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Unveiling the Himalayan crestless porcupine: Occurrence in Howrah and Hooghly districts and reproductive insights in captivity

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Abstract

Exploratory fieldwork and behavioural studies of semi-fossorial crepuscular species like Himalayan Crestless porcupine (*Hystrix brachyura* L.) are essential for learning about their habitat requirements, behavioural traits, and ecosystem dynamics. Fieldwork in the Lower Gangetic plain, specifically in the Howrah and Hooghly districts, focused on rescue sites and adjacent areas to assess potential wild population. Reproductive behaviours were observed in an ex-situ preservation setting, with environmental and dietary enrichment and non-invasive monitoring to minimise stress. Wild populations were detected even in agriculturally intensive areas. The species shows monogamous nature and breeds year-round. Courtship and mating occur mainly inside the burrows, producing 1-2 porcupettes per litter. Each litter encourage to construct a new burrow prior to birth. A long gestation period was observed. Although some paternal involvement was observed, maternal care plays the most significant role. Porcupettes rely on maternal milk for several weeks, with an early training in solid food intake. The young exhibits notable preference for specific foods. These findings boost our deeper understanding of the ecological adaptability of *H. brachyura* and help to formulate habitat-specific conservation approaches.

Keywords: Burrow, Himalayan porcupine, occurrence, Porcupette, reproduction

1. Introduction

Conservation mainly focuses on viability of populations, communities, and habitats [10]. Among the key conservation efforts for any species, some include exploratory work, studying their distribution, observing them in the wild, and simultaneously working to establish ex-situ conservation environments that replicate their natural breeding and rearing conditions. This helps make sure that the species can successfully breed and raise their offsprings outside of their original habitat. It is apparent that conservation planning takes into account how each species moves, eats, and reproduce [3]. Insights into animal behaviour are becoming an essential element of species-focused conservation strategies [32]. Species that spread over large areas and consist of multiple subspecies frequently receive limited attention from the conservation community, leading to unnoticed declines in their in their subpopulations [26, 30]. Understanding how behavior affects population can be key to helping stop or reverse population decline crucial to reversing population decline [12]. Himalayan Crestless porcupine or Malayan porcupine (*Hystrix brachyura*), an exclusive and enthralling nocturnal rodent species, is endemic to the Himalayan region and also distributed at all the countries of South Asia [23]. This fascinating species is found throughout northeast India, exhibiting a broad environmental tolerance ranging from tropical to temperate and sub-montane forests [29]. Himalayan crestless porcupine has also been reported from the Northern part of West Bengal and in Sundarbans, further expanding its unique habitat range [1, 22]. Threat to the population is mainly due to habitat loss, fragmentation and construction works, though poaching and hunting activities are quite common [20, 23] and the declining population in the wild underscoring the urgent need for conservation efforts to safeguard both its population and habitats. With a declining overall population size, this old-world porcupine species is globally

classified as 'Least concern' on the IUCN List ^[20]. But according to the Wildlife (Protection) Amendment, 2022, ^[31] this hystricomorph rodent species is designated as a Schedule I category of animals which receives highest level of protection and attention in India. Similarly, in Singapore and Peninsular Malaysia, the species is protected under the Wild Animal and Bird Act (Singapore, 1965) and Wildlife Conservation Act (Malaysia, 2010), respectively ^[5]. Due to its widespread distribution across heterogeneous habitats, semi-fossorial lifestyle in varying ecological niches, varieties of landscape features, and a range of environmental factors, *H. brachyura* demands special attention and comprehensive study. Animals perceive their surroundings and detect environmental cues, which then influence their responses and behaviours, reflected in their activities. Moreover, environment plays a role for the expression of certain genes, leading to potential trait variation. Genetic variation in niche construction can impact our understanding on some events such as transmission of traits from parents to offspring, pleiotropy, and epistasis of traits that can alter under the impact of different environmental factors ^[28]. Molecular phylogenetic studies also indicate that in-depth research is essential to explore the regional population structure of *Hystrix brachyura* across Southeast Asia, which will aid in the sustainable management and conservation of the species ^[27]. Populations consist of individual phenotypes ^[18], that reflect the interaction between genotype and environment across all levels of the organism, including morphology, development, physiology, and behavior, so population management should focus on the individual as a whole rather than being biased toward genotype ^[15]. Detailed studies on temporal activity patterns across its habitat range are still needed to ensure effective conservation of *H. brachyura*. Detection of intraspecific genetic variations across the habitat range demands a thorough study in an intrinsic manner.

