

Progress Report
**Assessment of Amphibian and Reptilian Diversity
along Ganga River**



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Introduction

Amphibians and reptiles play a crucial role in the ecosystem functioning (Chaudhary, 1998; Shrestha, 2001). Being predator they act as potential biological pest control and support many other animals as prey. Amphibians are considered as most threatened vertebrate group in the world (Stuart et al. 2004; Sodhi et al. 2008). Also one fifth of the reptiles are threatened worldwide (Whitfield et. al. 2007). The manifold causes of declines are habitat loss and fragmentation, climate change, pollution and emerging diseases (Bovo et al. 2018).

Globally amphibian and reptilian fauna are represented by 8,053 species (amphibiaweb.org) and 10,970 species (Uetz et al. 2019) respectively. India has rich diversity of herpetofauna including 434 species of amphibian (amphibiaweb.org) and more than 700 species of reptiles (Uetz et al. 2019).

Riparian habitats are important in determining the structure of community living in the aquatic environments (Gomi et al. 2006). Study on herpetofauna of the Ganges River basin can traced back to Walton (1911) and Boulenger (1920). Since then few works have been carried out by Bhatnagar (1969, 1972), Waltner (1974), Chopra (1979), Tilak and Husain (1977), Sanyal et al. (1979), Singh and Gupta (1979a, b), Bedi (1985), Tilak and Ray (1985), Lamba (1987), Osmaston and Sale (1989), Sarkar (1991), Husain (1995), Ray and Tilak (1995), Ray (1992, 1995, 1997, 1999), Husain and Ray (1995, 1997), Husain (2003, 2004), Khati (2004), Khanna and Tiwari (2006), Sarkar and Kumar (2006), Bahuguna (2008), Mehta (2008), Hegde et al. (2009a, b, 2013), Ohler et al. (2009). Most recent works includes Hegde and Roy (2011a, b), Das et al. (2012), Hegde (2013), Bahuguna (2018). Previously 12 Species of amphibians from Ganga river were reported by (Chanda 1991) and Sharma (1991) reported three species of lizards and five species of snakes. Bashir et al. (2012) reported six species of snakes and two species of lizards from upper Ganges (Bijnor- Narora).

However, most of these studies restricted to the protected areas of the Ganges River basin and Himalayan region. Study on herpetofauna along Ganga River still remain inadequate. In the present study, an attempt has been made to survey the herpetofaunal diversity along Ganga River.

Objectives of the study

- 1.** To determine the species richness and diversity of herpetofauna along Ganga and Alaknanda River.
- 2.** To map the distribution of herpetofaunal species along Ganga and Alaknanda River.
- 3.** To study the reproductive biology of threatened amphibian species of the Ganga River Basin.

Methodology

During May 2017 and September 2019 we conducted the study in 30 Sites (**Figure 1**) along Ganga river and Alaknanda river (Appendix 1). Study sites along Ganga river were mostly agricultural field and settlement area (**Figure 2**). We also surveyed few sites along the tributaries of Alaknanda river.

In each site we employed time constrained Visual Encounter Survey (VES) at dusk to document species richness. Sampling effort i.e., number of observer (single person) was kept constant during the sampling. All potential habitats (i.e., wetlands, crop fields and other temporary water bodies) at the locality was surveyed. During the study, number of individuals encountered, number of species, microhabitat, and behavioral activities were recorded. Photographs of representative of each species were taken in natural habitat. Specimens that were collected were fixed in formalin and preserved in 70% ethanol. Species were identified using field guides *viz.* Smith (1935, 1943), Schleich & Kastle (2002), Dutta (1997), Chanda (2002), Whitaker and Captain (2004) and Das and Das (2017). Nomenclature and taxonomic arrangement follows Frost (2018) for amphibian and Uetz et al. (2018) for reptiles. We also report the threat status of the recorded species using IUCN Red List criteria (<http://www.iucnredlist.org>). For the statistical analysis we considered the species which were encountered in the visual encounter survey. Species recorded opportunistically were only included in species composition of the study sites.

Observation on breeding behaviour was made with the help of red light or low beam torch from a distance about 1 m. We actively searched for calling males, amplexus or a female until it engage in amplexus. Duration of amplexus and foam nesting were recorded with stopwatch. Perch height of the individuals, distance of the nests from nearest waterbody were taken with a measuring tape. After the completion of spawning, body size (SVL) of the amplexant pair, size of the nest were taken with digital caliper (Mitutoyo) to nearest 0.1 mm. We also applied opportunistic search in daylight for the foam nests by thorough inspection of the ground floor across the vegetation. We also collected tadpoles and preserved to study the developmental stages. Developmental stages were identified using Gosner (1960).

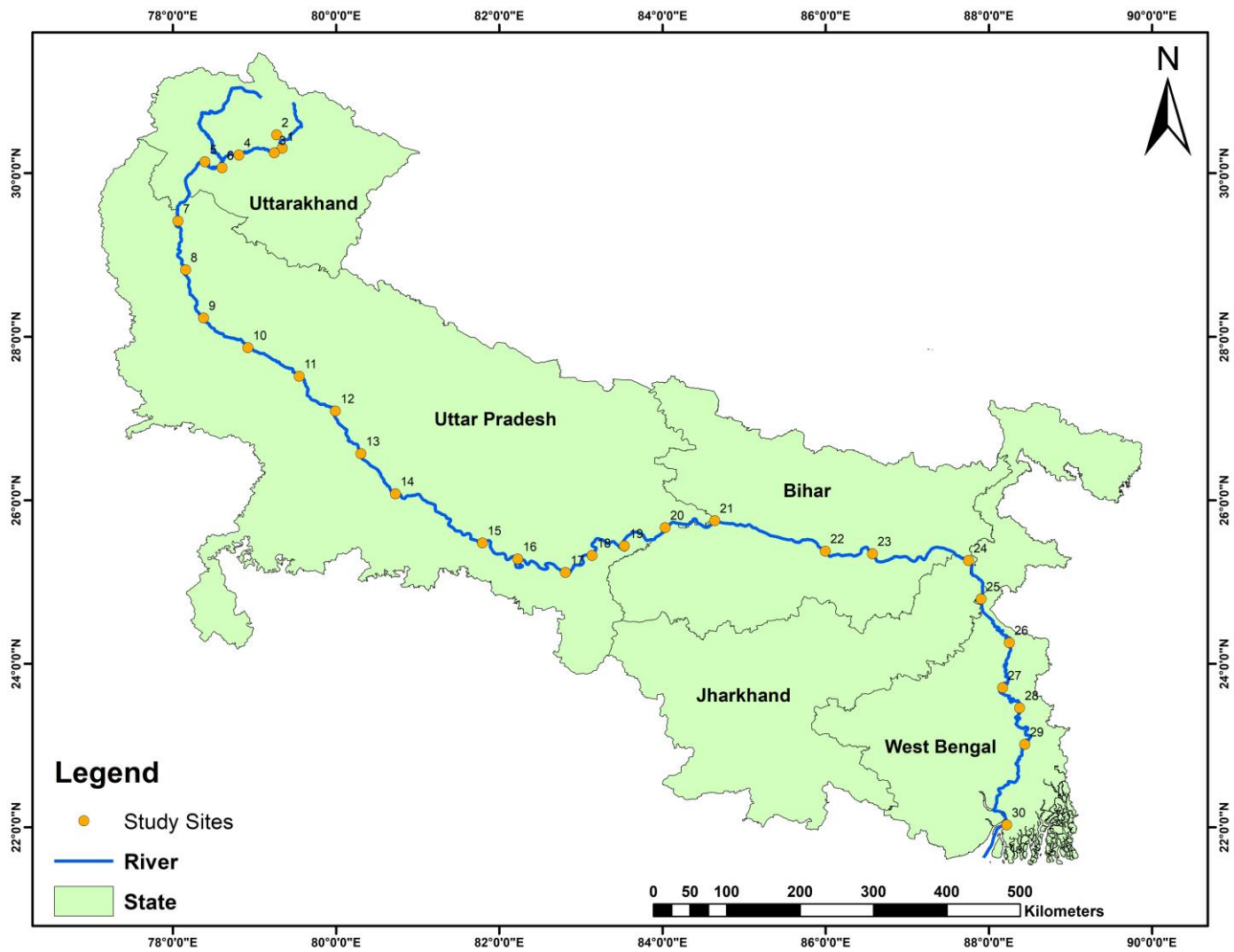


Figure 1: Map showing the study sites.

Result

During the period of study, we recorded total 40 species of herpetofauna from 16 families (Table 1). All recorded amphibians are anurans representing 16 species belonging to 11 genera and five families. Reptiles were represented by 14 species of snakes belonging to 12 genera and seven families; 11 species of lizards belonging to nine genera and four families. The family Dicroglossidae was the richest family (13.51%) with five species.

Species richness and diversity was found to be high in Bijnor (Table 2). On average, 27.82 individuals of anurans and 3.21 individuals species of reptiles were observed in each sample of one hour. Among the recorded species *Euphlyctis cyanophlyctis* was the most abundant species with relative abundance 0.32 and encounter rate 9.79/hour (Table 3).

Species accounts

Duttaphrynus himalayanus (Günther, 1864) **Himalayan Toad:** A large bodied toad with stout limbs. Body dorsally warty and pair of parotid gland present behind eye. Female larger than male. Dorsally olive brown or greyish brown. Belly cream coloured.

The species found along the streams and forest floors along Balkhila River at Mandal.

Duttaphrynus melanostictus (Günther, 1864) **Common Asian Toad:** Stout bodied toad with warty skin. A pair of parotid gland present behind the eyes. Cranial ridges present on head. Hind limbs stout and rudimentary web present between toes. Dorsally gray or brownish. Ventrally whitish or creamy. Cranial ridges, tip of the warts black. Male has a light reddish vocal sac.

Calling aggregations of the species were commonly encountered along the stagnant water at the bank of the river, crop fields, temporary watersheds, swampy areas. We observed breeding male and female individuals between March to September. Juveniles were recorded on the river banks.

Duttaphrynus stomaticus (Lütken, 1864) **Marbled Toad:** Similar to *D. melanostictus*, but warts not keratinized and cranial ridges absent. Parotid gland broad. Hind limbs stout and rudimentary web present between toes. Grey or grayish brown body. Light brown or whitish marbling on dorsal and lateral side of the body may be present. Ventrally whitish or creamy.

The species commonly encountered in the region. Calling aggregations were found along the stagnant water at the bank of the river and crop fields. Individuals were also recorded from

dry places away from water. We observed the juveniles almost throughout the study period along the river bank.

Euphlyctis cyanophlyctis (Schneider, 1799) **Skittering Frog:** Body flat with elongated head. Snout pointed and nostril dorsally placed. Dorsal skin tubercular and ventrally smooth. Hind limbs stout and toes fully webbed. Body dorsally olive brown or light brown and white on ventral. Irregular dark green spots present on dorsal surface of the body may be present. Ventrally white and sometimes with gray marbling.

Commonly encountered in shallow and stagnant watersheds along the river, crop fields, roadside temporary water pools.

Hoplobatrachus tigerinus (Daudin, 1802) **Indian Bull Frog:** A large bodied frog with an elongated head and pointed snout. Longitudinal glandular folds present on dorsum. Limbs stout and muscular. Body olive brown or yellowish green. A yellow mid-dorsal line from snout to vent present. Irregular dark olive blotches present on dorsum and limbs. Ventrally yellowish or creamy white. Male has dark blackish or blueish vocal sac.

Adult and juveniles of the species were recorded in shallow and stagnant watersheds along the river, crop fields, roadside temporary water pools.

***Minervarya* sp. Cricket Frog:** Body oval shaped with a pointed snout. Glandular warts or discontinuous ridge present on dorsum. Dorsally olive brown with or without a mid-dorsal line. Ventrally creamy white.

Commonly found along the river bank, agricultural fields and temporary water pools. Juveniles of *Minervarya* sp. were found almost throughout the study period along the river bank. We also observed an adult of *Minervarya* sp. feeding on *Microhyla* sp. in Narora. This is the first report of Dicroglossid frog feeding on *Microhyla* sp.

Sphaerotheca breviceps (Schneider, 1799) **Indian Burrowing Frog:** Body globular with a short head. Snout short and rounded. Skin granular with short glandular folds and tubercles. Limbs short. A shovel shaped inner metatarsal tubercle present on foot. Body colour grayish brown or light pinkish brown with olive blotches. A yellowish mid-dorsal line may be present. Male has dark black vocal sac.

Calling individuals of *S. breviceps* were found in roadside water puddles near Nayar confluence, Uttarakhand. We encountered another individual on roadside in Tigri Ghat. We

also recorded calling aggregation in stagnant water bodies on the sandy bank of Alaknanda River in Srinagar, Uttarakhand.

Nanorana minica (Dubois, 1975) **Nepal Paa Frog:** A small sized frog. Body oval shaped with slender limbs. Supra-tympanic fold distinct. Discontinuous ridge and tubercles present on dorsum. Dorsally brown. Dark bands present on limbs. Ventrally cream coloured.

