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## Novel observations of aquatic behaviour in Indian star tortoises (*Geochelone elegans*): Implications for ecology, conservation, and captive care

Soham Mukherjee\*

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### ABSTRACT

The Indian star tortoise (*Geochelone elegans*) is widely regarded as a strictly terrestrial testudinid associated with arid and semi-arid landscapes. Published accounts emphasise dry scrub, grassland, and agricultural mosaics, with little mention of deliberate use of open water. Over 17 years (2006–2023), I recorded multiple instances of voluntary swimming by *G. elegans* in Gujarat, India, in both natural and captive settings. In the wild, single adults were observed purposefully crossing flooded monsoon depressions and small lakes, maintaining buoyancy and directional movement over distances of 20–50 m. In captivity, one adult female at a wildlife rehabilitation centre engaged in routine afternoon swims across a 3-ft-deep pond, and a pair of adults in a zoological enclosure repeatedly entered and swam or wallowed in a shallow pond, with a clear seasonal peak in warmer months. These observations are, to my knowledge, the first detailed field and captive accounts of sustained swimming in *G. elegans*. They suggest that this species possesses greater ecological and behavioural flexibility than currently reflected in the literature and that shallow aquatic features may be a relevant, though currently neglected, component of environmental enrichment in captivity. I discuss these observations in the context of chelonian adaptability, conservation in increasingly fragmented and flood-prone landscapes, and evidence-based recommendations for enclosure design and welfare.

### INTRODUCTION

The Indian star tortoise (*Geochelone elegans* Schoepff, 1795) is a medium-sized testudinid native to the Indian subcontinent, with disjunct populations in north-western India and adjoining Pakistan, peninsular India, and Sri Lanka (Das, 1991; D’Cruze, Mookerjee, Vyas, Macdonald, & de Silva, 2018). It is typically associated with arid and semi-arid scrub, grasslands, and agricultural mosaics, and is generally characterised as a terrestrial species (Ernst & Barbour, 1989; D’Cruze *et al.*, 2018). Across much of its range, *G. elegans* now persists in highly modified, human-dominated landscapes and is subject to intense illegal collection for the pet trade (D’Cruze *et al.*, 2015; Sahoo *et al.*, 2024).

The global conservation profile of *G. elegans* has received increasing attention in recent years, including assessments of its conservation status, illegal trade, genetic structure, and distribution modelling (D’Cruze *et al.*, 2018; Kundu *et al.*, 2022; Sahoo *et al.*, 2024). However, detailed natural history and behavioural accounts remain comparatively sparse, particularly in relation to fine-scale habitat use and responses to extreme weather events. Standard descriptions portray *G. elegans* as a land-dwelling tortoise that relies on ground cover, burrows, and vegetation for shelter, with activity strongly tied to monsoon rainfall but little explicit reference to the use of open water bodies (Das, 1991; Ernst & Barbour, 1989; D’Cruze *et al.*, 2018). In herpetoculture and much of the husbandry literature, Indian star tortoises are likewise treated as strictly terrestrial, with emphasis on dry, well-drained substrates

and relatively cautious use of water, usually limited to shallow drinking and occasional soaking (Fife, 2007; Highfield, 1996). Within this framework, deliberate swimming is generally assumed to be either abnormal or risky, raising concerns about drowning or stress in deep water.

During long-term fieldwork and captive management in Gujarat, India, I documented several cases in which adult *G. elegans* voluntarily entered, traversed, and exited natural and artificial water bodies, using coordinated limb movements and maintaining buoyancy over appreciable distances. These observations challenge the conventional view of *G. elegans* as a strictly land-bound species, and suggest an under-recognised capacity for aquatic locomotion.

### The objectives of this paper are therefore to

1. Describe a series of opportunistic and routine observations of swimming behaviour by *G. elegans* in both natural and captive environments in Gujarat, India.
2. Situate these observations within the broader literature on *G. elegans* ecology and on aquatic behaviour in tortoises.
3. Discuss implications for understanding habitat use, responses to monsoon flooding, and the design of captive environments that better reflect the behavioural repertoire of this species.

By documenting and interpreting these behaviours, the study contributes to a more nuanced understanding of *G. elegans* ecology and provides practical insights for conservation management and animal welfare.