Due to their crepuscular and burrow-living regime, productive execution of ecological surveys and behavioral studies of the Himalayan crestless porcupine are challenging in the wild. For researchers, ex-situ conservation areas with enrichments that mimic natural habitats offer a better opportunity for observation and data collection for this species. Not only for education and research purposes, but with the increasing focus on captive animal welfare and the recent introduction of welfare assessments by the World Association of Zoos and Aquariums, it is crucial to develop thorough and effective methods for evaluating animal well-being ^[9].

In our present study, we conducted exploratory fieldwork to investigate the occurrence of wild populations of *Hystrix brachyura* in specific pockets of Lower Gangetic districts of Howrah and Hooghly, where this species has been repeatedly rescued by forest staff and local communities. In this paper we describe behavioral traits of the rescued wild animals, including social interactions, reproductive behaviour, responses to temporal and seasonal variations, paternal care, and burrow-building characteristics under captive condition. The current study placed special emphasis on reproductive behaviours of an elusive species. Successful reproduction is a prerequisite for a population's survival, genetic diversity, and adaptive capacity, so management must ensure conditions that facilitate reproduction and support the development of diverse phenotypes ^[15]. Old World porcupines form lifelong pairs and engage in frequent socio-sexual behaviours, even outside the breeding period ^[24]. Our studies also present some aspects of socio-sexual traits in *H. brachyura*.

2. Materials and Methods

2.1 Case History

Two male and one female individual were rescued from three different locations across the Howrah and Hooghly districts. They were subsequently integrated into the ex-situ conservation program for treatment and care. Later, two more adults – one male and one female – were rescued and introduced into the ex-situ facility. Since no wild populations of the species had been reported in those areas, a field study was conducted to collect direct and/or indirect evidence of the species.

Continuous monitoring of the captive individuals was done to study their behavioural patterns. Environmental and dietary enrichment were implemented in their enclosures at the ex-situ conservation site. Upon observing the initial mating behaviour in the pair, intensive monitoring was conducted until the birth of the porcupette.

In one instance, a pregnant female was isolated after infighting with another inhabitant, and she gave birth to a porcupette outside the den. A detailed study of the young was conducted, including observations of maternal care.

2.2 Study area

The field study was conducted in the Lower Gangetic districts of Howrah and Hooghly, area of flat alluvial plains and known for extensive agricultural activities. The topography and agro-climatic features of the region lie between the Hooghly (Bhagirathi) on the east and the Rupnarayan river to the west, the Damodar River cutting through the landscape. The soil of this area, commonly known as red sandy loam which is highly fertile and availability of water is additional advantage. The study of behavioural pattern was done at Garchumuk Zoological Park (22.3456°E and 88.0858°N). Garchumuk is located at the confluence of the Hooghly and Damodar Rivers.

2.3 Environmental and dietary enrichment

Animals sense the environment and detect environmental cues, which then influence their responses and behaviours, reflected in their activities. As part of enrichment, planting local grasses and seasonal herbs along with placing natural materials such as branches and hollow tree logs in certain areas of the enclosure, helps create a natural environment, while providing hiding places and water provisions. Dietary enrichment includes sprouts, as well as a variety of seasonal and locally grown fruits, vegetables, tubers, serving the dual purpose of encouraging and stimulating natural foraging behaviours and food preferences, while also ensuring a balanced diet. Loose loam soil was provided to facilitate the smooth execution of den building activities.

Enrichment and non-invasive monitoring reduce stress for the animals and offers clearer, real-time insights into its internal state. This ensures that the data is not affected by stress, its particularly useful in animal welfare, conservation, veterinary care, where minimizing stress is a key to success.

2.4 Den Features and burrowing activities

The pattern of burrowing by individuals, including changes in the number of holes and burrows across consecutive breeding seasons within the enclosures, was recorded. The area of the burrow den and the dimensions of the burrow entrances were measured using a measuring tape and scale. Individual porcupines were marked and released into the enclosure to monitor their patterns of hole usage. Occasionally, a portion

of the daily feed was placed near a burrow opening to observe the porcupines' behaviour. Over time, the opening was partially blocked for a few hours with a whole coconut, while food was placed at other entrances to encourage the porcupines to use alternative routes. Additionally, individuals with specific sizes and markings were observed entering one hole and exiting through another to assess the interconnectivity of the burrow den. By correlating all observations, the patterns of tunnel entrances, routes, and interconnectivity within the burrow den were mapped using non-invasive techniques.