Individuals were recorded in forest floor, along river and stream side in Mandal. We also recorded the species along roadside near Rudra Prayag. Tadpoles were found in pool water of hill streams.

Hylarana tyleri Theobald, 1868 **Leaf Frog:** Slender body with elongated head. Snout pointed. Tympanum large. Dorsolateral fold present on the body. Limbs long and slender. Toes webbed. Fingers and toes with small oval disc. Head and dorsum green. Dorsolateral fold white bordered with dark brown stripe on both side. A dark brown stripe from tip of the snout to anterior corner of the eye. Lips whitish.

We encountered individuals of the species on *Eichhornia* sp. in temporary water bodies near agricultural field in Nabadwip, West Bengal.

Amolops formosus (Günther, 1876) **Assam Cascade Frog:** Body slender and elongated. Snout rounded. Limbs long and slender. Adhesive disc present on fingers and toes. Webs well developed on toes. Dorsally green with irregular dark brown markings. Cross bands present on limbs and digits.

The species recorded in fast flowing streams in Mandal.

Amolops jaunsari Ray, 1992 **Jaunsar Stream Frog:** Body stout. Limbs elongated and slender; digits with large adhesive disc. Dorsal skin tubercular. A discontinuous dorsolateral glandular fold present. Webs on toes well developed. A olive green frog with black or brown spots on dorsum. Under white. Dark bands present on limbs. Discs on fingers white.

We recorded the species on boulders along hilly stream in Guala, Nandprayag.

Uperodon taprobanicus (Parker, 1934) **Sri Lankan Painted Frog (Figure...):** Body globular; head short and snout rounded. Tympanum concealed by supratympanic fold. Limbs short and stout. Finger tips broad spade like; while toe tips rounded, not broad. Dorsal skin tubercular. Body colour brown with dark edged broad orange on head and dorsum. White spots and irregular brown markings present on ventral side.

Individuals of the species were recorded on tree trunk in Munger, Bihar.

Uperodon globulosus (Günther, 1864) **Indian Balloon Frog:** Body stout with a small head. Snout rounded. Tympanum concealed by supratympanic fold. Limbs short and stout. A shovel shaped inner meta-tarsal tubercle present on foot. Brown on dorsal. Yellow spots present on lateral side of the body. Under whitish or pale yellow. Males have a black vocal sac.

Calling aggregation was recorded in water puddles among Typha grasslands and near human habitation in Bijnor, Uttar Pradesh.

Microhyla nilphamariensis Howlader, Nair, Gopalan and Merila, 2015 **Narrow-mouthed Frog:** Small sized frog. Body oval shaped with a short head. Hind limb stout and rudimentary web present between toes. Skin smooth or partially tuberculate. Body light brown to dark brown. Dorsum with irregular shaped dark brown patch extending posteriorly from the level of eyes. Markings variable. Longitudinal lines may be present at the flank. Males have dark throat.

Calling aggregations were recorded along water puddles along agricultural field. Large number of froglets were recorded in agricultural field in Narora and Brijghat, Uttar Pradesh.

Polypedates taeniatus (Boulenger, 1906) **Terai Tree Frog:** A small sized tree frog with elongated body. Limbs long and slender. Finger and toe tips with rounded adhesive discs. Toes webbed. Belly granular. Dorsally brown with broad golden dorsolateral stripe. Upper lip golden. Longitudinal golden stripe also present on hind limb. Ventrally cream coloured.

The species very common in Bijnor and Tigri and Narora. This tree frog is found in Typha and Saccharum grasslands along the Ganga River.

Polypedates maculatus (Gray, 1830) **Common Indian Tree Frog:** Body elongated and slender. Limbs long and slender. Fingers and toes with round adhesive pad; toes webbed. Body brown or yellowish brown with dark brown irregular spots of different size. A “W” shaped dark marking present between upper eyelids. Ventral side of the body whitish. Groin and outer lateral side of the thigh has dark brown reticulation.

Only single individual was recorded at day time in bushes along Ganga River in Fattehpur, Uttar Pradesh.

Eryx johnii (Russell, 1801) **Red Sand Boa:** Body short, stout and cylindrical. Head indistinct from the neck. Tail short and blunt. Anterior head scales slightly larger than body scales. Eyes small. Body colour dark brown; paler on ventral.

One individual was recorded from Kachla on a sunny day in September, 2017.

Python molurus (Linnaeus, 1758) **Indian Rock Python:** Body stout and head distinct from neck. Sensory pits present on lips. Eye pupil vertical. Body brownish and gray towards the lateral side. Large brown irregular patches present on dorsum. Head slightly pinkish with brown arrow shaped mark extending upto neck, anterior portion of the marking diffused.

One juvenile was recorded at night on the Ganga river bank in Handia, Allahabad.

Enhydris sieboldii (Schlegel, 1837) **Siebold's Smooth-scaled Water Snake:** Stout bodied snake. Head slightly distinct from neck. Snout blunt and nostril dorsally present. Eyes small with vertical pupil. Body light brown with dark brown markings. Markings black bordered, broad and closely spaced; joined along midline on forebody. A series of small brown spots present on lateral side of the body. Three broad stripes present on head which unites between the eyes. Markings darker in juvenile than that of adult.

Active at night. The species was very commonly encountered in Bijnor barrage. One juvenile was recorded from Tigri in July, 2017.

Xenochrophis piscator (Schneider, 1799) **Checkered Keelback:** Body stout. Head slightly broader than neck. Eye pupil round. Dorsal scales keeled. Dorsally olive brown with few rows of black spots alternatively present; diffuses towards tail. Two black streak present extending from the eye to upper lip.

Active in both day and night. Adults and juveniles were commonly recorded at the river bank and wetlands throughout the study area.

Xenochrophis cerasogaster (Cantor, 1839) **Painted Keelback:** Body elongated and slender with narrow head. Eye pupil rounded. Dorsal scales keeled. Body olive brown or bright reddish. Lips yellow. A yellow stripe with red base present along the margin between dorsal and ventral scales. Ventral scales dark brown or reddish with red and light yellow spots.

Two individuals of the species were recorded from the wetlands along Ganga river in Bijnor in the month of September, 2017.

Amphiesma stolatum (Linnaeus, 1758) **Buff-striped Keelback:** Body slender and head narrow. Eyes large with rounded pupil. Dorsally head and body olive brown. Black transverse bands present along the body. A pair of yellowish stripe present from the neck to tail. A black streak present on lateral side of the head radiating from eye.

Only one individual was sighted on roadside near Ganga river in Bijnor.

Ptyas mucosa (Linnaeus, 1758) **Indian Rat Snake:** Body slender with elongated head. Head distinct from neck. Eye large with round pupil. Dorsal scales smooth. Dorsally yellowish brown or olive brown. Black cross bars present on lips. Ventral yellowish.

The species was recorded at the river bank near human habitations at day time.

Lycodon aulicus (Linnaeus, 1758) **Common Wolf Snake:** A slender bodied snake. Head flat and distinct from neck. Dorsal scales smooth. Dark or light glossy brown on dorsal. Whitish or yellowish bands present along the dorsal side which bifurcates laterally and joins partially with each other. A whitish or yellowish collar present on neck.

Nocturnal by its habit. We recorded one individual on a concrete wall in Srinagar, Uttarakhand. Another individual encountered at river bank of Hooghly in Kalyani, West Bengal.

Oligodon arnensis (Shaw, 1802) **Common Kukri Snake:** Body slender with slightly broader head. Dorsal scales smooth. Dorsally grayish brown with black transverse bands. Three inverted “V” shaped black markings present on head and neck.

Only one roadkill individual recorded in Tigri, Uttar Pradesh.

Dendrelaphis tristis (Daudin, 1803) **Common Bronzeback Tree Snake:** Body long and slender. Head distinct from neck; elongated. Eye large and pupil rounded. Tail very long. Dorsally bronze brown. Black postocular stripe present. A pale yellow spot present on posterior head. Black ventrolateral line present either side of the body. Ventrally creamy white or pale yellow.

Only one roadkill individual was recorded near Rudraprayag, Uttarakhand.

Psammophis condanarus (Merrem, 1820) **Condanarus Sand Snake: Description:** Body long and slender with an elongated head that slightly distinct from neck. Eye pupil rounded. Tail long. Dorsally brown. Black bordered pale yellow lateral stripe runs along the body on

each side radiating from snout. Another one light brown vertebral stripe present. Ventrolateral and ventral side pale yellow.

Only single individual was encountered in Bijnor while it was roosting on Typha grass at the Ganga river bank.

Bungarus caeruleus (Schneider, 1801) **Common Krait:** Body slender. Head not much broader than neck. Mid dorsal scales hexagonal. Body colour glossy black or dark brownish black. Paired thin white bands present along the body and tail except neck. Small white spots present on neck.

One individual recorded in agricultural field in Kulpi, West Bengal.

Naja naja (Linnaeus, 1758) **Spectacled Cobra:** Body slender. Head distinct from neck. Dorsal scales smooth. Body colour dorsally brown to black. A “spectacled” mark present on the back side of the hood; also visible from front side followed by a dark area.

We found the species in Deomali, Fattehpur which was kept by a charmer.

Naja kaouthia Lesson, 1831 **Monocled Cobra:** Body slender. Head slightly broader than neck. Dorsal scales smooth. Dorsal colour brown or blackish brown. A whitish ring shaped or eye shaped mark present on the hood. Ventrally glossy gray or creamy coloured.

One individual encountered in agricultural field in Kulpi, West Bengal.

Eutropis dissimilis (Hallowell, 1857) **Striped Grass Skink:** Body stout with keeled scales. Dorsal colour brown with three black bordered yellowish stripes. White spots present along the flank.

We encountered the species along river bank, agricultural field and human habitation. The species is very common in Bijnor to Narora.

Lygosoma punctata (Gmelin, 1799) **Dotted Garden Skink:** Body elongated with a long tail. Ear opening rounded. Dorsal scales smooth. Limbs well developed. Dorsally bronze-brown. Broad dorso-lateral cream coloured stripe present from snout to base of the tail. Tail bright pink.

The species was recorded near human habitation in Nandprayag, Uttarakhand.

Asymblepharus himalayanus (Günther, 1864) **Himalayan Ground Skink:** Body elongated. Head indistinct from neck. Dorsal scales smooth. Limbs well developed. Dorsally bronze-brown. A broad black stripe present laterally on head and flank.

The species was recorded on forest floor and near human habitation in Mandal, Uttarakhand.

Calotes versicolor (Daudin, 1802) **Garden Lizard:** Body stout and laterally compressed. Head large. Tail long. Body scales pointed, directing backward and upward. A series of spines present on back starting from posterior head. Body colour brown, grayish brown, yellowish brown with variable markings. Neck becomes red with black throat in breeding male.

The species was commonly encountered in the bushes along river bank and settlement area. The species was recorded almost in all the study sites.

Laudakia tuberculata (Gray, 1827) **Kashmir Rock Agama:** A large bodied lizard with a long tail. Body flattened. Head distinct from neck. Scales strongly keeled. Grayish brown dorsally. Head paler than dorsum. In breeding season the body of male becomes bluish and blue marking appears on throat. Black and yellow spots present on dorsum in juveniles.

We encountered the species frequently near human habitation and on the rocky habitats along the Alaknada river and Mandal.

Sitana sp. **Fan Throated Lizard:** Body slender with a long tail. Hind limb has four toes. Dorsal scales keeled. Body brown. A series of rhomboidal shaped markings on dorsum. Dark cross bars present on forehead and limbs. Male has a pale yellowish gular pouch with a central blue line.

Only one individual of the species was recorded from bushes at the bank of Ganga river in Balia, Uttar Pradesh.

Hemidactylus kushmorensis Murray, 1884 **Kushmore House Gecko:** Body slender. Head distinct from neck. Eye pupil vertical. Large tubercles present on dorsum. Lateral side of the tail spinose. Dorsal gray with irregular brown spots. Ventrally creamy coloured.

Very commonly encountered species in the bushes and rocky embankments along Ganga river.

Hemidactylus flaviviridis Ruppell, 1835 **Indian House Gecko**: Body stout and flat. Eye pupil vertical. Tail broad and flat at the base. Dorsal body gray to yellowish. Sometimes, dark transverse bands may be present on dorsum.

Encountered near human habitations. The species is abundant on rocky habitats along Ganga river in Nayar confluence.

Hemidactylus cf. frenatus Duméril and Bibron, 1836 **Asian House Gecko**: Body flat and slender. Head distinct from neck. Eye pupil vertical. Lateral side of the tail spiny. Grayish brown with dark brown streaks on dorsal and lateral side of the body; also on side of the head. Limbs and tail with dark brown reticulation.

Only one individual of the species was sighted on a *ziziphus* sp. at the bank of Hooghly river in Kalyani, West Bengal.

Cyrtodactylus fasciolatus (Blyth, 1861) **Banded Bent-toed Gecko**: Body slender. Head long and eye pupil vertical. Tail longer than the body. Digits elongate and bent. Dorsally grayish brown with dark brown bands on neck, body and tail. Head slightly yellowish with small brown blotches.

