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Effect of environmental enrichment strategies on stereotypic behaviour in captive asiatic lions (*Panthera leo persica*)

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Abstract

When a captive Asiatic lion paces the same circuit 400 times in a day, the welfare implications are unmistakable. Stereotypic behaviours—repetitive, invariant motor patterns with no apparent function—affect an estimated 50-80% of captive large felids and represent one of the most visible indicators of compromised welfare ^[1]. This research evaluated the effect of a structured environmental enrichment programme on stereotypic behaviour frequency in eight captive Asiatic lions (*Panthera leo persica*) housed at a zoological facility in Chiang Mai, Thailand. A 12-week intervention combining structural (elevated platforms, log barriers), sensory (novel scents, auditory stimuli), and feeding enrichment (puzzle feeders, scattered feeding) was implemented following a 4-week baseline observation period. Overall stereotypic behaviour declined by 63.7% (from 85.1 to 30.9 events/day, $p < 0.001$). Pacing showed the largest absolute reduction (42.3 to 14.8 events/hour, $p < 0.001$). Behavioural diversity index (Shannon's H') increased from 1.24 to 2.18 ($p < 0.001$). These results demonstrate that multi-category enrichment programmes can substantially reduce stereotypic behaviour in captive Asiatic lions.

Keywords: Environmental enrichment, stereotypic behaviour, Asiatic lion, *Panthera leo persica*, captive wildlife, animal welfare, pacing, behavioural diversity, zoo management, Thailand

Introduction

Consider a lioness that has spent eight years in a 200 m² enclosure: she paces a figure-eight path so worn that bare earth tracks mark her route. This scenario, replicated in zoological facilities worldwide, illustrates the welfare crisis facing captive large felids ^[1, 2]. Stereotypic behaviours in zoo carnivores correlate with enclosure size, feeding predictability, and social stress, but they can be modulated through environmental enrichment—deliberate modifications to the captive environment designed to increase behavioural opportunities and reduce abnormal behaviour ^[3].

The Asiatic lion subspecies (*P. l. persica*) is critically endangered, with fewer than 700 individuals remaining in the wild ^[4]. Captive breeding programmes play a vital role in genetic management, making welfare optimisation both an ethical imperative and a conservation necessity—stressed animals reproduce poorly ^[5]. While enrichment efficacy has been documented for African lions, tigers, and leopards, species-specific data for Asiatic lions remain sparse ^[6, 7]. This research tested a structured multi-category enrichment programme in a Thai zoological facility housing Asiatic lions.

Materials and Methods

Materials

Eight Asiatic lions (4 males, 4 females; age 5-14 years) housed in two adjacent enclosures (280 m² and 310 m²) at the Chiang Mai Royal Zoological Institute were observed. The institutional animal welfare committee approved the protocol (CMRZI-AWC-2023-008). All lions had been captive-born and housed at the facility for at least three years.

Methods

Behavioural observations used continuous focal sampling with video recording during active

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periods (0600-1800 h) for four weeks pre-enrichment (baseline) and during weeks 1-4, 5-8, and 9-12 of enrichment. Stereotypic behaviours recorded were pacing, head bobbing, overgrooming, circling, and self-directed biting. Enrichment was rotated on a three-day cycle across categories: structural (day 1), sensory (day 2), feeding (day 3). Behavioural diversity was calculated using Shannon's diversity index (H'). Faecal glucocorticoid metabolites (FGM) were measured by enzyme immunoassay at baseline and week 12 [8]. Pre-post

comparisons used Wilcoxon signed-rank tests ($p < 0.05$).

Results

All eight lions showed reductions in total stereotypic behaviour by week 12. The most dramatic change occurred in pacing, which declined by 65% from baseline. Feeding enrichment produced the most immediate effect (observable within the first week), while structural enrichment gains accumulated more gradually.

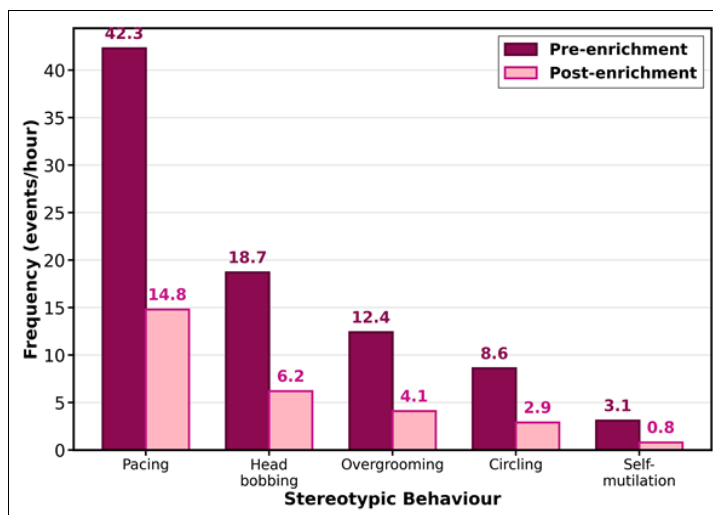


Fig 1: Frequency of stereotypic behaviours before and after the 12-week enrichment programme