2.5 Reproductive behaviour

Visual observation and CCTV monitoring were conducted meticulously throughout the year, with behavioral traits documented on a seasonal and individual basis. The gathered data was carefully organized in an orderly manner, then examined and explained using a detailed, straightforward approach, often focusing on patterns or trends, and interpreted in a clear and descriptive way. Outside the burrows, activities such as mutual grooming, copulation, parental care, and lactation until the weaning period were primary focus and were the carefully documented. However, inside the burrows, observing these same events was not possible with the current set up. The age of the porcupettes was estimated based on indirect evidences, such as post-birth behaviours exhibited by the parents, including an increased frequency of burrow visits and specific activities. Gestation period was estimated correlating the time of mating and the time of birth. Additionally, the appearance and behaviour of the porcupettes after their first emergence from the burrow were considered.

2.6 Data Analysis

Since the study animal is mainly nocturnal and a burrowing animal, it often poses difficulties in estimation of their abundance and population monitoring as the animals spend most of their lives underground. Indirect signs, which were used as a tool for abundance estimation, have been found to be a potential method for determining the occurrence of animals in the Howrah-Hooghly district. Evidences such as presence of den, burrowing site, feeding signs, nail marks, faecal deposits, presence of quill and occasional sighting etc. were used to define presence-absence of the study species by means of calculating the sign-encounter Rate^[14]. Seasonal data were collected to see the variation in the signs.

To study the mating behaviour and gradual behavioural changes of the zoo-born porcupette, an ab-libitum survey was conducted, followed by focal sampling to observe the behaviour of both the mother and the newborn porcupette. Since the female of the pair1 (from initially rescued animals) gave birth five times, variations in behaviour were considered. The land cover pattern of study site from where the sign samples was collected^[4], was done using ArcGIS version 10.4 (Esri). The collected data were analyzed Excel and SPSS Ver 10 (IBM)^[17].

Ethical approval was not required for the study as it was observed as a part of the daily activity of the zoological park which is a unit under the governance of West Bengal Zoo Authority. The protocols and procedures regarding observation and studying the animal, were ethically reviewed.

3. Results

Occurrence of Wild Population

Sign encounter rate was high in Spring (3.3 ± 0.51), followed by summer (2.3 ± 0.9). In monsoon indirect or direct sighting

was very low (0.56 ± 0.06). In the transition between Monsoon and winter, the season marked as post monsoon, the SER gradually increases. The SER in the Winter season is 1.89 ± 0.59 , whereas in post monsoon it is 1.08 ± 0.46 (Fig 1). The rescue locations, along with sites where both direct evidences were gathered, are predominantly located within cropland areas, interspersed with patches of woody savanna and cropland-vegetation mosaics (Fig 2). In Hooghly, these areas are notably close to urban and built-up environments, highlighting their proximity to developed regions.