<sup>1</sup> Life Science Education Trust, Bangalore, India

\* Corresponding author’s e-mail: [Soham.naja@gmail.com](mailto:Soham.naja@gmail.com)

## LITERATURE REVIEW

### Ecology, distribution, and conservation status of *Geochelone elegans*

The ecology and distribution of *G. elegans* have been synthesised in several regional and global treatments (Das, 1991; Ernst & Barbour, 1989; D’Cruze *et al.*, 2018). The species occurs in three main disjunct regions: north-western India and adjacent Pakistan (Thar Desert and Saurashtra–Kachchh landscapes), southern and south-eastern India, and Sri Lanka (D’Cruze *et al.*, 2018). Within these regions, *G. elegans* is associated with dry deciduous scrub, thorn forest, grassland, coastal scrub, and agricultural mosaics, including hedgerows, plantations, and field margins (Das, 1991; D’Cruze *et al.*, 2018).

In Gujarat, *G. elegans* has been recorded from multiple protected areas and non-protected landscapes, including Gir, Hingolghadh, and several districts with extensive agricultural land use (Vyas, 2006; D’Cruze *et al.*, 2018). The species is most active during the monsoon when it forages and reproduces, but it may also remain active in cooler months during favourable conditions (D’Cruze *et al.*, 2018).

Conservation concern for *G. elegans* is high. It is listed as Vulnerable on the IUCN Red List, with illegal collection for the international pet trade considered the principal threat (D’Cruze *et al.*, 2018; Sahoo *et al.*, 2024). Genetic studies using mitochondrial DNA and species distribution modelling have highlighted a loss of genetic diversity and the importance of distinct regional lineages, reinforcing the need for evidence-based, region-specific conservation planning (Kundu *et al.*, 2022; Sahoo *et al.*, 2024).

### Terrestrial and aquatic habitat use in tortoises

Testudinid tortoises are classically portrayed as terrestrial reptiles adapted to dry or seasonally dry habitats (Ernst & Barbour, 1989; Swingland & Klemens, 1989). Many species demonstrate behavioural and physiological strategies that allow them to cope with high temperatures, water scarcity, and seasonal resource pulses, including burrowing, partial aestivation, and temporal shifts in activity (Swingland & Klemens, 1989).

Nonetheless, there are scattered accounts of tortoises using water more actively than commonly assumed. Some island and continental species, such as Galápagos and Aldabra tortoises, may cross shallow tidal channels or swim short distances, although these behaviours are not usually emphasised in standard field guides (Moll & Moll, 2004; Swingland & Klemens, 1989). A brief natural history note in Herpetological Review documented active swimming in red-footed tortoises (*Geochelone carbonaria*), with animals using coordinated limb strokes and maintaining buoyancy in relatively deep water (Strong & Walde, 2006). Such reports suggest that, at least in some testudinids, the capacity for aquatic locomotion persists despite a primarily terrestrial lifestyle.

For *G. elegans* specifically, comprehensive accounts of distribution and ecology highlight its association with

dry habitats and human-modified landscapes but do not describe swimming or routine use of open water (Das, 1991; D’Cruze *et al.*, 2018; Ernst & Barbour, 1989). Given that much of the range is monsoonal with frequent temporary flooding and formation of ephemeral pools, it is plausible that tortoises occasionally encounter and traverse water bodies, but these behaviours may be rare, brief, or under-reported.

### Captive husbandry, environmental enrichment, and welfare of tortoises

Captive husbandry recommendations for *G. elegans* typically emphasise dry, well-drained substrates, provision of shelter, and cautious use of water features (Fife, 2007; Highfield, 1996). Soaking trays or shallow basins are recommended primarily for hydration, with warnings against deep water that could pose a drowning risk, especially for juveniles or compromised individuals (Fife, 2007; Highfield, 1996).

In the broader zoo and welfare literature, environmental enrichment is recognised as essential for allowing animals to express a wide range of species-typical behaviours, thereby reducing chronic stress and improving welfare (Morgan & Tromborg, 2007). For reptiles, structural complexity, opportunities for active choice (e.g. temperature gradients, microhabitats), and varied substrates are increasingly seen as important components of good practice (Highfield, 1996; Morgan & Tromborg, 2007). Despite this, water bodies in terrestrial tortoise enclosures are often limited to shallow static trays designed only for drinking or short soaks.