The species was commonly encountered in Srinagar and Nayar confluence on the rocky habitats along river bank.

Varanus bengalensis (Daudin, 1802) **Indian Monitor**: Large bodied lizard. Head triangular with elongated snout. Tail laterally compressed. Body colour grayish brown. Juvenile olive brown with transverse bands of yellow spots.

The species was recorded near human habitation and along river bank where Bank Myna nested.

Reproductive Biology of *Polypedates taeniatus*

We studied breeding and nesting behaviour of endemic terai tree frog, *Polypedates taeniatus* in Bijnor, Uttar Pradesh during July-August 2018 and August 2019.

The individuals of *P. taeniatus* starts emerging with the onset of raining in the month of July. Breeding activities continues till the end of August. Male starts calling after 18:30 h from ground to a perch height of 150 cm ($x = 30.64 \pm 41.61$ cm, $n = 145$) on grass blades (**Figure**

20). Females were observed between 19:22 h and 20:45 h perching at a height of 81 ± 35.07 cm ($n = 5$). Amplexus and nesting behaviour ensues in the following steps:

1. Female slowly moves on grass blades towards calling male.
2. The female carefully descends to the ground slowly comes close to the calling male.
3. When the female approaches very close, the male quickly mount on the female and exhibits axillary amplexus.
4. Amplexus forms on ground ($n = 2$) or above ground upto a height of 70 cm ($x = 48.33 \pm 18.93$ cm, $n = 3$).
6. The amplexant pair starts foam nesting on ground where the male was calling. If amplexus form in grass blade then the amplexant pair descends to the ground prior to find a suitable place to construct foam nest. The distance traveled by amplexant pair to a suitable place for egg laying was 13-305 cm ($n = 2$).
7. After 28-125 min ($n = 2$) of amplexus, the pair start constructing foam nest. Foam nest constructs on ground at the base of Typha or under grass (**Figure 20**).
8. The amplexant pair stands on the hind limbs grasping the surrounding grasses for egg laying.
9. Female initiate foam nest construction by rubbing her hind limbs below vent. Male also show the same movement of hind limbs and pelvic thrusts during spawning. This process continue until finished the construction of foam nest. Time taken to complete the foam nest was 29-57 min ($n = 2$).
10. After spawning, the amplexant male moves out slowly from the amplexus and leave the place.
11. The female leave the nest just after few seconds of the male left.

Nest and egg clutch

The amplexus pair forms cream coloured rounded foam nest on ground or water puddles among grasses (**Figure 20**). Size of the foam nest found as $L = 56.68 \pm 11.84$ mm, $W = 51.07 \pm 6.57$ mm, $H = 37.99 \pm 6.53$ mm ($n = 10$). Eggs numbered 220 and 308 in the two collected

clutches. Eggs are round, unpigmented and cream coloured. Diameter of the egg was found 1.35 ± 0.06 mm (n = 27).

Description of Tadpole

The hatchlings of *P. taeniatus* develops in temporary water pools created by rain or overflow from the river. Tadpoles are elliptical and elongated in shape. Tail long muscular, laterally compressed with a pointed tip (**Figure 20**). Eyes lateral. Nostril lateral, small; closer to the snout. Pineal ocellus not distinct. Single rectangular shaped spiracle ventro-laterally placed on left side.

Egg mass predation

We found cream coloured larvae inside foam nests (n= 3) of *P. taeniatus* (Table 1), which predated the entire egg mass of the nest. The larvae were identified as dipteran larvae belonging to family Sarcophagidae (**Figure 20**). The length of the larvae was 4.63 - 10.04 mm ($\bar{x} = 6.19 \pm 2.57$ mm, n = 4).

Discussion

The present survey yielded 37 species herpetofauna from the study area including 16 species of anurans, 13 species of serpents and 9 species of lacertids (**Table 1**). In the present study, species richness was found to be high in Bijnor of the middle stretch of Ganga River (**Table 2**). As the region represent transitional zone between Himalayan hills and Gangetic plain and the movement of the animals from the nearby protected forest such as Hastinapur wildlife Sanctuary may increase the species richness in the area. In our study, three species (*D. melanosticus*, *Fejervarya* sp. and *E. cyanophlyctis*) were in the most abundant range with 128-255 individuals recorded (**Figure: 5**). Similarly species like *P. molurus*, *D. tristis*, *L. aulicus*, *N. kaouthia*, *B. caeruleus* represented by single individuals. Four species, i.e., *H. tyleri*, *E. dissimilis*, *C. versicolor*, *E. sieboldii* were found to be moderately abundant within the frequency range of 4-7 individuals, as shown by the peak of the curve (**Figure: 5**). Coefficient biogeographic resemblance among three zones (i.e. Alaknanda, middle Ganga and lower Ganga) varies between 0.35-0.44 (**Figure 6**). The species resemblance between middle and lower Ganga is higher (0.44) because, there is no geographical barrier to limit the movement of the species between the two zones. On the other hand the number of unique species in Alaknanda zone is higher (**Figure 7**) because the species occurring in the zone are confined to the high elevation of Himalaya unlike the widely distributed species of the Gangetic plain. Three species anurans, *D. melanosticus*, *Fejervarya* sp. and *E. cyanophlyctis* were frequently encountered and distributed almost in all study sites (**Table 2** and **3**). We recorded few species viz. *P. taeniatus*, *H. tyleri*, *E. sieboldii*, *C. fasciolatus*, which were found to be locally common. *Polypedates taeniatus* and *E. sieboldii* were found to be very common in Bijnor, Uttar Pradesh. *Hylarana tyleri* was recorded only from Nabadwip in West Bengal. Similarly, *C. fasciolatus* is restricted to the high elevational zone of the upper stretch of Ganga River (Nayar confluence) and Alaknanda River (Srinagar). Study also recorded rare species of snake such as *X. cerasogaster* and *P. condanarus* from Bijnor. We reported *M. nilphamariensis* from the region for the first time. Earlier population of *M. nilphamariensis* of this region was considered as *M. ornata*. Recently, Garg et al. (2018) assigned the population of the region to *M. nilphamariensis*. Besides, we recorded few species (*Fejervarya* sp., *Sitana* sp. *Hemidactylus* cf. *frenatus*, *H.* cf. *kushmorensis*) which are either conferred to closely related species or identity is unknown. Most of the species complexes are widespread, though the member of these species complexes can have limited

ranges within this broad range Bain et al. (2003). Members of the species complexes recorded in our study are *C. versicolor* (Zug et al. 2006), *L. aulicus*, *X. piscator* (Vogel & David 2006).

During the study period we documented the reproductive behaviour of *Polypedates taeniatus* for the first time. The species is locally abundant in Bijnor, Uttar Pradesh; mostly restricted to the fragmented grasslands like *Typha angustifolia*, *Saccharum spontaneum*. *Polypedates taeniatus* breeds for a short period between middle of July and end of August. Duration of amplexus (85-154 min), foam nesting (29-57 min) and clutch size (220-308). The reproductive mode of *P. taeniatus* belongs to the type 28 (i.e. foam nest in ground and after flooding exotrophic tadpoles develop in standing water body) as delineated by Haddad and Prado (2005). We also reported egg mass predation by Sarcophagid larvae which is hitherto unknown from India. Our observation on predation upon egg mass reflects the vulnerability of the species in embryonic stage and effects on population dynamics by predation.

Ganges Basin known for some name bearing taxa, type localities of which within the biogeographical limit of the river basin, i.e., *Minervarya chilapata*, *Chiromantis dudhwaensis*, *Polypedates taeniatus*, *Enhydris sieboldii* and *Xenochrophis cerasogaster*. The region desires a systematic study on herpetofauna as it is evident from the recent discoveries amphibian species by Ohler et al. (2009). Systematic study and intensive sampling throughout the region in combination with integrated taxonomy would be beneficial to understand the taxonomic identity of the species and their geographical distribution and conservation requirements. Number of species recorded in this study was low in comparison to other studies in India. Most of them are common and widely distributed in India, South Asia and Southeast Asia. However, few species viz. *Duttaphrynus himalayanus*, *Nanorana minica*, *Amolops jaunsari*, *Amolops formusus*, *Laudakia tuberculata*, were recorded from Alaknanda Basin and restricted to high elevational region. The number herpetofaunal species of region will increase with further extensive sampling. However, the present result was based on of single visit and time constrained survey. Considering the paucity of knowledge on diversity, distribution of the herpetofauna in the region, the present study assumes significance. The present study provides basis for future study on many aspects such as ecotoxicology taking herpetofauna as model organism.

The species recorded during the study period are composed of Indo-Malayan genera (*Amphiesma*, *Enhydris*, *Naja*, *Python*, *Varanus* and *Xenochrophis*), followed by of Indian genera (*Bungarus*, *Hemidactylus*) and transitional elements such as *Lycodon* (sensu Das

1996). Among the recorded species, *P. molurus* and *V. bengalensis* accorded the highest legal protection status, under Schedule I of WL(P)A, 1972. Four species, *N. naja*, *N. kaouthia*, *X. piscator*, *P. mucosa* are under Schedule II of the Act. Rest of the snake species and two anurans (*H. tigerinus* and *E. cyanophlyctis*) are listed under Schedule IV of the Act (**Table 1**). Among the amphibian species *N. minica* is considered as vulnerable under the IUCN Red List. Rest of all recorded anuran species (except *M. nilphamariensis*), two species of snakes (*P. condanarus* and *N. kaouthia*) and two species lizards (*H. cf. frenatus* and *V. bengalensis*) are categorized as Least Concern (LC).

Future Direction

- 1.** To understand the movement ecology of stream frogs (e.g. *Nanorana vicina* and *Amolops formosus*) species in response to habitat dynamics in Upper Ganges.
- 2.** To Estimate the population of the endemic Terai Tree Frog (*Polypedates taeniatus*) and restoration of its habitats (Typha grasslands) in Middle Ganges.
- 3.** To understand the resource partitioning among the sympatric species in lentic habitats along Lower Ganges.
- 4.** To create buffer zone around the wetlands for the conservation of amphibian species.

	<i>Fejervarya</i> sp.	Cricket Frog	+	+	+	+	+	-	+	+	+	+	+	+	+	-	+	-	-	+	+	+	+	+	+	-	+	+	+	+	+	-	-
	<i>Sphaerotheca breviceps</i>	Indian Burrowing Frog	+	+	+	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Nanorana minica</i>	Nepal Paa Frog	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ranidae	<i>Hylarana tytleri</i>	Leaf Frog	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
	<i>Amolops formosus</i>	Assam Cascade Frog	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Amolops jaunsari</i>	Jaunsar Stream Frog	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Microhylidae	<i>Microhyla nilphamariensis</i>	Narrow-mouthed Frog	-	+	-	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	+
	<i>Uperodon taprobanicus</i>	Sri Lankan Painted Frog	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
	<i>Uperodon globulosus</i>	Indian Balloon Frog	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhacophoridae	<i>Polypedates taeniatus</i>	Terai Tree Frog	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Polypedates maculatus</i>	Common Indian Tree Frog	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 2: Species richness and diversity in different study sites.

	Guala (Nandprayag)	Mandal	Padli (Karnprayag)	Srinagar	Shivpuri	Nayar Confluence	Bijnor	Tigri Ghat	Narora	Kachla	Shamsabad	Kannauj	Kanpur	Allahabad	Bhadoi	Mirzapur	Varanasi	Gangabarar	Ballia	Chhapra	Semaria	Munger	Sahibganj	Farakka	Jiaganj	Katwa	Nabadwip	Kalyani	Haldia
Species Richness	7	10	4	8	7	7	12	11	9	5	5	5	6	2	4	2	1	1	1	5	4	3	3	7	5	5	5	6	7
Species Diversity	0.69	1.27	1.1	1.47	1.01	1.37	2.34	2.17	1.89	1.45	1.42	1.07	0.75	0.56	1.21	0.38	≈ 0	≈ 0	≈ 0	1.36	1.25	0.56	0.61	1.24	1.26	1.31	1.26	1.49	1.6

Table 3: Relative abundance and encounter rate of herpetofaunal species recorded in Visual Encounter Survey.

