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EXAMINING THERMAL TOLERANCE AND PHYLOGENETIC CHARACTERISTICS OF JUVENILE ERYX JOHNII IN THE THAL DESERT

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Abstract
Juvenile Eryx johnii (Indian Sand Boa) inhabit the Thal Desert, a region marked by intense heat, dryness, and limited prey availability – conditions that strongly challenge their survival. Compared to adults, juveniles show reduced thermal tolerance and are more prone to dehydration, making them vulnerable to climate-driven shifts in soil moisture and food availability. Their persistence relies on fossorial behaviors such as burrowing and refuge-seeking, which enable thermoregulation and protection from predators. Phylogenetic analyses classify Eryx johnii in the Erycinae group and trace its divergence back to the Miocene, highlighting adaptations suited to desert habitats. Anthropogenic threats – including illegal trade and exploitation for traditional medicine – further endanger this Near Threatened species. Filling knowledge gaps on juvenile ecology, thermal limits, and habitat use is vital for developing climate-resilient conservation strategies

INTRODUCTION

Eryx johnii, also known as the Indian or Red Sand Boa, is a non-venomous member of the Boidae family native to arid and semi-arid zones of the Indian subcontinent, including the Thal Desert in Pakistan [1]. Adults typically reach lengths of 60–91 cm and possess cylindrical bodies with smooth dorsal scales, wedge-shaped heads, and small eyes — morphological features suited to their fossorial lifestyle [2]. Their reddish-brown to dull yellow coloration enables camouflage within sandy substrates.

This species inhabits dry scrublands, sandy plains, and rocky foothills, preferring loose soils that facilitate burrowing for thermoregulation and predator avoidance. Reproductively, Eryx johnii is ovoviviparous, producing up to 14 offspring in late summer or during monsoon seasons. Juveniles often display brighter markings, enhancing camouflage and reducing predation risk [3,4]. Juvenile fossorial behaviors such as digging and refuge-seeking are essential for thermoregulation in harsh desert climates [5]. Despite their ecological significance, research on juvenile thermal ecology and adaptive strategies remains sparse.

Figure 1. Juvenile stage of Eryx johnii

The Thal Desert spans ~23,000 km² in Punjab, Pakistan, characterized by loose sand dunes, sparse vegetation, and extreme climatic conditions [6]. Rainfall is low (150–350 mm annually), summer temperatures exceed 45 °C, consists of drought-tolerant shrubs and grasses supporting fauna adapted to resource scarcity. Juveniles regulate rodent and insect populations, providing indirect benefits for local agriculture [7]. However, juvenile distribution and winters approach freezing. Vegetation and microhabitat preferen ces remain poorly documented.

Figure 2. Map of the Thal Desert in Punjab, Pakistan

Phylogenetically, Eryx johnii belongs to the Erycinae subfamily and is closely related to Eryx conicus [8]. Fossorial adaptations — specialized scales and burrowing behaviors — facilitate survival in arid environments. Molecular studies trace divergence to the Miocene, revealing longterm desert specialization [9,10]. Recent phylogeographic research on Pakistani arid reptiles supports Miocene origins for Erycinae [11]. Despite ecological significance, Eryx johnii faces threats from illegal pet trade and exploitation in traditional medicine [12]. Although listed as Near Threatened and protected under wildlife laws, enforcement challenges persist [13]. Habitat loss from agriculture and settlement accelerates declines, necessitating habitat protection and awareness programs. Misguided afforestation and land-use changes further disrupt native desert ecosystems [14,15]. Protecting juvenile microhabitats (burrows, sparse vegetation refuges) is crucial for resilience against climate stress. Global data show juvenile CT_{max}

shifts of only ~0.13 °C per °C warming [16], implying limited adaptive scope.

DISCUSSION

Thermal tolerance defines the temperature range enabling physiological function. For desert reptiles like Eryx johnii, extreme Thal Desert temperatures (>45 °C) challenge survival. Juveniles, with smaller body size and immature thermoregulatory systems, exhibit narrower thermal ranges than adults [17]. High surface area-to-volume ratios and low-fat reserves increase dehydration risk. Juveniles minimize exposure by remaining in burrows or shaded refuges during peak heat [5,18]. However, reduced surface activity restricts foraging and growth [19]. Prolonged heat impairs immunity and metabolic efficiency, heightening disease susceptibility [20].

Climate warming may intensify these risks, emphasizing the need to quantify life-stage-specific thresholds [21]. Phylogenetic studies using mitochondrial markers (cytochrome b, COI genes) confirm Erycinae placement [22,23]. Juveniles show fossorial morphological traits (reduced eye exposure, reinforced skulls) suggesting strong adaptation to subsurface life [24,25]. Miocene aridification likely drove this specialization [11]. Genetic studies reveal low-to-moderate diversity in juvenile cohorts, suggesting philopatry and limited gene flow — factors constraining adaptability [26]. Juvenile CT_{max} is evolutionarily conserved and slow to shift [27,28], limiting rapid response to warming. Microhabitats, especially sandy burrows, buffer extreme temperatures but face degradation [29]. Limited plasticity in thermal traits further restricts juvenile coping capacity [30].

Table 1. Thermal tolerance and adaptive traits of juvenile vs adult Eryx johnii in arid environments.

Parameter	*Juvenile Eryx johnii*	*Adult Eryx johnii*
Thermal tolerance range (°C)	*28-40*	*25-45*
Critical thermal maximum (CT_{max})	*~40*	*~45*
Critical thermal minimum (CT_{min})		*~25*
Behavior under heat stress	*Burrowing, shade seeking*	*Surface activity reduced, occasional burrowing*
Vulnerability to dehydration	*High*	

Conservation planning for Eryx johnii juveniles should focus on protecting their microhabitats, monitoring genetic diversity, and addressing their specific vulnerabilities under future climate scenarios. Protecting burrow systems and sandy refuges will help buffer temperature extremes and reduce dehydration risks. Along with habitat conservation, anti-poaching measures and community awareness programs are needed to curb illegal trade. More research on juvenile thermal limits and adaptive traits will also help design better strategies to support their survival in desert ecosystems [29,30].

Conclusion

Juvenile Eryx johnii have narrower thermal limits than adults, making them more vulnerable to the harsh climate of the Thal Desert. Their survival relies on behaviors such as burrowing and shade-seeking, yet prolonged heat exposure heightens dehydration risk and limits growth. Projected climate change may intensify these pressures by reducing soil moisture, prey availability, and habitat stability. Phylogenetic evidence reveals long-term desert specialization but limited capacity to adapt to rapid warming. Safeguarding juvenile microhabitats, curbing illegal trade, and prioritizing research on thermal limits are essential for developing effective conservation strategies.

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Author Contributions

All authors contributed equally to study design, data collection, and manuscript preparation. All authors approved the final version for submission.

Conflict of Interest

The authors declare no conflict of interest.

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