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Understanding the welfare of aquarium fish

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Commentary on **Oldfield & Bonano** on *Fish Welfare*

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Abstract: Bony fishes (*Osteichthyes*) are prevalent in public and domestic aquaria, yet evidence-based welfare practices exist for only a limited number of species. Oldfield & Bonano's (O&B's) target article highlights critical questions about the wellbeing and sociality of *Osteichthyes*. Advancing research on their biology, physiology, psychology, and behavior is essential to develop and validate welfare measures, ensuring guidelines for welfare-focused housing and husbandry.

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The saying, "imperfect care given is better than perfect care withheld," while well-intentioned, should not justify inadequate animal husbandry. Oldfield & Bonano (2024) (O&B) stress the need for deeper research on aquarium fish to ensure proper care. Their target article advocates an evidence-based approach to improve the welfare of *Osteichthyes* in ex situ facilities. The need for scientifically grounded husbandry practices across taxa, beyond mammals, remains pressing, as noted by Melfi (2008) and further supported by Binding et al. (2020) and Rose et al. (2019).

O&B emphasize the dominance of mammals in zoo and aquarium research. This extensive mammalian research can inform experimental designs and protocols for non-mammalian species. Behavior, as an observable response to stimuli (Barnard, 1983), explains the mammalian and avian bias in behavioral literature reviews. These taxa are accessible and easy to observe. However, fish have also been central to pioneering behavioral studies, such as Tinbergen's work on three-spined sticklebacks (*Gasterosteus aculeatus*) (Tinbergen, 1952) and Lorenz's on moorish idols (*Zanclus cornutus*) (Howlett, 1999; Lorenz et al., 1998). Trinidadian guppies (*Poecilia reticulata*) are frequently used for research on social evolution (Croft et al., 2004) and behavioral plasticity (Fox et al., 2024). It is time to revive this focus on fish research in aquariums and use existing literature to develop methods for assessing welfare across fish species. As O&B advocate, robust evidence is crucial for ensuring methodological soundness in welfare studies.

O&B cite the AZA (Association of Zoos and Aquariums) definition of animal welfare, encompassing physical, mental, and emotional states measured over time. While welfare fluctuates based on experiences (Broom, 1988), we must critically examine how mental and emotional states are inferred, especially for fish. For most fish species, the priority should be improving welfare inputs: the resources and environments we provide. Regardless of the

assessment tools used, without evidence-based care and appropriate environments, positive welfare cannot be ensured

O&B rightly stress the need to better understand the biology, behavior, and husbandry of captive bony fish to ensure reliable welfare. The AZA's definition of welfare is commendable, but it must be grounded in practical, evidence-based care. For bony fish, gathering and applying this evidence on care and developing welfare indicators based on behavioral research is essential.

Understanding fish welfare is crucial. Although they are not bony fish, observations on wild lemon sharks (*Negaprion brevirostris*) show that chronic stress can lead to stereotypic swimming behavior (Miller et al., 2011). This suggests fish are highly responsive to their environment, which can have negative effects on them. Since stereotypic behavior indicates stress (Mason & Latham, 2004), more research is needed to define, measure, and assess these behaviors in aquarium fish as a key indicator of emotional and mental welfare.

O&B describe midas cichlids' (*Amphilophus citrinellus*) responses to their aquariums as anxiety, similar to the way Qualitative Behavioural Assessment (QBA) interprets animals' moods through behavior. Originally developed for farm livestock (Wemelsfelder et al., 2000), QBA has been trialed for farmed salmon (*Salmo salar*) welfare assessment (Wiese et al., 2023). Further adapting QBA for aquarium fish could help assess their internal states and responses to housing and husbandry. Collecting QBA data before, during, and after environmental enrichment or varying visitor intensity would provide insights into the effects of external stimuli.