	Name of the Species																							
	<i>Duttaphrynus himalayanus</i>	<i>Duttaphrynus melanostictus</i>	<i>Duttaphrynus stomaticus</i>	<i>Euphyctis cyanophlyctis</i>	<i>Hoplobatrachus tigerinus</i>	<i>Fejervarya sp.</i>	<i>Sphaerotheca breviceps</i>	<i>Nanorana minica</i>	<i>Amolops formosus</i>	<i>Amolops jaunsari</i>	<i>Hylarana tyleri</i>	<i>Microhyla nilphamariensis</i>	<i>Polypedates taeniatus</i>	<i>Python molurus</i>	<i>Enhydris sieboldii</i>	<i>Xenochrophis piscator</i>	<i>Lycodon aulicus</i>	<i>Naja kaouthia</i>	<i>Bungarus caeruleus</i>	<i>Eutropis dissimilis</i>	<i>Calotes versicolor</i>	<i>Hemidactylus cf. kashmorensis</i>	<i>Hemidactylus flaviviridis</i>	<i>Cyrtodactylus fasciolatus</i>
Relative Abundance	0.01	0.17	0.07	0.32	0.07	0.17	0.02	0.01	0.01	0.01	0.01	0.06	0.02	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01
Encounter Rate	0.24	5.31	2.21	9.79	2.07	5.34	0.52	0.21	0.07	0.1	0.17	1.28	0.52	0.03	0.24	0.97	0.07	0.03	0.03	0.14	0.55	0.55	0.66	0.31

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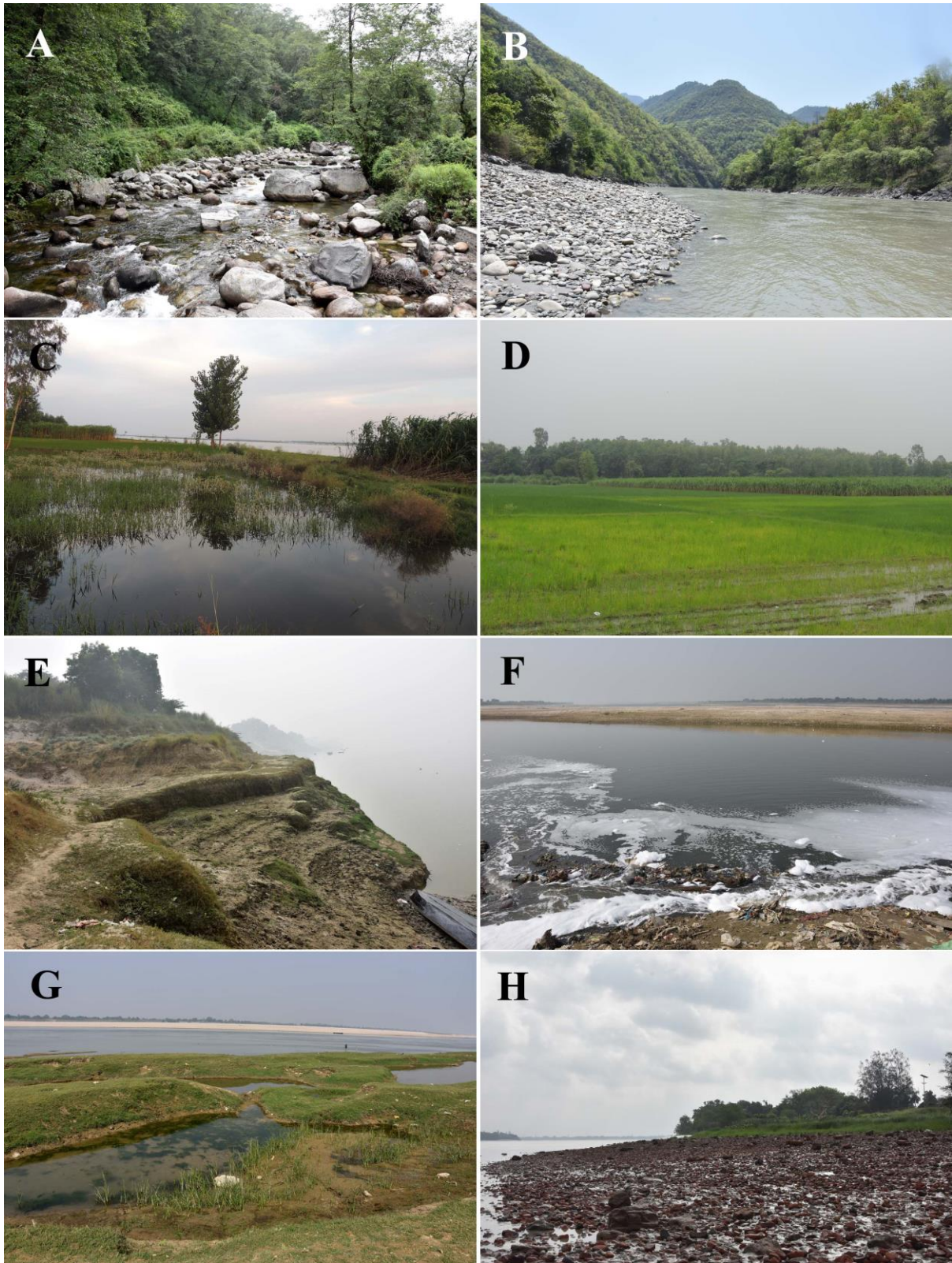


Figure 2: Habitat of different study sites. **A.** Balkhila river in Mandal; **B.** Ganga river at Nayar confluence; **C.** Temporary water pool with agricultural field at Brijghat; **D.** Agricultural land at Narora; **E.** River bank at Handia; **F.** Sewage release into the Ganga river at Mogalsarai (Vanaras); **G.** Temporary water pool along river bank in Mogalsarai (Vanaras); **H.** Human altered river bank along Hooghly river.



Figure 3: Field activities during the study period.

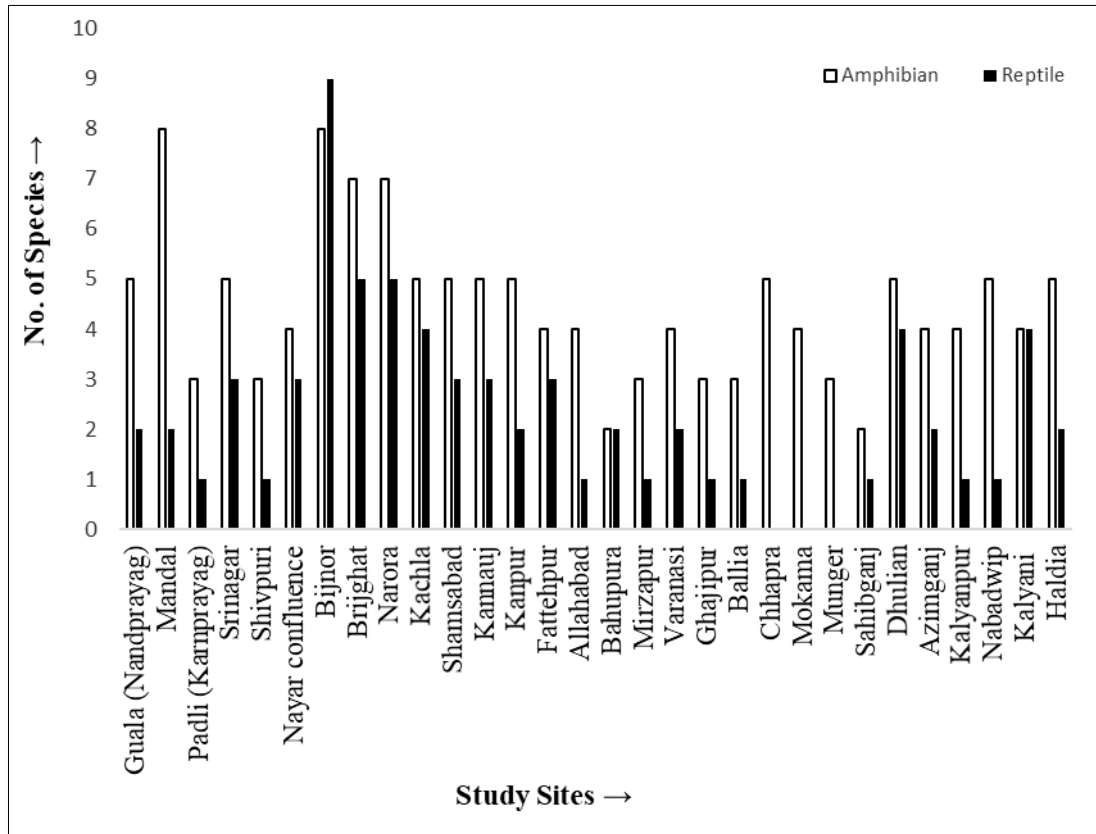


Figure 4: Diagrammatic representation of herpetofaunal species composition in different study sites.

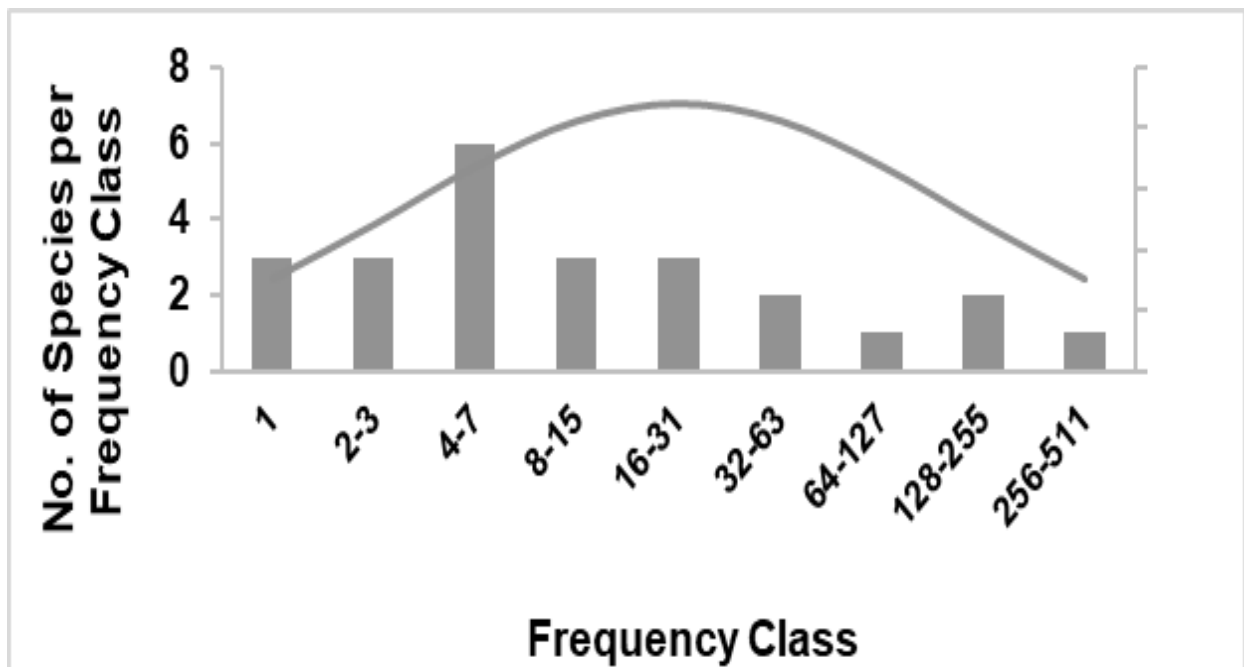


Figure 5: Log normal distribution plot of herpetofaunal species recorded during study period.

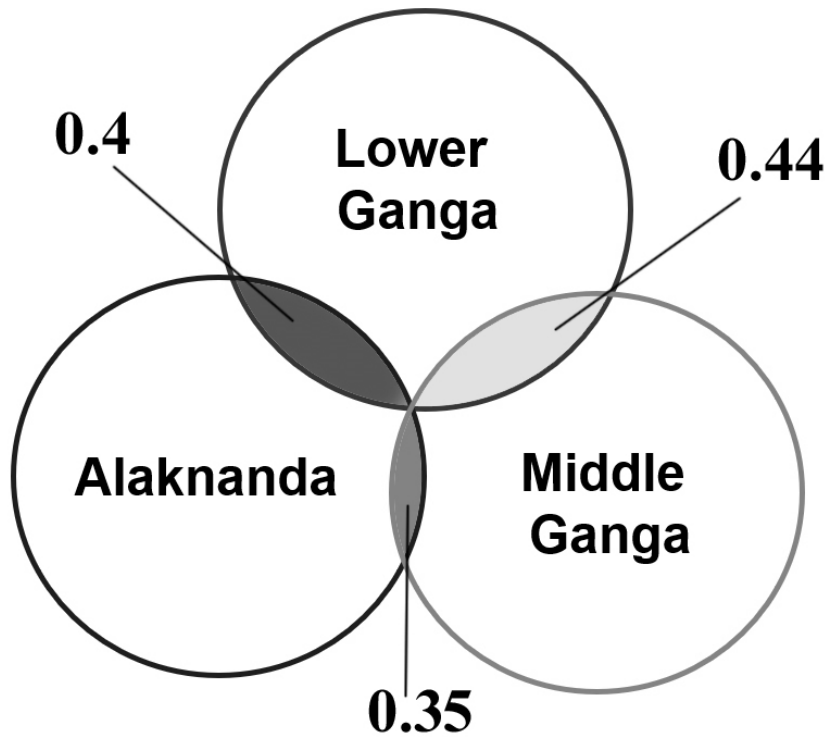


Figure 6: Coefficient of biogeographic resemblance among the three zones i.e., Alaknanda, Middle Ganga and Lower Ganga.