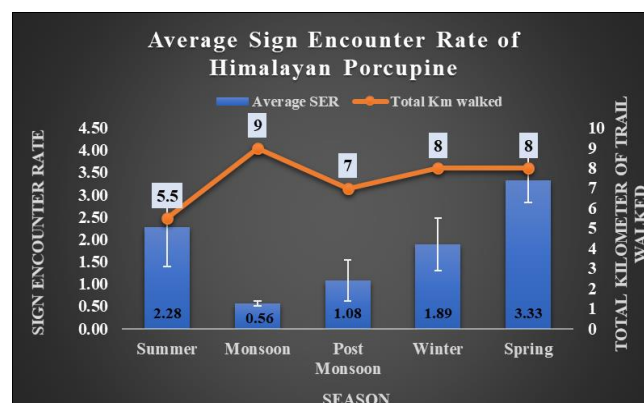


Fig 1: Season wise Average Sign Encounter Rate of *Hystrix brachyura*

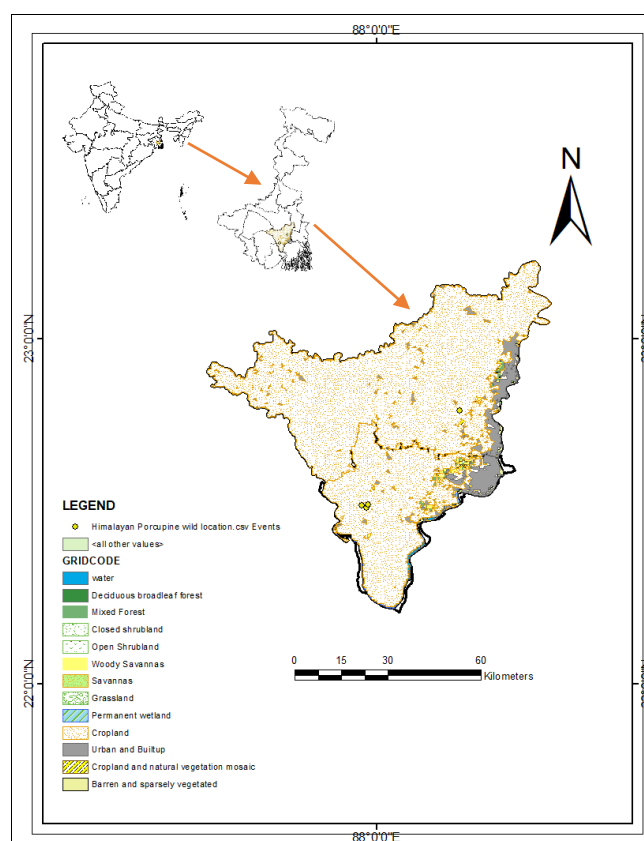


Fig 2: Occurrence of *Hystrix brachyura* in wild habitat of Howrah and Hooghly District

Den Building features

For the initial couple of years Pair 1 excavated new den burrows and these burrows are interconnected; however, next two dens were constructed separately without interconnected tunnels (Fig 3). The openings of the burrows were seen to vary from 8 to 11 inches and the length of the interconnected tunnels were recorded to be 3 ft, 3.6 ft and 4 ft.

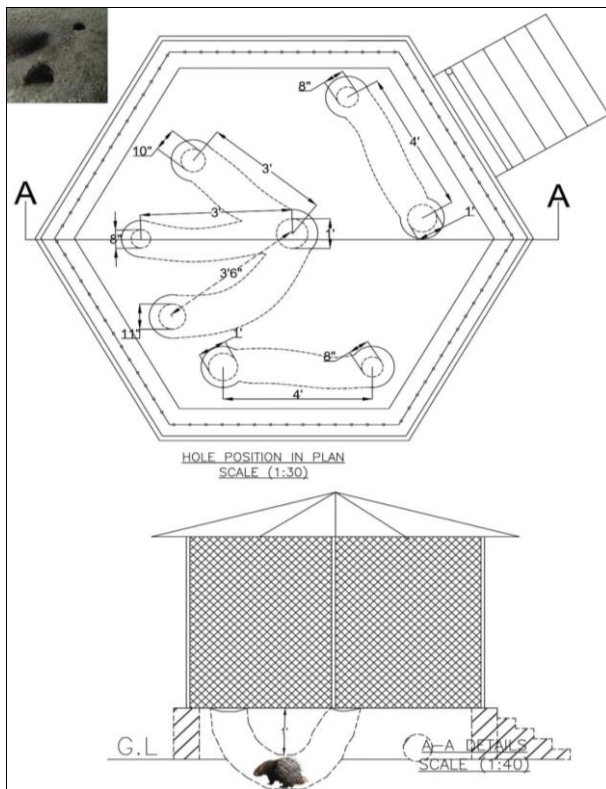


Fig 3: Spatial schematic of Porcupine burrow system with photographic inset showing a partial field view of active burrow entrances in ex-situ conservation site of Garchumuk Zoological Park