Aquarium fish benefit from evidence-based environmental enrichment (Gatto et al., 2024) but providing enrichment needs to be grounded in biological evidence (Brereton & Rose, 2022). **Figure 1** outlines a process for determining enrichment needs: identifying desired behaviors, considering their function in the wild, adjusting the captive environment accordingly, and evaluating the outcomes after implementation.

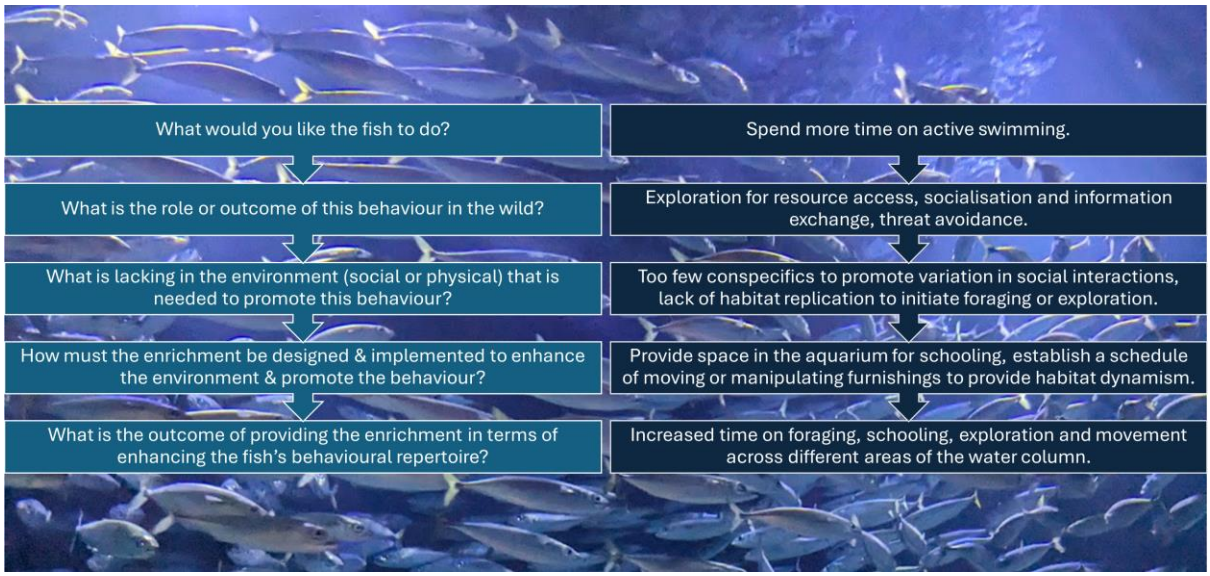

Figure 1: *Determining enrichment needs.* Five steps to understand how to deliver enrichment to aquarium fish based on a specific behavioural outcome or desired enhancement of an animal's behaviour pattern. Decision tree on the left, worked example on the right.

Finally, O&B raise the important issue of inactivity. Captive animals, though healthy and well cared for, may live in environments that are too comfortable. Inactivity is observed across species (Fureix & Meagher, 2015), and O&B wisely propose it as a research focus. Future zoo/aquarium inactivity studies could consider:

1. What are the long-term welfare impacts of inactivity?
2. Do inactive individuals face more health challenges?
3. Could inactivity lead to a loss of adaptive behaviors and phenotype changes over generations?
4. Does inactivity reinforce the misconception that fish have simpler needs than mammals?

Within a few generations captive fish have shown behavioral changes that are potentially maladaptive for the wild (Kelley et al., 2006). Promoting natural behaviors and reducing inactivity can be achieved through ecologically relevant enrichment. Since no single welfare measure is sufficient, a mixed-methods approach may be best: (i) reviewing bony fish biology and behavior, (ii) tailoring inputs like food, social grouping, and housing based on ecological knowledge, and (iii) collecting both quantitative and qualitative data on fish responses. This approach offers the most reliable means of improving husbandry and housing practices in ex situ facilities.

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