Given the monsoon-linked ecology of *G. elegans* and the rare but documented instances of aquatic locomotion in other tortoises, it is reasonable to ask whether shallow ponds or more naturalistic aquatic microhabitats might be behaviourally relevant to this species. However, there is almost no published work examining how *G. elegans* interacts with water in captivity, or whether such features contribute to behavioural diversity and welfare.

### Knowledge gaps

In summary, the existing literature on *G. elegans* provides robust information on taxonomy, distribution, conservation status, and broad habitat associations (Das, 1991; D’Cruze *et al.*, 2018; Kundu *et al.*, 2022; Sahoo *et al.*, 2024) but contains almost no detailed information on aquatic behaviour. For testudinids more generally, occasional reports of swimming indicate that strict terrestriality should not be assumed without empirical examination (Strong & Walde, 2006; Swingland & Klemens, 1989). The lack of published accounts for *G. elegans* represents a genuine gap: in flood-prone, human-modified landscapes, the ability (or inability) to negotiate water could influence survival, movement, and habitat connectivity. In captivity, untested assumptions about aversion to water may restrict environmental enrichment options.

The present study addresses this gap by documenting

deliberate swimming in *G. elegans* and considering its implications for ecology, conservation, and husbandry.

## MATERIALS AND METHODS

### Study period and locations

Observations were made between July 2006 and November 2023 in Gujarat, India. They include:

1. Opportunistic observations of free-ranging *G. elegans* in natural or semi-natural habitats during wildlife rescue operations and ecological surveys in Bhavnagar district, Hingolghadh Wildlife Sanctuary, and an open scrub-agricultural landscape in Ahmedabad district.
2. Routine observations of captive *G. elegans* at a wildlife rehabilitation centre in Ahmedabad.
3. Routine observations of captive *G. elegans* housed in a zoological park in Gujarat.

These sites lie within the known north-western distribution of *G. elegans*, characterised by semi-arid to sub-humid climate with a pronounced monsoon season and extensive agricultural land use (D'Cruze et al., 2018; Vyas, 2006).

### Animals and settings

Wild observations involved unmarked, free-ranging adult *G. elegans* encountered during ongoing work on wildlife rescue and ecological surveys. Sex was not determined in the field for all individuals, as the primary focus was on documenting behaviour rather than morphometrics.

In captivity, observations involved:

- A single adult female *G. elegans* housed in a mixed-species enclosure at a wildlife rehabilitation centre in Ahmedabad.
- Two adult *G. elegans* (one male, one female) in a dedicated tortoise enclosure at a zoological park.

At the rehabilitation centre, the enclosure measured approximately 18.3 × 12.2 m (60 × 40 ft) and included a centrally located pond 7.6 × 4.6 m (25 × 15 ft) with a maximum depth of approximately 0.9 m (3 ft) at the centre and along the longer sides. The pond margins on the shorter sides were gently sloped to allow easy entry and exit. A low barrier (~30 cm) separated the land area from the pond.

At the zoological park, the enclosure contained a central pond approximately 15 inches (~38 cm) deep with gently sloping sides, allowing tortoises to enter and exit without assistance. Surrounding substrate consisted of soil and vegetation typical of a semi-natural tortoise exhibit.

### Observation protocol

Wild observations were opportunistic but documented in detail whenever swimming behaviour was observed. For each event, the observer recorded:

- Date and time.
- Location and habitat description.
- Weather conditions and water depth (estimated visually).
- Approximate distance traversed in water.
- Approximate duration of the crossing (measured with a watch).

- Qualitative description of posture, limb movements, and entry/exit behaviour.

In captivity, observations were made during routine daily husbandry rounds, typically between 09:00 and 17:00 hrs. For the rehabilitation centre enclosure, particular attention was paid to the behaviour of the female tortoise between 11:00 and 13:00 hrs, when she was noted to be most active. At the zoological park, the behaviour of both adults was recorded throughout the year, with more detailed notes during warmer months when swimming or wallowing was most frequent.

