



Editorial

Fundamental Knowledge on Forgotten Species: An Exploration of Data from Rarely Studied Captive Animals

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Zoological institutions contribute a large amount of fundamental and applied knowledge on a diverse array of animal species. Despite this significant contribution, published research conducted within zoos or other captive wildlife facilities has historically been skewed toward charismatic mammals [1], which comprise only a small proportion of the species that are maintained in zoological collections, and are not reflective of taxonomic group sizing. Modern zoos play an important role in developing effective animal welfare, conservation, and environmental education; therefore, this shortfall in knowledge on “forgotten species” may have large, unseen, and negative impacts. The aim of this special issue was to encourage the reporting and publication of data on rarely studied species within captive facilities. This collection of 14 papers brings to light new information on a diverse range of taxonomic groups, from reptiles and birds, to amphibians and sharks.

1. Non-Avian Reptiles

Reptiles are a broad taxonomic group that are well-represented in zoo collections but for which there is limited experimental evidence for conditions that support good welfare. Enrichment is considered an essential component of appropriate captive husbandry for mammals, yet research on this aspect of welfare has been largely overlooked for reptiles, including the monitor lizards (Varanidae). To provide a base of knowledge for informing enrichment design, Howard and Freeman [2] undertook a scoping review of the physiological, cognitive, and behavioral abilities of Varanidae to suggest enrichment methods that may be appropriate and effective. They stressed the need for greater publishing and sharing of findings to promote positive quality of life for these species in captivity. Additionally, also with a focus on Varanidae, Waterman et al. [3] monitored the effect of food- and scent-based enrichment on three monitor lizard species, including Komodo dragons (*Varanus komodoensis*), reporting an increase in exploratory behaviour, with scent-based enrichment being as effective for encouraging natural behaviours as food. The effect of enrichment and environmental change was also explored by Turner et al. [4], who monitored the behaviour of three tortoise species after an enclosure size increase, the addition of floor substrate, or handling protocol adjustments. These changes primarily altered social interactions, but larger, more positive, environmental changes are proposed to improve behavioural diversity. Reptile social behaviour was also studied by Walsh et al. [5], who compared differences in sociality and congregation behaviour between captive and wild American alligators (*Alligator mississippiensis*). Social behaviours were much more frequent and diverse in the wild population, while captive activity budgets were dominated by a small number of non-social behaviours. The results of these studies show that there is more work zoos can do to improve the welfare of reptiles in their collection and promote full behavioural repertoires, as is encouraged in mammals.



Citation: Descovich, K.; Kemp, C.; Rendle, J. Fundamental Knowledge on Forgotten Species: An Exploration of Data from Rarely Studied Captive Animals. *J. Zool. Bot. Gard.* **2023**, *4*, 50–52. <https://doi.org/10.3390/jzbg4010005>

Received: 19 December 2022

Accepted: 19 December 2022

Published: 9 January 2023



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2. Birds

Birds such as the southern ground hornbill (*Bucorvus leadbeateri*) are intelligent and long-lived, which can present challenges for maintaining welfare in captivity. Brereton et al. [6] examined the effect of enrichment on the behaviour of two captive hornbills. Carcass provision resulted in long periods of food manipulation and plastic mirrors encouraged stalking and mirror pecking, similar to behaviours observed in wild hornbills, suggesting a positive effect of these enrichment types. In the paper by Bryant et al. [7], enclosure use by two blue-throated macaws (*Ara glaucogularis*) was explored, specifically the effect of UVA- and UVB-rich lighting on indoor area use. Macaws significantly increased the time they spent near the enriched lighting, suggesting indoor areas can be enhanced through lighting choice. Lastly, Thomas et al. [8] detailed the veterinary treatment provided to a zoo-housed Verreaux's eagle owl (*Bubo lacteus*) after toe constriction caused by plastic litter. While positive health outcomes were achieved, this case study highlights the dangers of macroplastic pollution to wildlife, even to those housed in a captive setting.

3. Amphibians

Two amphibian papers were represented in this Special Issue, both focused on behavioural indicators of stress and welfare. Dias et al. [9] developed the first ethogram for *Xenopus longipes* frogs through observation of a group of 24 individuals from this critically endangered species. This ethogram was then used to measure activity budgets and behavioural response to restraint during a routine health check. Many behaviours were significantly impacted in the period post restraint, suggesting health assessments should be non-invasive whenever possible. Similarly, Carter et al. [10] used food intake as a measure of stress in the terrestrial amphibian, *Herpele squalostoma*, after environmental disturbance imposed by floor substrate change for routine cleaning. Regardless of the food prey offered, substrate disturbance had a significant suppressive effect on feeding, and this behavioural indicator may be useful for future studies on the welfare of this caecilian species.

4. Sharks

The final paper in this special issue examined activity levels and three-dimensional space use in five captive sharks, all of different species. Hart et al. [11] found that area usage in the 'xy plane' was fairly consistent; however, time spent at different depths was uneven. Although space use and activity largely reflected the natural behavioural biology of each species, the behaviour of the smooth dogfish (*Mustelus canis*) was found to be abnormal, demonstrating the importance of monitoring behavioural patterns in captive sharks.

5. Mammals

Although mammals are a popular research focus of captive collections, there has been a bias towards primates, ungulates, and large carnivores. Several understudied mammalian species were represented by papers within this special issue. Free et al. [12] assessed the welfare of common cusimanse (*Crossarchus obscurus*) with an adapted 'Animal Welfare Assessment Grid'. Using resource- and animal-based measures, 21 factors were identified, and the final template was validated by retrospectively scoring the welfare of four zoo-housed individuals. With a focus on behaviour, Spiezio et al. [13] monitored two pairs of zoo-housed red pandas (*Ailurus fulgens*) using the 'Behavioural Variety Index'. Observed individuals performed approximately three quarters of all behaviours reported previously for this species and no abnormal behaviour was found. Behavioural activity, as well as space use, was also examined by Finch and Humphreys [14] for two Goodfellow's tree kangaroos (*Dendrolagus goodfellowi*), an endangered, arboreal macropod. High arboreal spaces were found to be of key importance, with more time spent at the top height by the tree kangaroos than at any other height. Lastly, the work of Truax et al. [15] focused on cognition in African crested porcupines (*Hystrix cristata*). This study used the 'loose-string task' to determine if porcupines, a cooperative breeder, can work with their partner to

receive a reward. Although the porcupines were successful in the task, they did not clearly demonstrate understanding of their partner's role in task success.

The collection of research in this special issue opens the door to future studies on these species, as well as the multitude of others in need of systematic observation and empirical assessment. We thank the authors for their contributions to this issue and for their commitment to the management of their respective study species. We hope their work encourages future and on-going programs of research that shed light on optimal management of these "forgotten species".

Author Contributions: Conceptualization, K.D., C.K. and J.R.; writing—original draft preparation, K.D., C.K. and J.R.; writing—review and editing: K.D., C.K. and J.R. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

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