REPTILES & AMPHIBIANS

Temporal Changes in Freshwater Turtle Assemblage in Gomti River, North India

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Abstract.—We conducted mark-recapture surveys in 1992 and 2003 in the Gomti River, North Pradesh, India, to assess temporal variation in the geomydid turtle assemblage. The Crowned River Turtle (*Hardella thurjii*) was the most abundant species in 1992 and the Indian Tent Turtle (*Pangshura tentoria*) was most abundnat in 2003, with the population of *H. thurjii* showing a substantial decline. The Three-striped Roofed Turtle (*Batagur dhongoka*) had apparently disappeared from the river in 2003, presumably due to urbanization and development along the river. Our study suggests that long-term monitoring of freshwater turtle populations is required to understand the population trends across space and time and for determining the influence of environmental and anthropogenic drivers in the Gomti River.

For long-lived species like turtles, distinguishing changes in populations and assemblages from short-term fluctuations can be hard to detect outside of long-term studies (Magurran et al. 2010). Globally, turtles are now encountering population declines, extirpations at local and regional levels, and even extinctions (Lovich et al. 2018) attributable to issues that include unsustainable harvest for meat and the pet trade, habitat degradation and destruction, and pollution (Lovich et al. 2018; Gibbons et al. 2000). Nonetheless, some generalist turtle species are resilient and have adapted to highly modified habitats that, along with climate variability, habitat alterations, predation, and human disturbances, have been implicated as drivers of temporal variation (Ives and Klopfer 1997), resulting in changes in species composition, abundances, and demographic structures of turtle assemblages (Jergenson et al. 2014; Stokeld et al. 2014). By integrating such factors, conservation practitioners can develop effective strategies to mitigate the impacts of environmental change and ensure the long-term persistence of freshwater turtle assemblages.

The study of temporal variation in freshwater turtle assemblages provides critical insights into the dynamics and ecological processes governing these populations. Demographic studies have provided valuable insights into temporal variation in turtle populations. Noda and Ohkawara (2018) examined the age structure of a freshwater turtle assemblage over a 15-year period and found significant changes in the proportion of different age classes, indicating variations in recruitment and survival rates. They suggested that factors such as predation, habitat loss, and human disturbances could have influenced these demographic shifts. Understanding the demographic dynamics of turtle populations is crucial for effective management and conservation efforts. Temporal variation in freshwater turtle assemblages can also be influenced by anthropogenic factors. Stokeld et al. (2014) investigated the effects of urbanization on turtle communities in a riverine system. They found that urban areas had lower turtle diversity and abundance compared to more natural, less disturbed habitats. The study highlighted the negative effects of habitat fragmentation, pollution, and increased human disturbance associated with urbanization on freshwater turtle populations.

Figure 1. An Indian Tent Turtle (*Pangshura tentoria*) from the Ganges, India. Photograph by Shailendra Singh.

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Globally, India stands sixth in terms of freshwater turtle diversity with 31 taxa and 30 species (Blanck et al. 2023). However, 83% of the freshwater turtle diversity in India is listed as threatened on the IUCN Red List (IUCN 2024). The Lower Gangetic Plain is one of the global priority areas for turtle conservation (Buhlmann et al. 2009); this region and the state of Uttar Pradesh alone support 52% of India's total chelonian diversity (S. Singh et al. 2009). The Gomti River, a major tributary of the Ganges River, is home to 60% of Uttar Pradesh's turtle species. The Gomti River is of uniform depth, rendering it unsuitable for some turtles because of the lack of deep pools, which are a favored habitat for several species of Indian river turtles (Tornabene et al. 2019; Mali et al. 2018; Moll and Moll 2004). However, a few deep pools in the Gomti identified in 1992 by Basu (1993) supported a high density of turtles. Based on anecdotal information from local fishermen, turtles are frequently captured in fishing gear. The fishermen state they release the turtles back into the river and the turtles continue to inhabit the pool in fair densities. To detect possible temporal changes in this assemblage with a focus on three geomydid turtles, the Crowned River Turtle (*Hardella thurjii*), Three-striped Roofed Turtle (*Batagur dhongoka*), and Indian Tent Turtle (*Pangshura tentoria*) (Fig. 1), we employed capture-mark-recapture exercises in 2003 to compare sampling efforts on the Gomti River that were conducted along the same stretch of the river in 1991–1992 and which were described in an unpublished report by Basu (1993).