Swimming events were defined as episodes in which a tortoise voluntarily entered water deep enough that the plastron was not in contact with the bottom for at least part of the time, and used limb movements for propulsion. Wallowing in shallow water with plastron contact was recorded separately but noted where it preceded or followed swimming.

### Data handling and analysis

Given the small number of events and their opportunistic nature, data were summarised descriptively rather than subjected to formal statistical analysis. For each context (wild vs. captive), I report:

- Number of observed swimming events.
- Approximate distances and durations of swimming.
- Qualitative aspects of posture and limb movement.
- Seasonal patterns where discernible.

These observations are then interpreted in the light of existing literature on *G. elegans* ecology and tortoise behaviour.

### Ethical considerations

All observations were incidental to, or embedded within, ongoing conservation, rescue, and husbandry work. No animals were handled or manipulated for the purposes of this study beyond standard veterinary and husbandry procedures already in place. Observations followed established ethical guidelines for minimising disturbance in behavioural research (Association for the Study of Animal Behaviour & Animal Behavior Society, 2020). No experimental exposure to deep water was conducted; all aquatic interactions occurred voluntarily within existing environmental conditions.

## RESULTS AND DISCUSSION

Wild observations of swimming behaviour

Flooded scrubland, Bhavnagar district (22 July 2006)

During monsoon floods in Bhavnagar district, an adult *G. elegans* was observed at approximately 11:00 hrs swimming through a flooded low-lying area towards higher ground. The landscape, normally dry scrub and agricultural fields, had been transformed into a patchwork of temporary water bodies. The tortoise entered water that was deep enough to submerge the limbs and lower shell, keeping its head and the top of the carapace above the surface. It propelled itself using coordinated, alternating strokes of the fore and hind limbs, resembling the paddling

movements seen in semi-aquatic turtles.

The animal covered an estimated distance of 50 m in approximately 11 minutes before reaching a slightly elevated, partially submerged patch of ground, where it exited the water and moved into terrestrial vegetation. There was no sign of panic or disorientation; instead, the movement appeared directed and purposeful.

Small lake crossing, Ahmedabad district (15 July 2008)

In an open scrubland adjacent to agricultural fields in Ahmedabad district, an adult *G. elegans* was observed at 13:05 hrs entering a small lake approximately 40 m across at its narrowest visible point. The tortoise entered from the south bank, initially appearing to test the water depth before committing to the crossing. After a brief period of adjustment, it adopted a steady paddling motion using all four limbs, maintaining the head above the water surface and the carapace partly submerged.

The crossing took roughly 9 minutes. On reaching the far bank, the tortoise paused briefly at the edge, then climbed out and continued into nearby undergrowth. The behaviour strongly suggested deliberate traversal of the water body, rather than accidental displacement or being swept by current.

#### Waterlogged depression, Hingolghadh Wildlife Sanctuary (10 September 2011)

Within Hingolghadh Wildlife Sanctuary, a normally dry patch of ground had become a shallow waterlogged depression (~20 m across) during a period of heavy monsoon rain. At approximately 15:00 hrs, an adult *G. elegans* was seen approaching and then deliberately entering the water. The tortoise adopted a slightly higher head posture, with much of the carapace at the surface, and used faster, more vigorous paddling strokes than in the previous two observations. It crossed the water body in about 3 minutes, emerging on the opposite side and moving into dry ground.

Taken together, these three wild observations demonstrate that adult *G. elegans* can:

- Voluntarily enter water bodies that are sufficiently deep to require active swimming.
- Maintain buoyancy and directional control over distances of at least 20–50 m.
- Use coordinated limb movements closely resembling those described for swimming in other tortoise species (Strong & Walde, 2006).

These events occurred during or shortly after monsoon rainfall, in landscapes where temporary flooding is common. Rather than avoiding water entirely, these tortoises used swimming to traverse inundated areas, presumably to reach preferred microhabitats or escape deepening water.

From an ecological perspective, such behaviour suggests that *G. elegans* is not as constrained by surface water as a simplistic terrestrial classification would imply. In flood-prone, agricultural mosaics, the ability to cross inundated fields or depressions may facilitate movement between habitat patches, access to foraging areas, and escape

from rapidly rising water levels. This capability could be increasingly relevant under scenarios of more extreme rainfall and flooding associated with climate change.