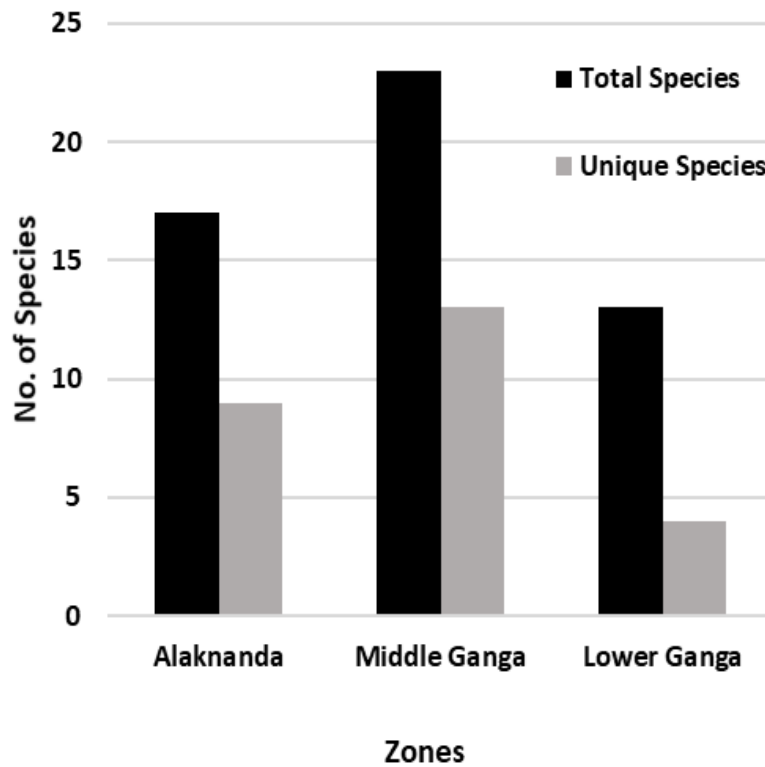


Figure 7: Species richness and along with the number of unique species of the three zones.

Plate 1: Amphibian species recorded along Ganga and Alaknanda river.



Figure 4: Amplectant pair of *D. melanostictus*



Figure 5: *D. melanostictus* (a calling male)



Figure 6: Amplectant pair of *D. stomaticus*



Figure 6: *Duttaphrynus stomaticus*



Figure 7: Amplexus pair of *D. himalayanus*



Figure 7: *D. himalayanus* (male)



Figure 7: *Hylarana tyleri*



Figure 7: *Hylarana tyleri*

Plate 2: Amphibian species recorded along Ganga and Alaknanda river.



Figure 7: *Amolops jaunsari*



Figure 7: *Amolops jaunsari* (Female)



Figure 7: *Amolops formosus*



Figure 7: *Nanorana minica*



Figure: Froglet of *Nanorana* sp.



Figure 11: *Hoplobatrachus tigerinus*



Figure 8: Amplectant pair of *E. cyanophlyctis*



Figure 9: *Euphlyctis cyanophlyctis*

Plate 3: Amphibian species recorded along Ganga and Alaknanda river.



Fejervarya sp.



Amplexing pair of *U. globulosus*



Microhyla nilphariensis



Frogllets of *M. nilphamariensis*



Polypedates taeniatus



Sphaerotheca breviceps

Plate 4: Lizard species recorded along Ganga and Alaknanda river.



Eutropis dissimilis



Asymblepharus himalayanus



Cyrtodactylus fasciolatus



Hemidactylus flaviviridis



Hemidactylus cf. kushmorensis



Hemidactylus cf. frenatus



Calotes versicolor



Sitana sp.

Plate 5: Snake species recorded along Ganga and Alaknanda river.



Enhydris sieboldii



A juvenile of *Enhydris sieboldii*



Figure 24: *Xenochrophis piscator*



X. piscator feeding on *D. melanostictus*



Figure: *Dendrelaphis tristis*



Figure: *Oligodon arnensis*



Figure 32: *Psammophis condanarus*



Figure 33: *Amphiesma stolatum*

Plate 6: Snake species recorded along Ganga and Alaknanda river.



Figure 26: *Lycodon aulicus*



Figure 27: *Bungarus caeruleus*



Figure 28: *Naja naja*



Figure 29: *Naja kaouthia*



Figure 30: *Eryx johnii*



Figure 31: *Python molurus*

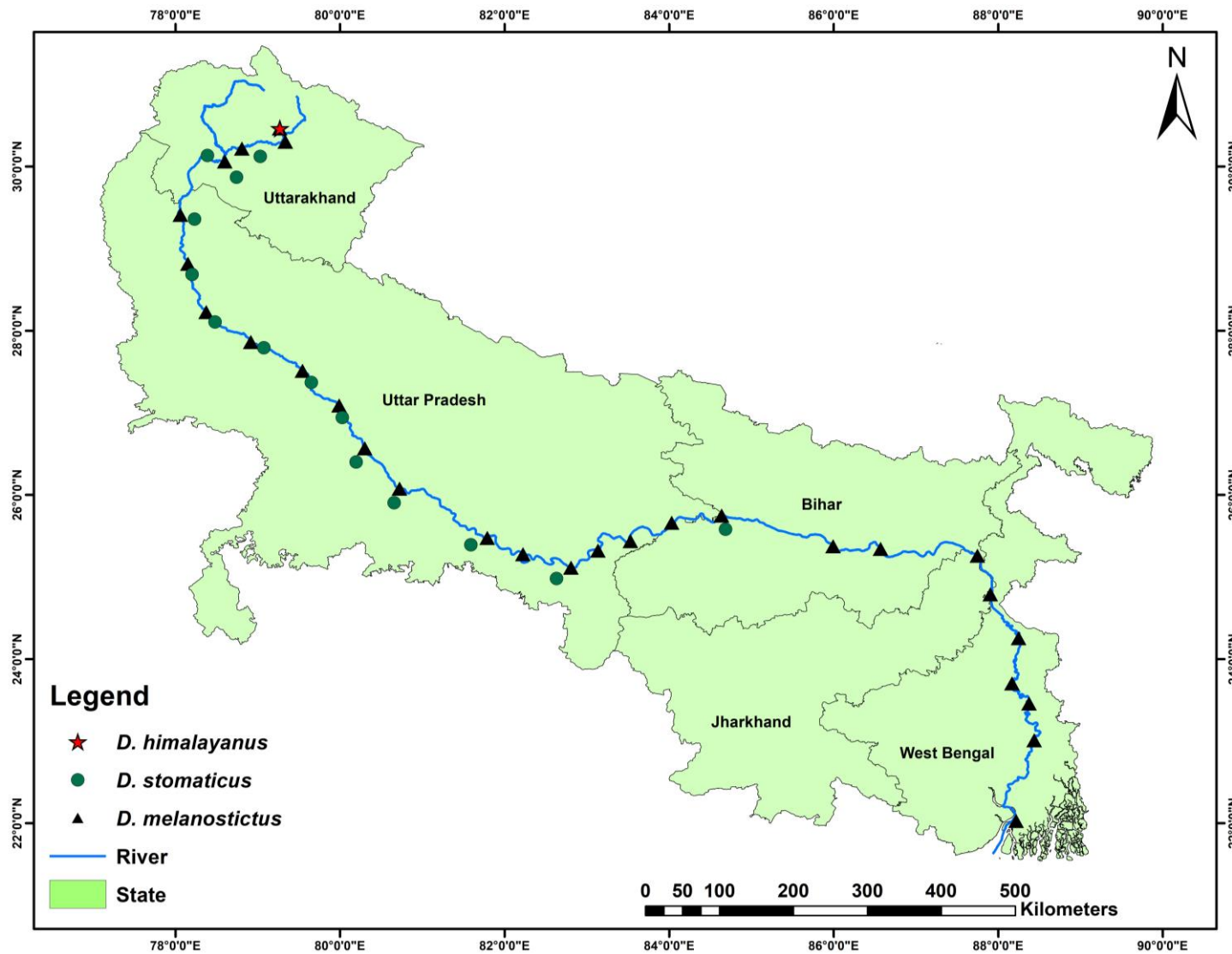


Figure 8: Species distribution of the family Bufonidae across the study sites.

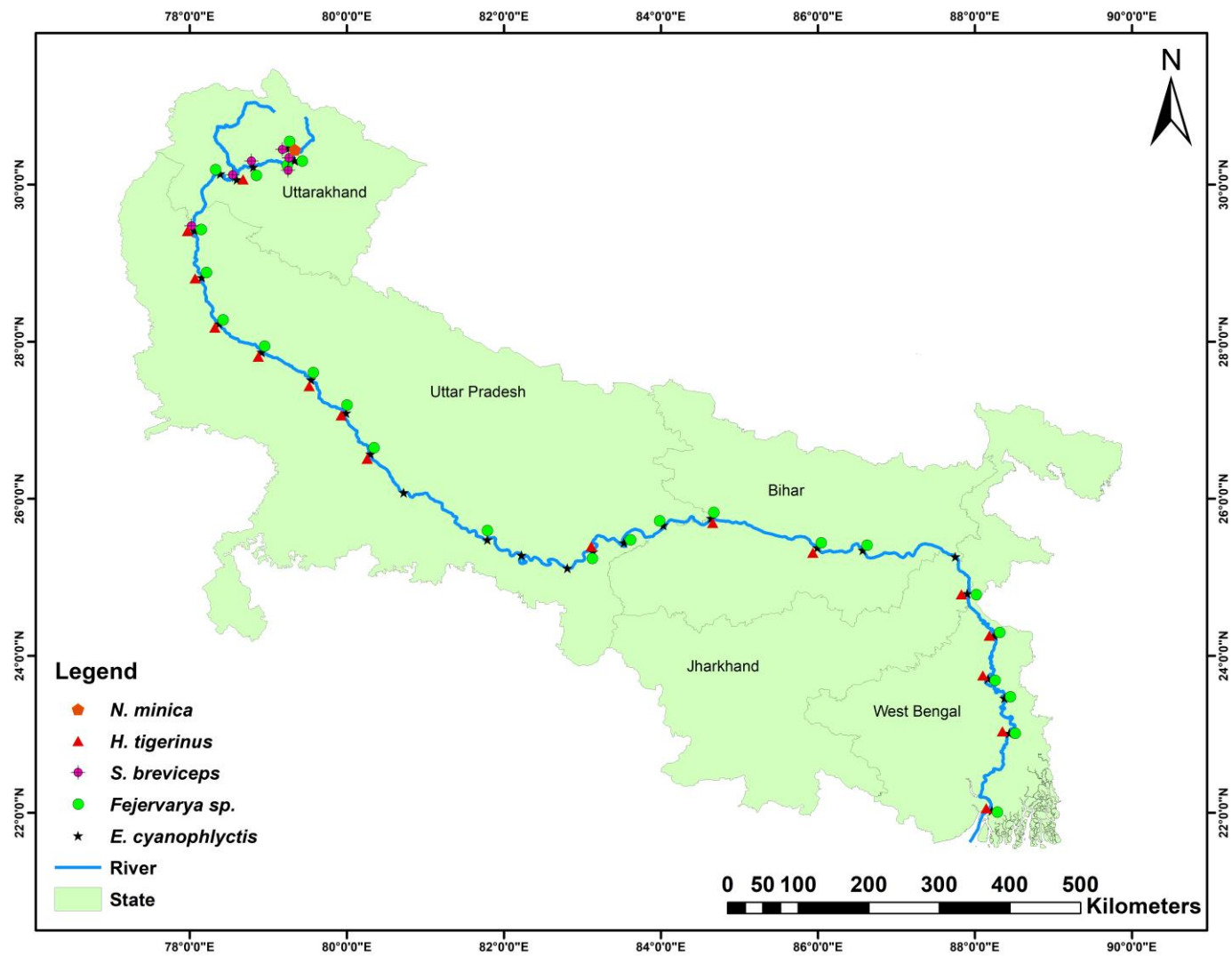


Figure 9: Species distribution of the family Dicoglossidae across the study sites.

