octonotata* | n—*Cylindera bigemina*. © K. Choudhury

CONCLUSION

The detection of 15 species of tiger beetle for the first time reflects the low survey effort and opportunistic nature of the collections. Therefore, a long-term survey covering maximum habitats over different seasons will be required at the earliest to explore and document the entomological wealth of the region. Though the species inventories are few in number, the present findings have high significance for understanding insect biodiversity in the region and provides a baseline data for further research programmes.

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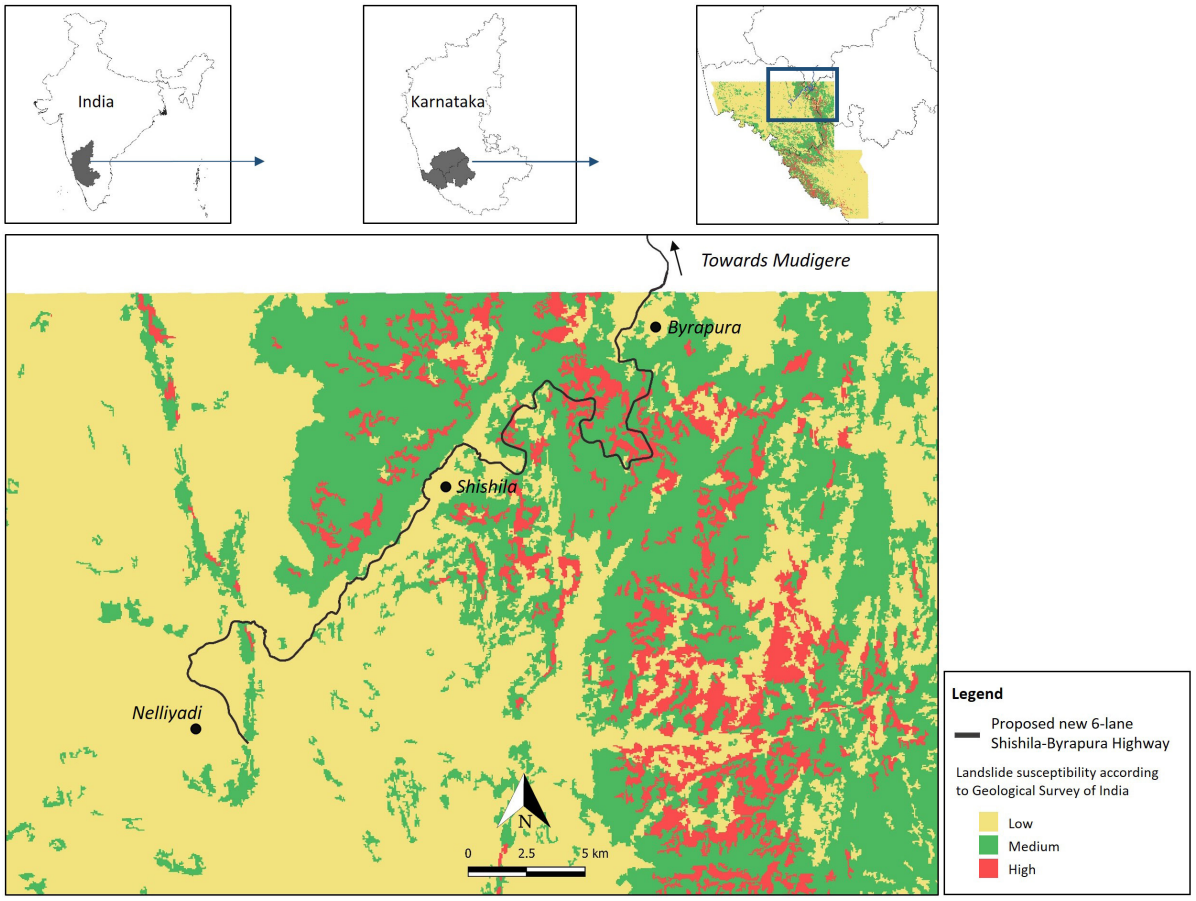
Legend for the Appendix 3 has been wrongly written within map, which could be problematic to the representation of the results. Legend should read as:



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