#### Captive observations: routine swimming in a rehabilitation enclosure

Between 3 August and 17 September 2017, a captive adult female *G. elegans* in a mixed-species enclosure at a wildlife rehabilitation centre was observed engaging in regular swimming behaviour. On most days during this period, typically between 11:00 and 13:00 hrs, she would:

1. Walk along part of the enclosure perimeter.
2. Approach the pond, climb over the 30 cm barrier, and descend the slope into the deeper central area of the pond.
3. Swim across the pond using steady limb strokes, occasionally pausing and then resuming movement.
4. Exit at the opposite slope and continue terrestrial exploration or basking.

These swims appeared to be part of a routine movement pattern rather than occasional escape attempts or responses to disturbance. No other species in the enclosure were observed to force or chase the tortoise into the water, and there were no signs of distress (e.g. frantic thrashing, repeated failed attempts to exit). The tortoise consistently exited the pond unaided at chosen points. The adult female Indian star tortoise swimming across the central pond at the rehabilitation centre is shown in Figure 1.



**Figure 1:** Adult Indian star tortoise (*Geochelone elegans*) swimming in the artificial pond at a wildlife rehabilitation centre in Ahmedabad, Gujarat, India. The pond reaches approximately 0.9 m depth in the centre and has gently sloping margins that allow voluntary entry and exit. Photo credit: Akanksha Mukherjee.

The depth (up to ~0.9 m) was sufficient to require genuine swimming at least in the central area, with the plastron clearly off the bottom. The tortoise maintained a horizontal body posture, head elevated above the water, and used alternate fore- and hind-limb strokes similar to those seen in the wild observations.

From a welfare standpoint, this behaviour suggests that

access to deeper water did not constitute an inherent threat for this individual; rather, it appeared to function as a form of voluntary locomotor activity. The repetition of this pattern over several weeks, in the absence of obvious stressors, implies that swimming may have been intrinsically rewarding or at least behaviourally relevant. Captive observations: seasonal swimming and wallowing in a zoo exhibit

Between March 2022 and November 2023, two adult *G. elegans* (one male, one female) in a zoological park were observed regularly entering a shallow central pond (~38 cm deep). Their behaviour ranged from simple wallowing (standing in shallow water with the plastron in contact with the bottom) to short bouts of swimming in slightly deeper areas (Figure 2).



**Figure 2:** Adult Indian star tortoises (*Geochelone elegans*) wallowing in the shallow central pond of a zoo exhibit in Gujarat, India. The gently sloping sides allow voluntary entry and exit and were used frequently during warmer months. Photo credit: Sardar Patel Zoological Park.

Key patterns included:

- Voluntary entry into the pond by both individuals, without prompting or disturbance.
- Gentle paddling or stationary wallowing, sometimes combined with drinking or defecation.
- Clear seasonal variation: frequent use of the pond during warmer months, with a marked reduction in both swimming and wallowing as ambient and water temperatures decreased towards winter.

The seasonal decline in aquatic behaviour is consistent with the thermoregulatory and activity patterns reported for *G. elegans*, which is most active during warmer, wetter periods (D’Cruze *et al.*, 2018). In this context, the pond likely served as both a thermoregulatory microhabitat and an enrichment feature.

### Integration with existing knowledge on chelonian behaviour

The observations presented here align with, and extend, occasional reports of aquatic behaviour in other tortoise species. Strong and Walde (2006) described red-footed tortoises (*G. carbonaria*) swimming actively in relatively

deep water, challenging the assumption that testudinids are incapable of swimming. Similarly, large island tortoises have been noted to cross shallow channels or float in tidal waters in some situations, although this behaviour is not usually emphasised (Moll & Moll, 2004; Swingland & Klemens, 1989).

In standard accounts of *G. elegans* ecology, the species is described as terrestrial, with activity closely tied to rainfall and a preference for dry scrub and agricultural habitats (Das, 1991; D’Cruze *et al.*, 2018; Ernst & Barbour, 1989). These descriptions are accurate at the broad scale but do not preclude occasional use of water. The present observations show that *G. elegans* can and does swim under certain circumstances, particularly when crossing flooded areas or when provided with appropriately designed ponds in captivity.