Materials and Methods

The Gomti River (Fig. 2), the basin of which has a total area of 30,437 km^2 entirely in the state of Uttar Pradesh, originates from Fulhaar Lake in Mainkot about 30 km east of Pilibhit, Pilibhit District (25.4166, 83.2333) and enters the Ganges 960 km to the southeast at Kaithi, Varanasi District (28.6666, 79.9833). The river is fed by ground water and sheet run off. The surveys were conducted along the deep 600-m-long, 250-m-wide Daranga Pool in Hardoi District, the eastern bank of which is characterized by sandy substrate whereas the higher western bank has a hard muddy substrate. The smaller 4–5-m-wide Dunandiya Channel is shallower and largely covered with aquatic vegetation.

We sampled turtles during eight days in June and three consecutive days in August 2003, typically peak activity times of freshwater turtles in northern India, in the Daranga and Dunandiya pools of the Gomti River (27.261445 80.516608). We used fishing gear of local fishermen to trap turtles. Nylon gill nets with mesh sizes of 7.5 and 13 cm baited with fried chicken and watermelon were set in early morning and checked at least every two hours to avoid mortality due to drowning. For each turtle captured, we recorded plastron length and mass to the nearest mm and 0.1 kg, respectively, replicating methods of Basu (1993) Turtles were marked by notching marginal scutes (Buhlmann et al. 2008), sexes were determined visually based on tail lengths, and all were released within 1.5–2 h at the precise location of capture.