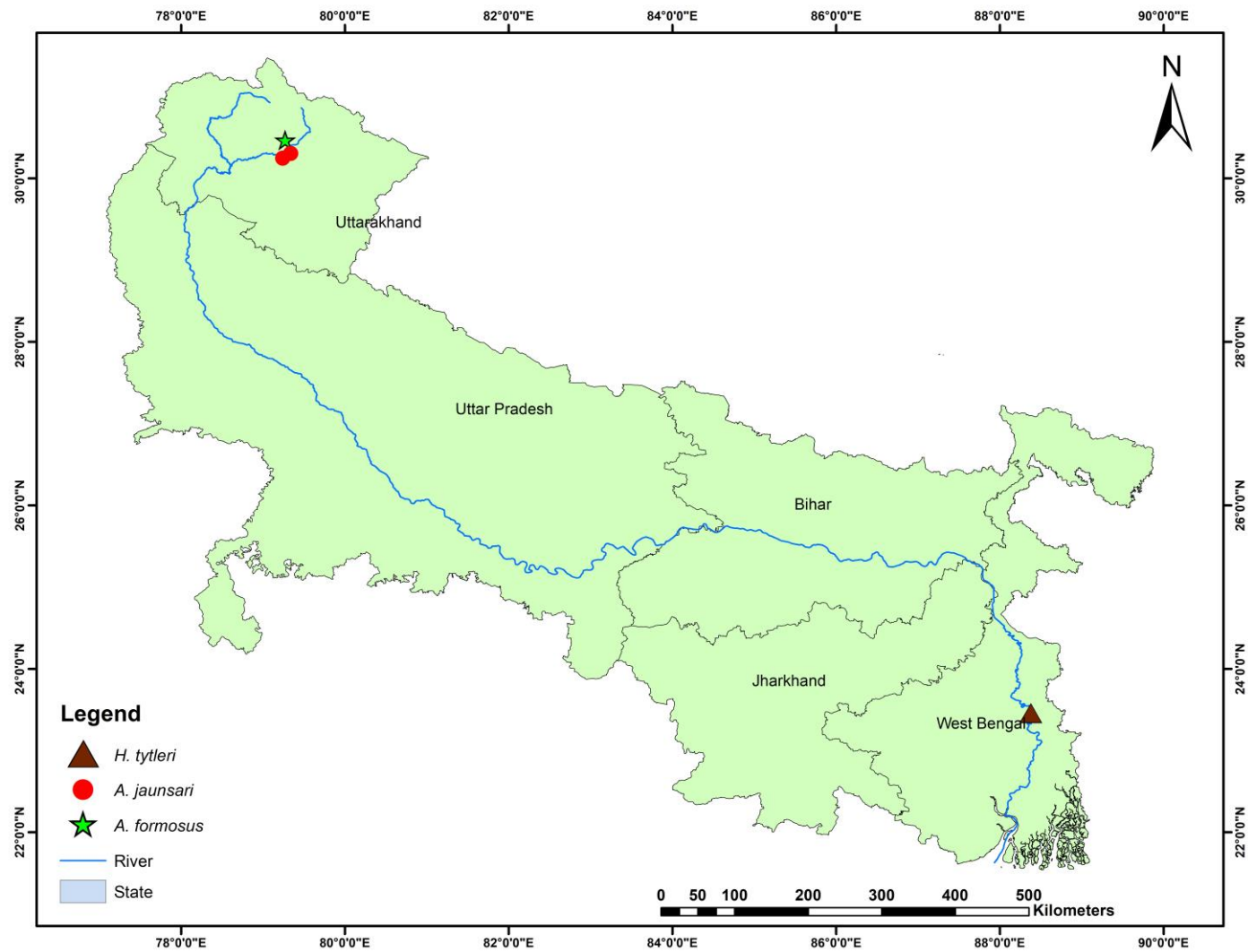


Figure 10: Species distribution of the family Ranidae across the study sites.

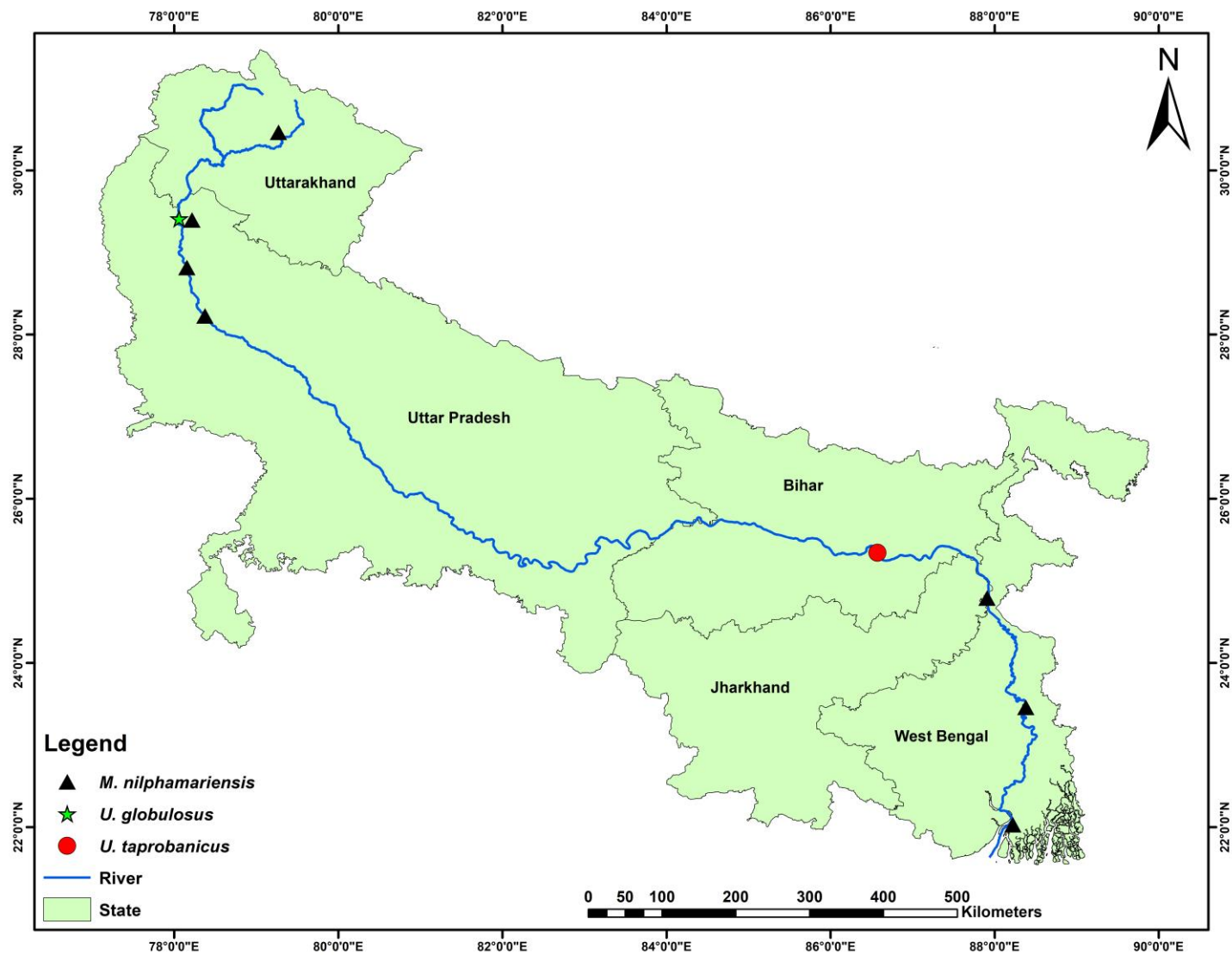


Figure 11: Species distribution of the family Microhylidae across the study sites.

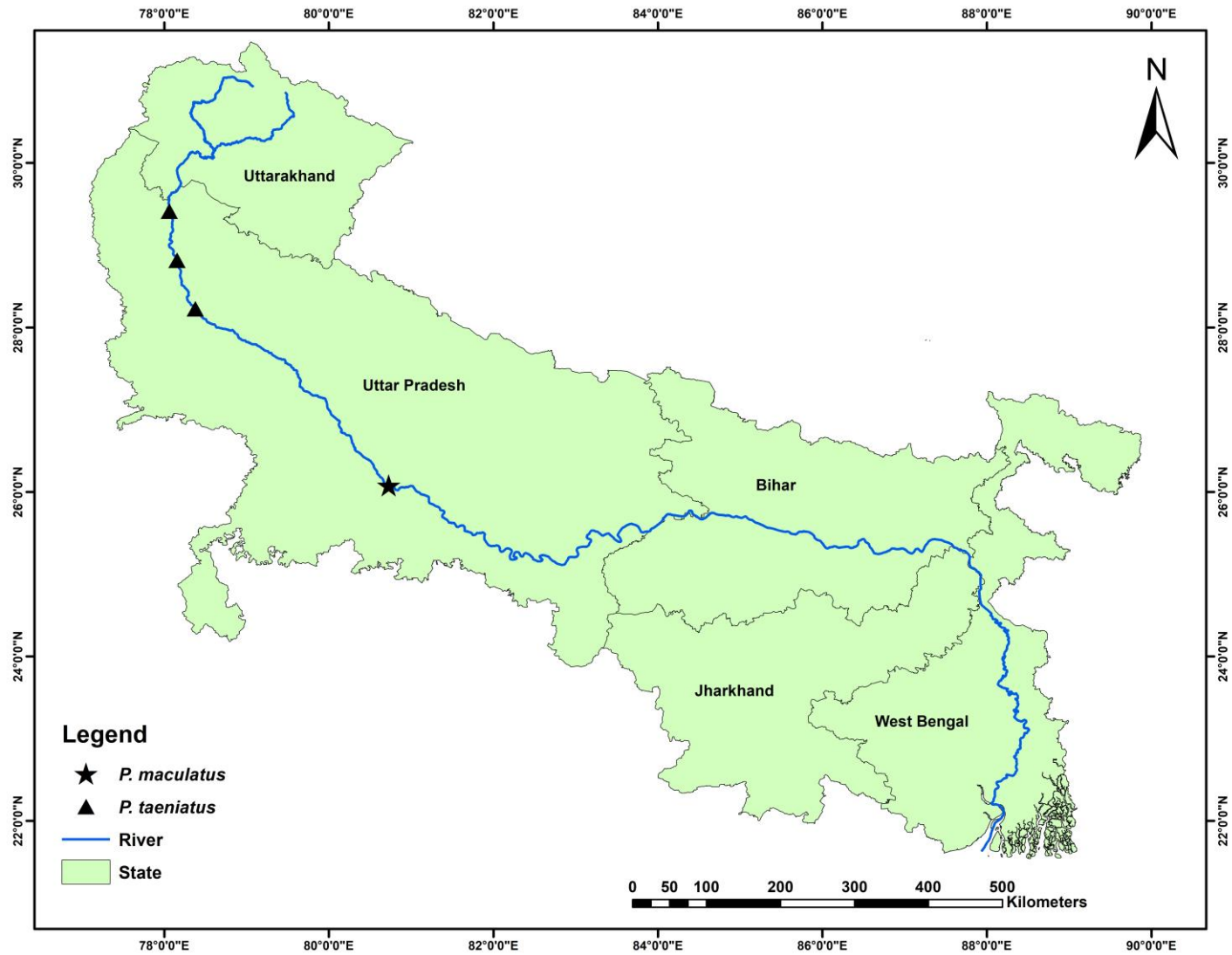


Figure 12: Species distribution of the family Rhacophoridae across the study sites.

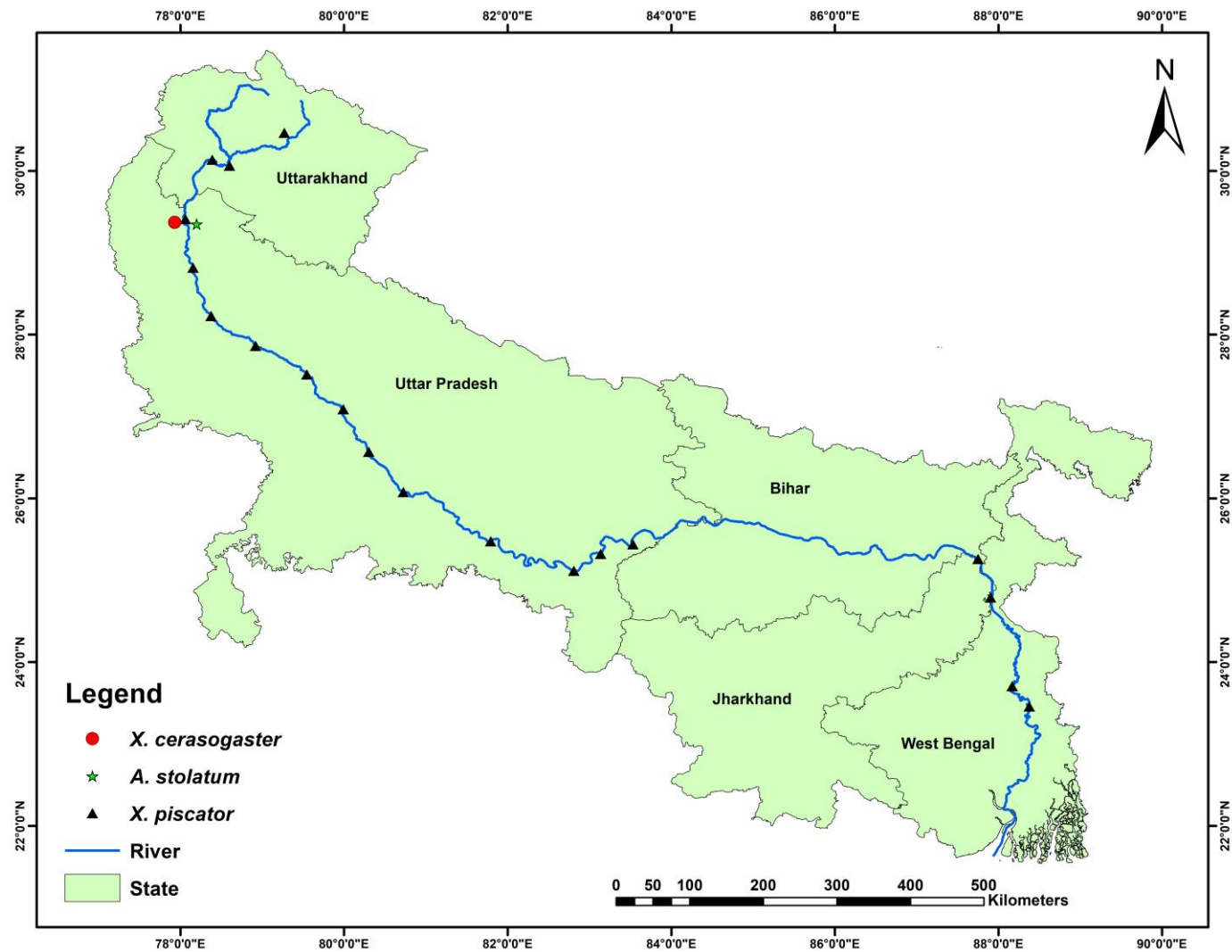


Figure 13: Species distribution of the family Natricidae across the study sites.