Rather than contradicting existing ecological summaries, these behaviours refine them: *G. elegans* is a primarily terrestrial species that nonetheless retains a functional capacity for aquatic locomotion. In evolutionary terms, this is not surprising. Many reptile lineages show residual abilities inconsistent with their dominant niche (e.g. climbing in “ground” snakes, burrowing in ostensibly surface-dwelling lizards), which may confer advantages in heterogeneous or rapidly changing environments.

### Implications for habitat fragmentation, flooding, and conservation

Recent genetic and distribution-modelling work has emphasised the effects of habitat fragmentation and trade-related depletion on *G. elegans* populations throughout its range (Kundu *et al.*, 2022; Sahoo *et al.*, 2024). In western India, landscapes are often mosaics of agricultural fields, scrub patches, and linear features, with monsoon rainfall creating ephemeral water bodies that can temporarily isolate patches of higher ground.

The ability of *G. elegans* to traverse flooded depressions and small lakes, as documented here, may influence how individuals move through these mosaics during the monsoon. Tortoises that can swim across temporary water barriers may access otherwise isolated foraging or shelter sites, potentially enhancing connectivity at fine spatial scales. Conversely, individuals lacking access to elevated refugia or unable to swim may be at greater risk of drowning or being stranded.

Although it would be premature to generalise from a small number of observations, the data highlight a trait with potential conservation relevance, especially under scenarios of more frequent extreme rainfall events. Future field studies could investigate:

- The frequency of swimming or floating behaviour in wild *G. elegans* populations during different phases of the monsoon.
- Whether such behaviour is more common in certain habitat types (e.g. agricultural vs. protected scrub).
- How tortoise movement paths intersect with seasonal flooding patterns.

Integrating behavioural observations with fine-scale

hydrological and land-use data could reshape our understanding of how *G. elegans* uses fragmented, flood-prone landscapes.

#### Implications for captive husbandry and welfare

From a husbandry perspective, the observations suggest that shallow ponds with safe access and exit points can be behaviourally relevant enrichment features for *G. elegans*, at least for healthy adults. The female at the rehabilitation centre used a relatively deep pond (up to ~0.9 m) for routine swimming, while the zoo tortoises made frequent use of a shallower pond for wallowing and short swims. These findings intersect with broader work on stress and enrichment in captive animals. Morgan and Tromborg (2007) emphasise that environments allowing animals to perform a wide range of species-typical behaviours, including exploration and active choice, are critical for reducing chronic stress. For tortoises, structural complexity, gradients in microclimate, and behavioural options beyond a simple dry pen are likely to be important components of welfare (Highfield, 1996; Fife, 2007). On the basis of the present observations and existing husbandry literature, several cautious recommendations can be made for facilities holding adult *G. elegans*:

#### Provision of shallow ponds or basins

- o Ponds should have gently sloping sides and at least one very shallow “beach” area where the plastron can remain in contact with the substrate.
- o For deeper sections, depth should be matched to the size and condition of the animals; healthy adults can clearly manage depths sufficient for genuine swimming, but neonates, juveniles, or debilitated animals may require more conservative designs.

#### Emphasis on choice and safety

- o Water bodies should be accessible but not unavoidable (i.e. tortoises should not be forced to pass through deep water to reach essential resources such as food or shelter).
- o Escape routes must be obvious and physically easy to use, avoiding vertical walls or slippery edges.

#### Monitoring individual responses

- o Introduction of new water features should be accompanied by close behavioural monitoring to ensure that animals are comfortable and not at risk of drowning or hypothermia.
- o Individual variation is likely; some tortoises may rarely use water, while others may swim routinely.

#### Integration with broader enrichment strategies

- o Water features should complement, not replace, other forms of enrichment such as varied substrates, shelters, browse, and complex feeding regimes. These recommendations should not be interpreted as suggesting that *G. elegans* is semi-aquatic. Rather, they recognise that a primarily terrestrial tortoise species can still benefit from carefully designed aquatic microhabitats

that align with its natural behavioural repertoire and monsoon-linked ecology.