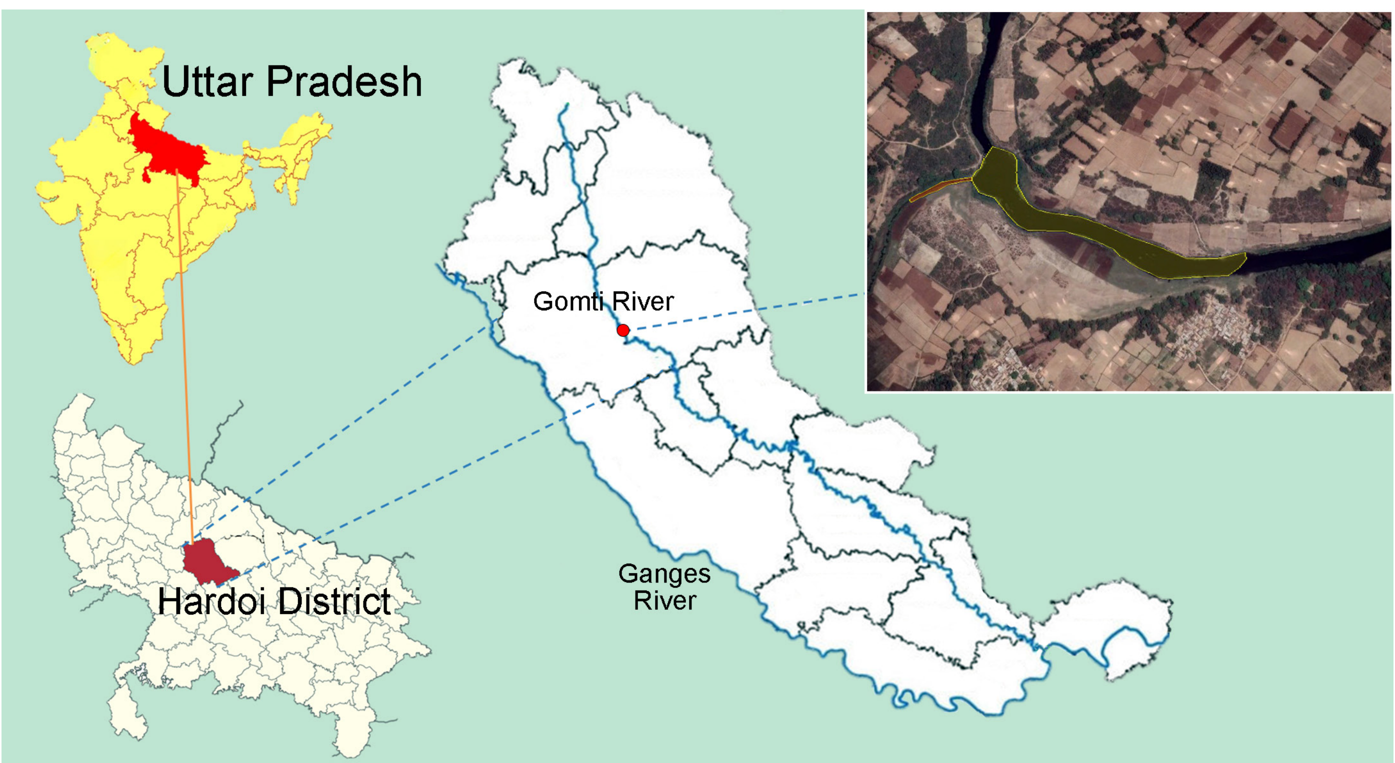

Figure 2. Map showing the location of the study area along the Gomti River, Hardoi District, Uttar Pradesh, India. Inset: The Daranga (olive) and Dunandiya (orange) Pools where sampling was conducted.

We calculated the abundance of adults using POPAN parameterization of Jolly-Seber models (Jolly 1965; Seber 1965) in Program MARK (White and Burnham 1999). Because only plastron lengths were recorded during the 1992 sample (Basu 1993), all size comparisons are based on plastron lengths. We used t-tests to evaluate sexual-size dimorphism in *Batagur* and *Hardella* and to compare differences in sizes between the 1992 and 2003 samples.

Results

Data are summarized in Table 1. In 1992, 502 captures of 314 individuals of *H. thurjii* resulted in an estimated population size of 426 ± 39 individuals. The sex ratio was male-biased (245 males and 69 females). Females were significantly larger than males ($t = 22.148$; $p < 0.0001$; $df = 389$; Table 1). In 2003, 37 captures of 29 individuals of *H. thurjii* were insufficient to calculate a population estimate. The sex ratio was still male-biased (21 males and 8 females). Females captured in 1992 were significantly larger than those captured in 2003 ($t = 4.527$; $p < 0.001$; $df = 108$; Fig. 3), but males did not differ significantly in size ($t = -0.852$; $p = 0.39$; $df = 311$; Fig. 4).

In 1992, 57 captures of 49 individuals of *B. dhongoka* in 1992 (Table 1) resulted in an estimated population size of 180 ± 46 individuals. Sex ratio was male-biased (32 males and 17 females). Females were significantly larger than males ($t = 5.284$; $p < 0.0001$; $df = 56$). No *B. dhongoka* were captured in 2003.

In 1992, 104 captures of 98 individuals of *P. tentoria* resulted in an estimated population size of 787 ± 307. The sex ratio was female-biased (3 males and 95 females). In 2003, 254 captures of 172 individuals resulted in an estimated population size of 164 ± 6. No males were captured in 2003. Sizes of females captured in 1992 and 2003 did not differ

Table 1. Total captures, number of individuals, population size estimates (N ± 1 SD), plastron lengths, and numbers of males, female, and unknown sex (UN) of three species of geoemydid turtles in the Gomti River, Uttar Pradesh, India, in 1992 and 2003.

Species	No. New Turtles (Total Captures)	Population Size Estimate (N)	Plastron Lengths (mm)		M:F:UN
Hardella thurjii			♀	♂	
1992	362 (452)	426 ± 39	265 ± 92	143 ± 13	245:69:48
2003*	37 (29)	—	152 ± 24	145 ± 13	21:8:–
Batagur dhongoka					
1992*	57 (49)	180 ± 46	208 ± 75	140 ± 12	21:8:–
2003	—	—	—	—	—
Pangshura tentoria					
1992	104 (98)	787 ± 307	165 ± 24	—	3:95:–
2003	254 (172)	164 ± 6	165 ± 18	—	1:171:–