Reproductive Behaviour

Even though the introduction of new individuals into the same enclosure multiple times, it was observed that the same male-female pair, responsible for offspring in different breeding seasons, remained constant indicating exclusive monogamous nature of the species. Reproductive behaviours were observed among two compatible pairs. Out of the five successful breeding sessions from Pair 1, marked by porcupette birth events, mating activity was assumed to predominantly occur inside the den. However, in one instance during spring, mating behaviour was observed above ground in day light (Image 1) and in another instance in summer mating activity was noted at night. Courtship behaviour showed the reflection of sexually dimorphic expressions. The male raising the quills on his back took the lead in the sexual counter by sniffing, licking neck and tail followed by investigating the anogenital area of the female. The female when receptive and willing began lifting her tail toward her back exposing her ano-genital area and gradually lowering her body close to the ground. It was not possible for us to assess whether sexual receptivity was dependent on estrous in the present setup. Although multiple mounting occurrences were observed, successful copulation occurred only once per mating session outside the burrow in both recorded instances, lasting approximately 30 seconds during the day and 40 seconds at night in case of pair 1. In case of pair 2 only mounting activities were noted few times outside the burrow without any intromission.

The female of Pair 1 produced five litters over four years and across different seasons, suggesting that the estrous cycle of *H. brachyura* is not seasonally dependent. In only one instance gestation period was estimated to range from 108 to 121 days, based on correlating evidence of mating and the probable time of birth. It was not known if any abortions happened inside the den. Births occur inside the burrows, with litter sizes ranging from one to two. The isolated pregnant

female once gave birth to a healthy precocial porcupette P1 above ground, and the mother exhibited intense nurturing behaviour (Image 2, Image 3). A few hours after birth, she remained close to the newborn, cleaning and licking its body while continuously suckling it. Lactating activity is the most prevalent behaviour in mother porcupines, reflecting a strong bond and a deep sense of attachment. Porcupettes born and reared inside the burrow typically emerged for the first time near the time of weaning, approximately 3-4 months after birth, as indicated by their weight, appearance, and behaviour. P1 was born in a separate enclosure above ground as its pregnant mother was isolated due to conflicts with a male other than father. At birth, P1 weighed 458 gm with soft quills and after five days it weighed 650 gm when the hardening of quills began. At the age of two weeks, the weight of that individual was 1.2 kg. And last weight was possible to measure at the age of 1 month, which was relatively increased, i.e. 3.435 kg and it suggested a rapid growth. P1 was fully dependent on its mother's milk until 5 weeks of age. The mother began teaching P1 to eat solid food at 34 days old, while lactation continued. P1 successfully began consuming solid food ten days after the initial training. Lactation continued until it was nearly 4 months old, with suckling activity gradually decreasing in and solid food intake increasing around 2 months. Interestingly pregnant mother and all porcupettes showed a strong preference for ripe banana over the other fruits and vegetables (Image 4, Image 5). In the initial weeks, frequent movement of the male inside the burrow was observed. However, more activities by the mother were noticed over the time. In addition to caring for the young inside the burrow, the mother engaged in activities like cleaning the den and foraging outside. Our observation suggests that maternal care plays a more prominent role than paternal care in this species, at least within the context of the current captive setup.



Image 1: Mating behaviour of Porcupines in day light



Image 2: Porcupette, 24 hours after Birth



Image 3a & 3b: Mother nurturing the Porcupette



Image 4: Pregnant mother Porcupine showing food preference



Image 5: Porcupette showing food preference

4. Discussion

The presence of wild populations of Himalayan crestless porcupine in areas of flat alluvial soil of Lower Gangetic plain highlights the broad range of tolerance in a wide range of habitats including human-dominated landscapes and underscores the need for framing policies accordingly to protect the species. Moreover, horizontal proliferation into a diverse habitat may suggest the possible presence of an Ecotype, a genetically distinct population within a species that has evolved specific adaptations to thrive in a particular environment or habitat [2]. Further studies will reveal the facts through comprehensive analyses at the physiological, biochemical, genetic levels.

Rodents with burrowing lifestyle excavate underground burrows for breeding and protection from predators and climatic adversities, although spend time outside to forage, defend territories, and search for compatible mates [7, 8, 16]. The species *H. brachyura* demonstrates a broad tolerance for various habitats up to 1500m, thriving in all types of forest environments, scrubby, open areas near forests, and even agricultural regions, though it requires rocky outcrops for its burrow, typically occupied by a family group [19, 25]. As in our current setup, where environmental and dietary enrichment were established in a very well-protected enclosure, it may be presumed that foraging and predator-related concerns were not linked to den building. Our current study reveals that home construction activities were observed before the birth of the offspring in the new litter highlighting an important aspect of innate behaviour. The number of dens increases with