#### Limitations and future research directions

The present study has several limitations:

- The number of documented swimming events is small, and all observations come from a single region (Gujarat, India).
- Wild observations were opportunistic rather than systematically sampled; thus, frequency and population-level prevalence of swimming behaviour cannot be estimated.
- In captivity, observations were made in the course of routine husbandry, without standardised behavioural sampling or control enclosures lacking ponds. Despite these limitations, the observations are robust in that they describe clear, repeated, and deliberate swimming behaviour in both wild and captive contexts. They provide a starting point for more structured work, such as:
  - Systematic focal-animal sampling for *G. elegans* in enclosures with and without ponds, to quantify how often and under what conditions tortoises use water.
  - Experimental choice tests, under strict ethical review, to determine whether tortoises preferentially use enclosures offering both dry and aquatic microhabitats.
  - Landscape-scale studies in monsoonal regions to assess how flooding influences movement paths and survival. Such work would help clarify whether swimming is an occasional coping behaviour or a more integrated part of the species’ behavioural repertoire.

#### CONCLUSIONS

This study documents, for the first time in detail, voluntary swimming behaviour in Indian star tortoises (*Geochelone elegans*) in both natural and captive environments in Gujarat, India. Adult tortoises were observed deliberately entering and traversing flooded depressions and small lakes in the wild, and routinely using ponds in captive enclosures for swimming and wallowing. These observations refine the conventional characterisation of *G. elegans* as a strictly terrestrial species, highlighting a capacity for aquatic locomotion that may be ecologically relevant in monsoonal, flood-prone landscapes. They also suggest that carefully designed aquatic features can serve as meaningful enrichment for captive adults, provided that safety and individual variation are taken into account. In conservation terms, acknowledging the ability of *G. elegans* to negotiate water may influence how we conceptualise habitat connectivity and refuge use during extreme rainfall events, particularly in fragmented agricultural mosaics. In welfare terms, incorporating shallow ponds into enclosure design, alongside other forms of structural and occupational enrichment, may help promote more diverse and naturalistic behaviour in captivity. More broadly, the findings underscore the value of long-term, observational natural history work in revealing

overlooked aspects of animal behaviour that carry direct implications for conservation and captive management.

### Annexure

Annexure 1. Summary of documented swimming observations in Indian star tortoises (*Geochelone elegans*) from Gujarat, India (2006–2023)

- Bhavnagar district (wild)
  - o Date: 22 July 2006
  - o Time: 11:00 hrs
  - o Context: Monsoon flood in scrub–agricultural mosaic
  - o Approximate waterbody width: 50 m
  - o Approximate crossing time: 11 minutes
  - o Behaviour: Voluntary entry; head and dorsal carapace above water; coordinated limb paddling; directed movement towards higher ground.
- Ahmedabad district (wild)
  - o Date: 15 July 2008
  - o Time: 13:05 hrs
  - o Context: Small lake in open scrubland adjacent to farmland
  - o Approximate waterbody width: 40 m
  - o Approximate crossing time: 9 minutes
  - o Behaviour: Voluntary entry; adjustment period followed by steady paddling; head above water; exit and continuation into undergrowth.
- Hingolghadh Wildlife Sanctuary (wild)
  - o Date: 10 September 2011
  - o Time: 15:00 hrs
  - o Context: Temporary waterlogged depression (~20 m across) formed during heavy monsoon rain
  - o Approximate crossing time: 3 minutes
  - o Behaviour: Deliberate entry; faster paddling, buoyant posture; rapid crossing and exit to dry ground.
- JCT wildlife rehabilitation centre, Ahmedabad (captive)
  - o Period: 3 August–17 September 2017
  - o Individual: Adult female
  - o Enclosure: 18.3 × 12.2 m, with a 7.6 × 4.6 m pond up to 0.9 m deep
  - o Behaviour: Near-daily voluntary swims across the pond around midday; routine pattern of perimeter walk, pond entry, sustained swimming, and independent exit.
- Sardar Patel Zoological Park, Gujarat (captive)
  - o Period: March 2022–November 2023
  - o Individuals: Two adults (one male, one female)
  - o Pond depth: ~38 cm, with gently sloping sides
  - o Behaviour: Regular voluntary entry to pond, wallowing and short bouts of swimming; clear seasonal peak in warmer months with reduced use in cooler season.

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