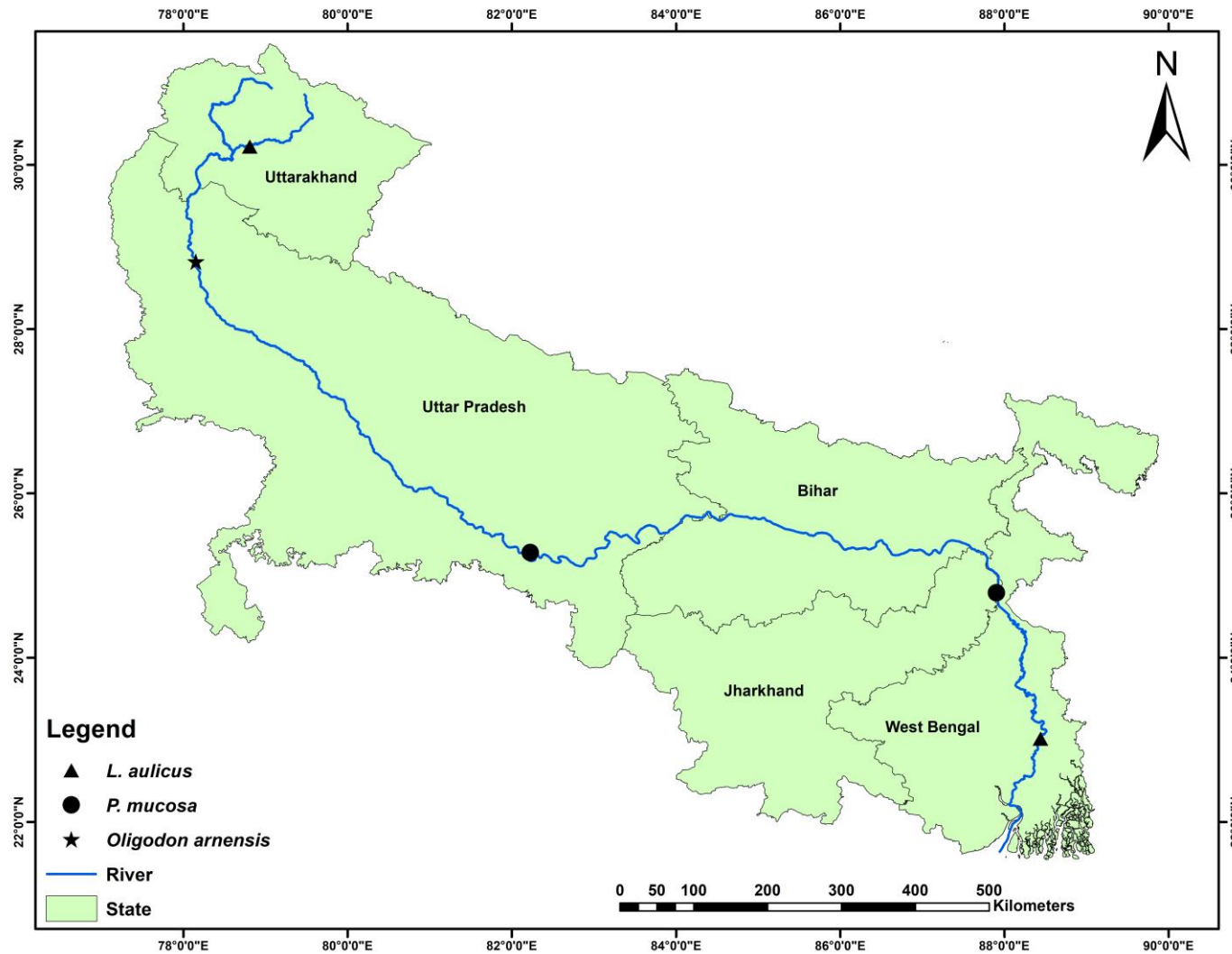


Figure 14: Species distribution of the family Colubridae across the study sites.

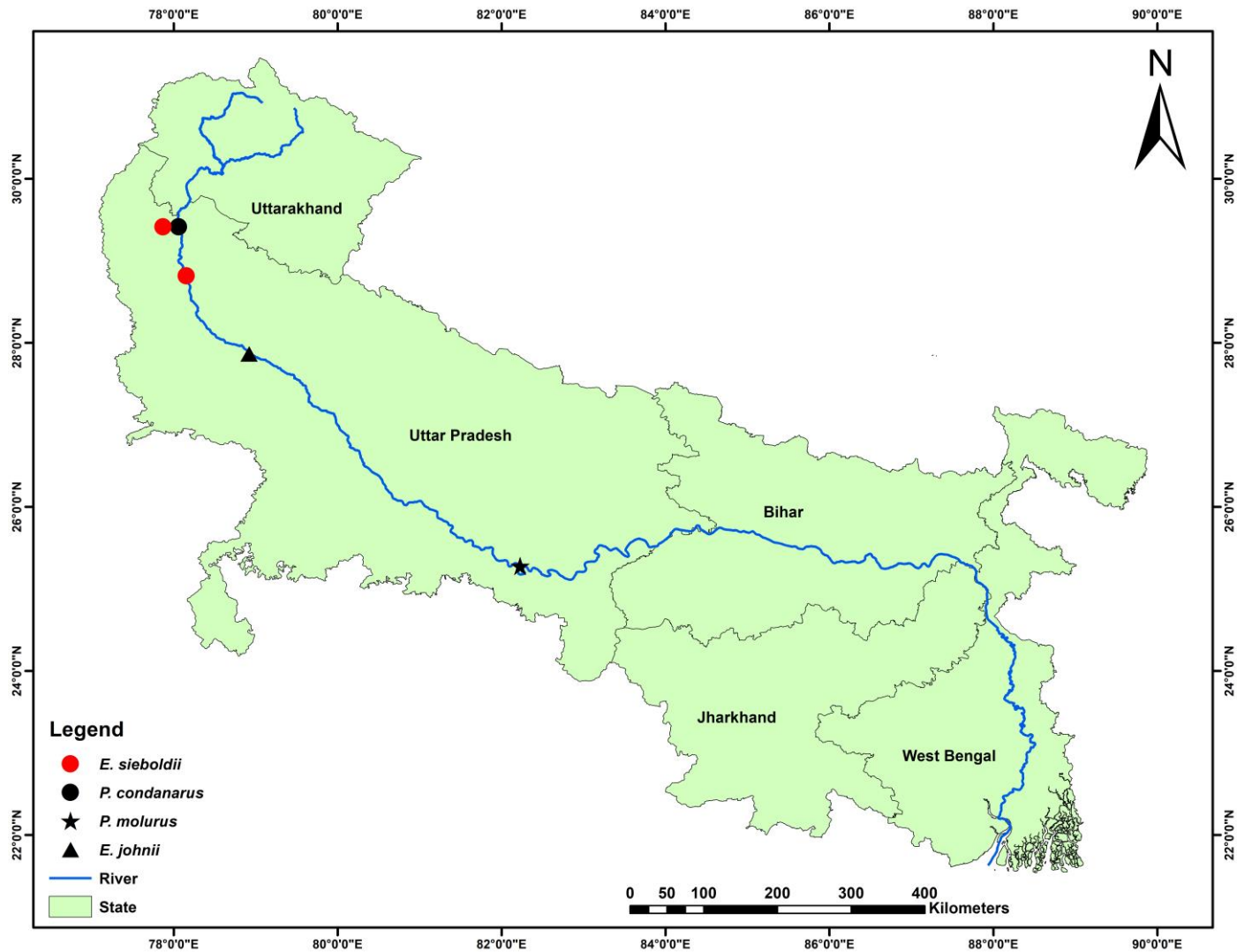


Figure 15: Species distribution of the family Homalopsidae, Lamprophidae, Pythonidae and Boidae across the study sites.

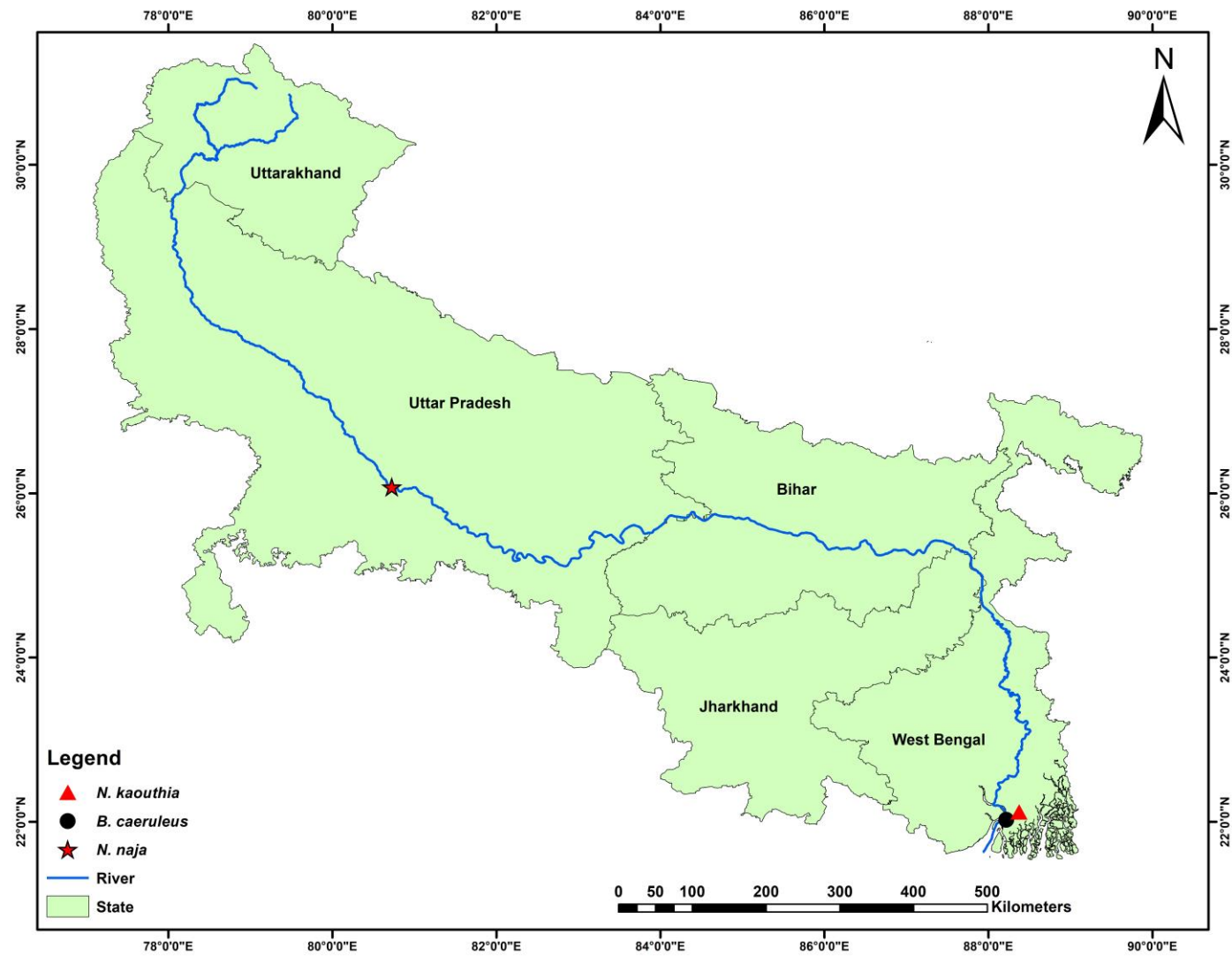


Figure 16: Species distribution of the family Elapidae across the study sites.