family expansion, even though the mother remains the same, indicating that she prefers a separate den for each litter to give birth, rear, and protect the newborn porcupettes. Furthermore, it was evident that the species is capable of effectively excavating burrows, creating stable dens in the red loam soil highlighting the geophysical features of the soil of the area as suitable for burrow construction. As both parents were rescued from the wild and provisions for burrowing dens were provided in the enclosure as an environmental enrichment component, this setup proved advantageous. Genetically programmed innate behaviours, such as sexual behaviour, and learned behaviours interact dynamically throughout an animal's life [21]. The young are likely to learn such activities from the parents, and this outcome may provide valuable insights for developing conservation breeding programs and establishing soft release areas before the animals are reintroduced into the wild.

In the crested porcupine (*Hystrix indica*), reproduction is not influenced by seasonality and occurs year-round [6, 11]. Similarly, the present study indicates that *H. brachyura* also lacks a specific breeding season, with monogamous pairs engaging in mutual grooming where male plays key role and mating throughout different seasons of the year. Our present observation clearly indicates the sexually dimorphic behaviour, particularly reflected in the sexually dimorphic expression during courtship and mating initially, and in offspring rearing later on. Generally, in rodents, sexually dimorphic behaviours arise from the sexually dimorphic expression of key transcription factors or sex hormones that activate transcription factors such as, androgen and estrogen receptors [21], with neural circuits ultimately regulating.

Various studies suggest that newborn porcupines spend a prolonged period in the burrow, likely to conserve energy and facilitate their growth [13] and emerge around the onset of weaning. The mother plays the most important role for the rearing the offsprings. Our current observation suggests that a prolonged suckling period and 1-2 offsprings per litter may represents a reproductive strategy that gives emphasis on intensive parental care during early developmental stages, thereby enhancing the offspring's survival chances. Environmental and dietary enrichment probably alleviated stress encouraging reproductive success under captivity and promoting the expression of natural innate behaviours, such as digging extensive burrow systems and engaging in species-specific paternal care.

Behaviour study is a crucial component of wildlife Conservation strategies. In addition to providing insights into ecological niche and ecosystem dynamics, such studies help to assess the impact anthropogenic activities on species and on its habitats. Moreover, they provide valuable information for developing preventive measures to combat the decline or potential extinction of species. Since both the parents were from wild population, they were able to construct home even in captivity when favourable conditions were provided, likely contributing their reproductive success. As the wild mother trained them in an environment similar to their natural habitat, there is a good chance the offspring will show behaviours seen in free ranging individuals if they are released into the wild.

In an ex-situ preservation system, management should adopt an integrative approach focusing on individual phenotypes, genetic polymorphism preservation, and adaptive potential. This approach should ensure optimal living and breeding conditions that naturally prepare animals- especially for small herbivorous mammalian species for a free ranging life,

promote reproductive success, and establish arrangement for a viable and sustainable population in the future. Our present study highlights this approach for the conservation of semi-fossorial mammalian species *Hystrix brachyura*.

5. Conclusion

The present study documents the occurrence of the Himalayan Porcupine (*Hystrix brachyura*) within the Gangetic alluvial plain, even in human-dominated landscapes, provided that habitat conditions remain favorable for their survival and population persistence. When the soil has suitable geophysical features, *Hystrix brachyura* constructs sub-horizontal, shallow-angled burrow dens. The investigation suggests that presence of dens near the cropland areas often causes conflict with human. Housing of Himalayan Porcupines in confined areas of zoos evoke awareness among people every so often. The species is strictly monogamous and does not have a specific breeding season, at least under captive conditions where environmental and dietary enrichment are provided. This study further indicates that home construction activities by the parents were observed before the birth of the offspring in the new litter highlighting an important aspect of innate behaviour and Porcupine's strong instinct to ensure the safety of its young. Pregnant females and their young show a strong preference for certain types of food. Our findings shed light on aspects of conservation strategies, both in-situ and ex-situ.

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Competing interests/Conflict of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Authorship contribution

IC- Conceptualization, Data curation, Formal analysis, Investigation and study, Development of methodology, Visualization, Manuscript writing, ID- Conceptualization, Formal analysis, Development of methodology, Resources, Validation and editing the writing.

Conflict of Interest

Not available

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