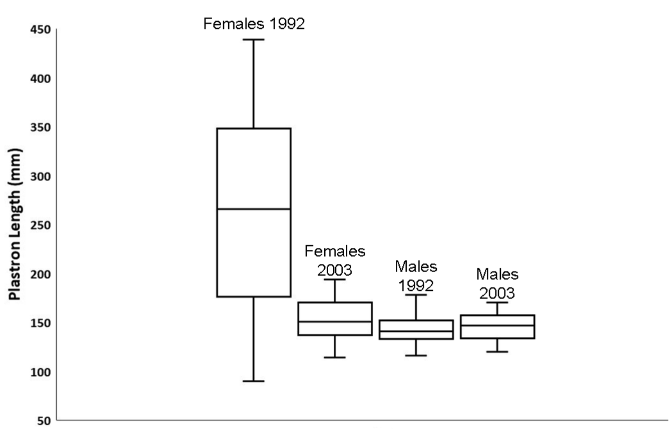

Figure 3. Box and whisker plots for male and female Crowned River Turtles (*Hardella thurjii*) captured in the Gomti River, India, in 1992 and 2003. Plots show the median, maximum, and minimum values, and upper and lower quartiles for plastron size.

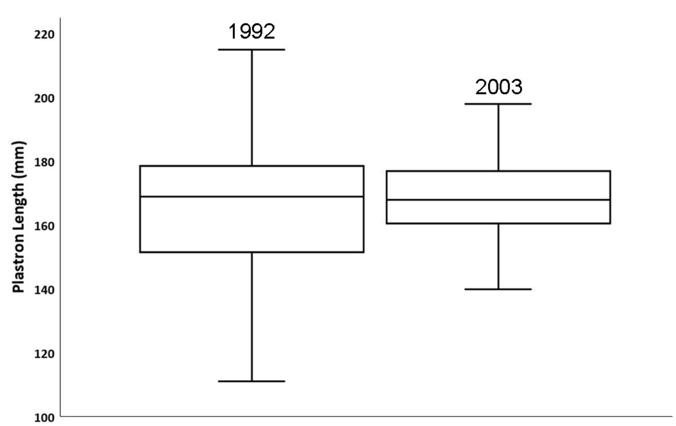

Figure 4. Box and whisker plot for female Indian Tent Turtles (*Pangshura tentoria*) captured in the Gomti River, India, in 1992 and 2003. Plots show the median, maximum, and minimum values, and upper and lower quartiles for plastron size.

significantly (t = -0.298; p = 0.765; df = 289) although turtles captured in the 1992 sample varied in size more than those captured in (Fig. 3).

Discussion

Our study elucidates the temporal dynamics of turtle assemblages in the Gomti River, specifically focusing on assessing changes in population in the family Geoemydidae, over a ten-year period. The Gomti Basin has experienced a significant decline in forest cover and wetlands, primarily attributed to rapid changes in land use and the escalating demand for pristine land driven by urbanization. This alteration has had detrimental effects on the water flow within the Gomti River, as a considerable number of its tributaries originate from bodies of water or forests. The reduction in the density of these tributaries has led to a decrease in water availability in the river (Ahmad et. al 2011). Research indicates that water quality also has suffered, with untreated wastewater discharge from approximately 50 major drains along the river's 960-km course (Ahmad et. al 2011).

Two resilient geoemydid species, *Hardella thurjii* and *Pangshura tentoria*, were present during both sampling periods, although the estimated population size of *P. tentoria* decreased substantially in 2003, and *H. thurjii* exhibited a significant decline in abundance and a notable decrease in sizes of females. These shifts in both species likely represent a decrease in adult survivorship, probably reflecting an increased harvest of larger turtles, resulting in changes in size at maturity and lower rates of post-maturity growth (Le Gouvello et al. 2020).

The heavily biased sex ratios observed in this study likely are related to the migratory behavior of adult females seeking more suitable habitats for nesting or foraging (A. Singh et al. 2021; Das and Bhupathy 2009).Ultimately, however, unsustainable levels of harvesting India's turtles for food (primarily softshelled turtles) and the pet trade (primarily hard-shelled turtles) have taken a toll (Sengottuvel et al. 2023). In addition to focused harvesting, indirect harvesting by fishermen has increased substantially. The Ganges River drainage represents the largest inland fishery in the world, and derelict gear is thought to lead to increased mortality of freshwater turtles (Nelms et al. 2021). As we strive to conserve native populations of Indian turtles, historical data becomes more important in providing baselines that establish success criteria for our efforts.

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