Table 1: Stereotypic behaviour frequency and welfare indicators before and after enrichment

Indicator	Baseline	Week 12	p-value
Total stereotypies (events/day)	85.1 ± 14.3	30.9 ± 8.7	<0.001
Pacing (events/hour)	42.3 ± 7.2	14.8 ± 4.1	<0.001
Head bobbing (events/hour)	18.7 ± 4.6	6.2 ± 2.3	<0.001
Shannon's H'	1.24 ± 0.18	2.18 ± 0.24	<0.001
FGM (µg/g dry faeces)	148.3 ± 28.7	94.6 ± 19.4	0.008
Time resting (%)	62.4 ± 8.1	44.7 ± 6.3	0.004
Time exploring (%)	4.2 ± 1.8	18.6 ± 4.2	<0.001

Table 2: Enrichment category effectiveness by time period

Category	Weeks 1-4	Weeks 5-8	Weeks 9-12
Structural (Δ%)	-12.4	-28.7	-41.3
Sensory (Δ%)	-18.6	-31.2	-34.8
Feeding (Δ%)	-34.1	-48.6	-54.2

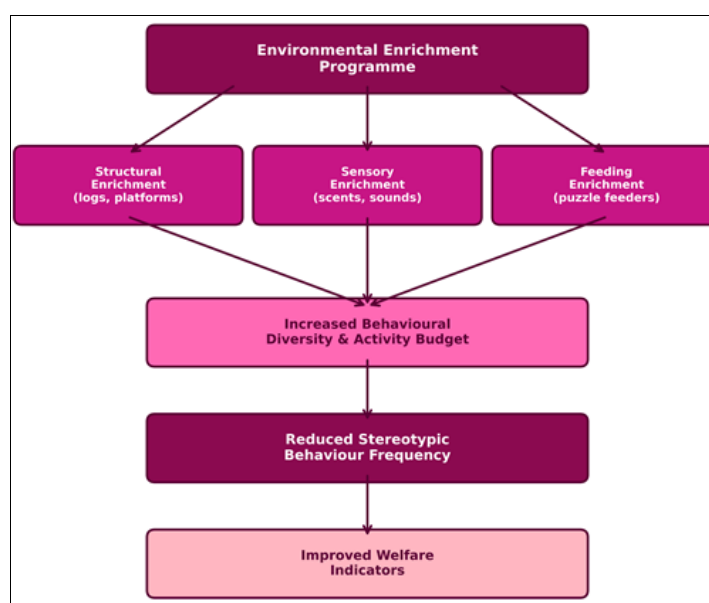


Fig 2: Schematic overview of the multi-category environmental enrichment programme and its proposed mechanism for reducing stereotypic behaviour

Discussion

The 63.7% overall reduction in stereotypic behaviour matches or exceeds results reported for African lion enrichment programmes in European zoos [6, 9]. Feeding enrichment was most effective, consistent with the hypothesis that feeding-related stereotypies in captive carnivores stem primarily from the absence of predatory foraging challenges [3, 10]. The FGM reduction of 36.2% provides physiological corroboration of the behavioural improvements, linking enrichment to reduced chronic stress [8].

One notable pattern was the cumulative effect of structural enrichment, which showed modest initial impact but the steepest improvement trajectory over 12 weeks. This suggests that physical environment complexity provides sustained benefit as animals gradually incorporate new features into their spatial repertoire, unlike novel sensory stimuli which may habituate more rapidly [7].

Limitations

The sample of eight lions at a single facility limits generalisability. Absence of a control group (enrichment withheld) means seasonal or other temporal effects cannot be excluded. Video analysis was labour-intensive and covered only daytime hours. Long-term persistence of enrichment effects beyond 12 weeks was not assessed.

Conclusion

The multi-category enrichment programme reduced stereotypic behaviour by nearly two-thirds in captive Asiatic lions, with feeding enrichment providing the most immediate benefits and structural enrichment showing the most sustained gains. The concurrent reduction in faecal glucocorticoid metabolites strengthens the welfare interpretation. Zoological facilities managing *P. l. persica* should consider implementing rotational enrichment as standard practice, with emphasis on feeding complexity and physical environment modification.

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