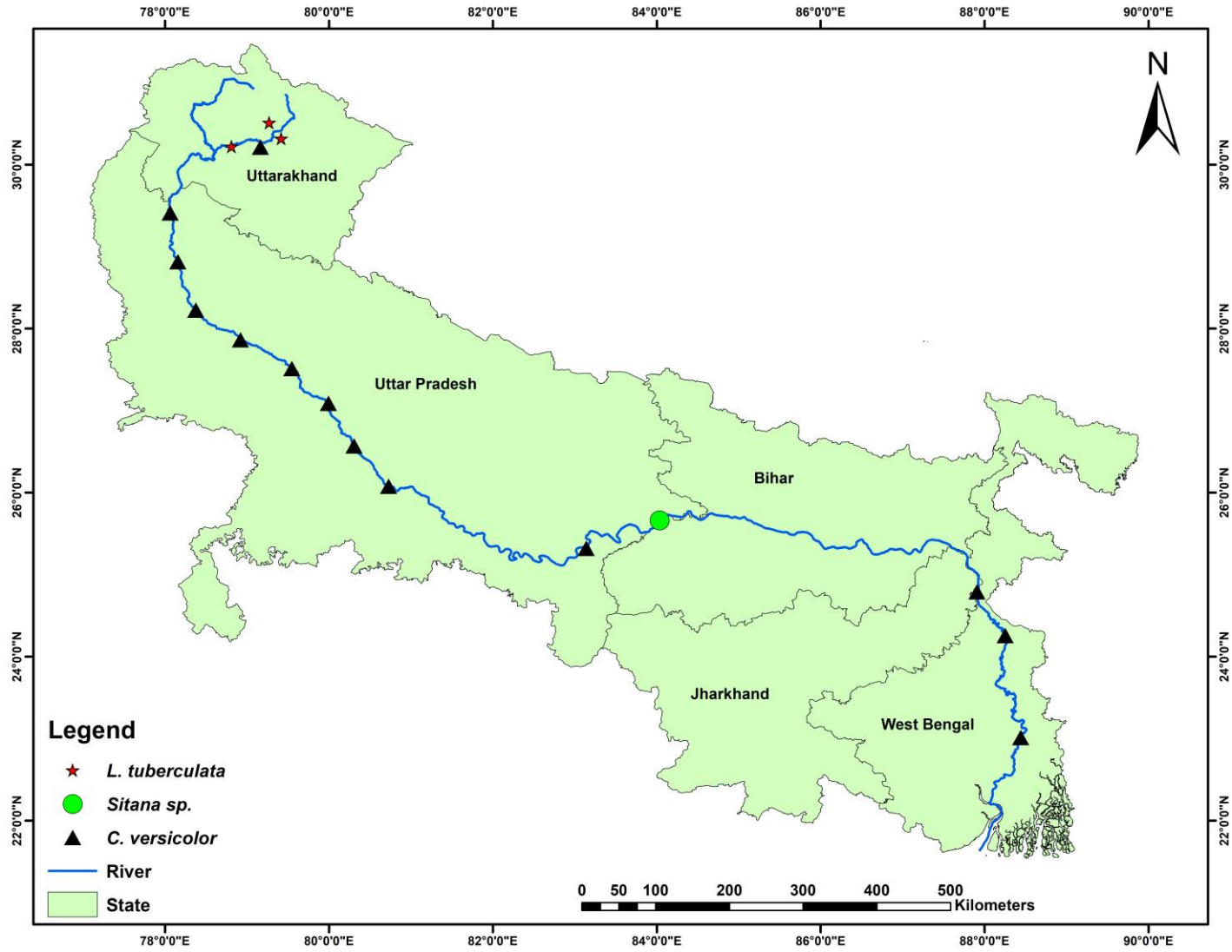


Figure 17: Species distribution of the family Agamidae across the study sites.

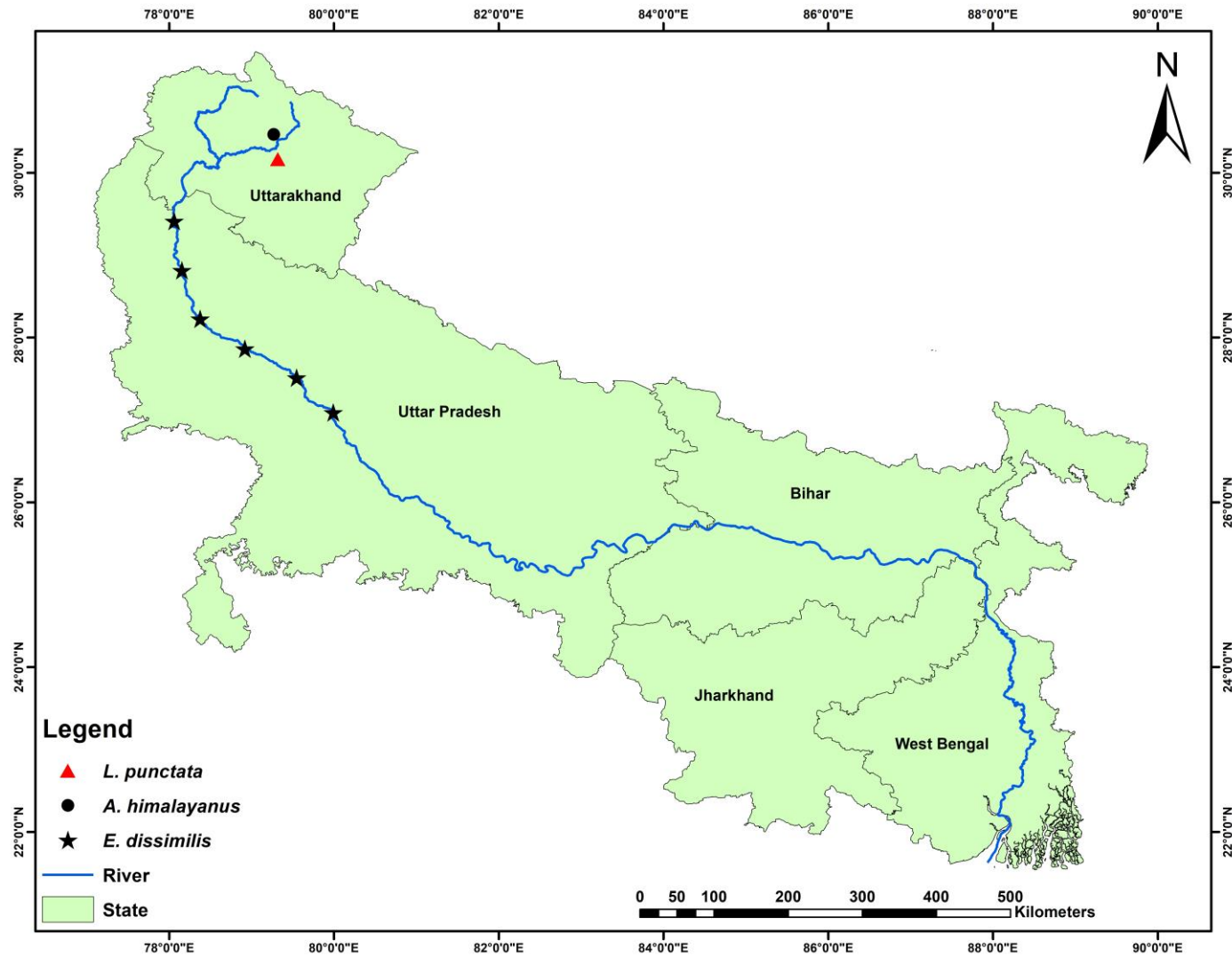


Figure 18: Species distribution of the family Scincidae across the study sites.

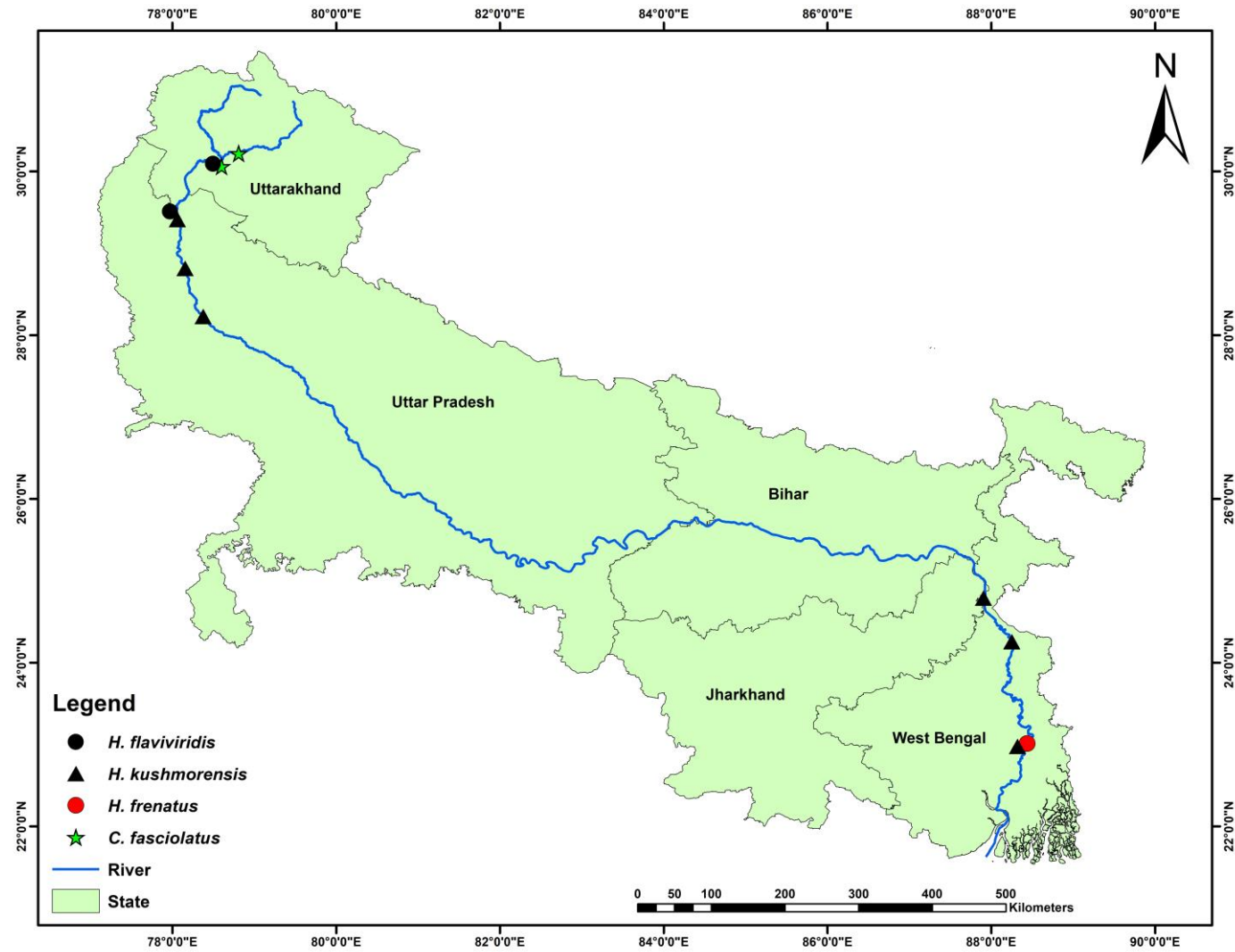


Figure 19: Species distribution of the family Gekkonidae across the study sites.



Figure 20: Breeding behaviour of *Polypedates taeniatus*. **A.** an amplexus pair; **B.** an amplexant pair building foam nest on ground; **C.** a completed nest; **D.** tadpole of *P. taeniatus*; **E.** habitat of *P. taeniatus*; **F.** a Sarcophagid larvae found in foam nest.

Appendix 1: Geo-coordinates of study sites.

Name of the Sites	State	Latitude	Longitude
Guala (Nandprayag)	Uttarakhand	30.30375	79.33692
Mandal	Uttarakhand	30.46604	79.26839
Padli (Karnaprayag)	Uttarakhand	30.24618	79.23866
Srinagar	Uttarakhand	30.22058	78.80846
Shivpuri	Uttarakhand	30.13647	78.38841
Nayar Confluence	Uttarakhand	30.06325	78.59941
Bijnor	Uttar Pradesh	29.41286	78.05965
Tigri	Uttar Pradesh	28.81646	78.15315
Narora	Uttar Pradesh	28.22814	78.3734
Kachla	Uttar Pradesh	27.86374	78.91684
Shamsabad	Uttar Pradesh	27.51319	79.54489
Kannauj	Uttar Pradesh	27.08985	79.98998
Kanpur	Uttar Pradesh	26.56937	80.30184
Fattehpur	Uttar Pradesh	26.07785	80.72472
Allahabad	Uttar Pradesh	25.47642	81.79109
Bahupura (Bhadoi)	Uttar Pradesh	25.2792	82.2244
Mirzapur	Uttar Pradesh	25.11487	82.8082
Varanasi	Uttar Pradesh	25.32198	83.13563
Gangabarar (Ghajipur)	Uttar Pradesh	25.43876	83.53009
Ballia	Uttar Pradesh	25.66243	84.03167
Chhapra	Uttar Pradesh	25.74902	84.63835
Semaria (Mokama)	Bihar	25.37486	85.99295
Munger	Bihar	25.34265	86.57045
Sahibganj	Jharkhand	25.2613	87.74992
Dhulian (Farakka)	West Bengal	24.78961	87.90534
Azimganj (Jiaganj)	West Bengal	24.25574	88.24987
Katwa (Kalyanpur)	West Bengal	23.70576	88.16869
Nabadwip	West Bengal	23.45931	88.37755
Kalyani	West Bengal	23.01316	88.44023
Kulpi (Haldia)	West Bengal	22.02837	88.21929