

Reevaluating Spider Nutrition: The Role of Arachidonic Acid in Captive Diets

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Highlights

- Captive spider diets often overlook essential fatty acid composition.
- Arachidonic acid (ARA) is a precursor for eicosanoid signaling implicated in arthropod development and reproduction.
- Available spider evidence links low dietary ARA to increased molting failure and juvenile mortality in a model species.
- Lipid-informed prey selection and enrichment can improve welfare and reproducibility in captive husbandry.

Abbreviations

ARA	arachidonic acid
DHA	docosahexaenoic acid
DW	dry weight
EPA	eicosapentaenoic acid
LA	linoleic acid
LC-PUFA	long-chain polyunsaturated fatty acid
MDS	Molting Death Syndrome

Abstract

This review examines spider nutritional physiology, which remains incompletely characterized despite spiders' importance in ecosystems and experimental settings. In captivity (including research facilities, zoological institutions, and private collections), feeding practices are often generalized and may not address metabolic demands that vary across taxa. Consequently, links between nutrition and outcomes such as growth, reproduction, and condition in captive spiders remain insufficiently delineated.

Recent work in arachnid physiology and lipid metabolism indicates that some husbandry practices warrant reevaluation. Arachidonic acid (ARA), an omega-6 fatty acid and precursor to eicosanoid signaling molecules, contributes to lipid-mediated pathways across animal taxa. In arthropods, eicosanoid pathways have documented roles in processes such as development and reproduction; corresponding mechanisms in spiders are less defined, leaving an important gap in arachnid nutrition research.

This review synthesizes evidence on the metabolic roles, dietary sources, and physiological relevance of ARA in spider nutrition. Available findings link lipids such as ARA with reproduction, cuticular maintenance, and metabolic function; low availability has been associated with stress responses, impaired development, and reduced fecundity in some captive contexts (Ginjupalli et al., 2015; Kangpanich et al., 2016; Stanley & Kim, 2018).

Integrating lipid analyses into captive management can support animal welfare, improve comparability across studies, and inform feeding practices for arachnids.

Keywords

arachidonic acid; spider physiology; nutritional biochemistry; lipid metabolism; captive husbandry; eicosanoid signaling; arachnid nutrition

Introduction

The captive rearing of spiders has expanded markedly in recent decades, reflecting their growing scientific and educational importance across disciplines such as arachnology, toxinology, developmental physiology, and behavioral ecology. In research institutions, zoological facilities, and private collections, spiders are now routinely maintained for controlled study of venom composition, reproductive mechanisms, and adaptation to environmental variation. Yet despite this proliferation of captive programs, nutritional practices remain largely empirical and are often not guided by biochemical or physiological data. Captive diets typically rely on accessible prey such as *Acheta domesticus* (house crickets), *Tenebrio molitor* (mealworms), and *Drosophila melanogaster* (fruit flies), selected for ease and availability rather than biochemical

congruence with natural diets. This generalized approach can overlook key aspects of arachnid metabolism, particularly lipid composition. Captive conditions can also influence spider performance and behavior (Trabalon, 2022) and interact with physiological constraints described for spiders across environmental gradients (Canals et al., 2015).

Among biochemical factors influencing arachnid physiology, arachidonic acid (ARA; 20:4 n-6) has received increasing attention in discussions of captive spider nutrition. ARA is a polyunsaturated omega-6 fatty acid and precursor to eicosanoids (e.g., prostaglandins, thromboxanes, and leukotrienes) that contribute to cellular signaling and homeostasis. In arthropods, eicosanoid pathways have been linked to multiple processes, including development and reproduction. Experimental work further indicates that dietary ARA availability may be associated with molting outcomes in spiders under captive conditions. For example, Wen et al. (2025) reported that juvenile *Pardosa pseudoannulata* deprived of ARA exhibited high mortality associated with failed ecdysis, whereas those supplied with ARA-enriched prey showed high survival to adulthood. The authors termed this outcome “Molting Death Syndrome” (MDS), characterized by incomplete or failed ecdysis and subsequent mortality.

Research in other arthropods suggests that ARA and downstream eicosanoids can contribute to immune function, reproduction, and development (Stanley, 2006; Stanley & Miller, 2006; Stanley & Kim, 2018). Despite these implications, standardized approaches for assessing, supplementing, or optimizing essential fatty acids in captive arachnid diets, particularly ARA, are not well established.

This review integrates biochemical, physiological, and ecological literature relevant to arachidonic acid in spider nutrition. By summarizing lipid-metabolism pathways governing ARA synthesis and utilization in arthropods, the paper proposes a conceptual framework for advancing dietary research in captive spiders. The framework emphasizes convergence between basic metabolic science and applied husbandry. Lipidomic profiling is discussed as a tool for guiding dietary assessment and reformulation. The aim is to support evaluation of how diet composition relates to health, longevity, and reproductive outcomes in captive spider populations.

Methods: Literature Search and Synthesis Approach

This review synthesizes published literature on spider nutrition, arachnid lipid physiology, and arthropod eicosanoid biology, with an emphasis on arachidonic acid (ARA) availability in common feeder insects and reported associations with spider developmental outcomes in captivity. The approach was narrative (non-systematic): sources were identified through iterative keyword-based searches and backward citation tracking, and were prioritized when they reported quantitative fatty-acid profiles,

controlled feeding comparisons, or mechanistic discussion of eicosanoid pathways relevant to arthropods.

Information sources and search strategy

Searches were conducted using combinations of terms related to spiders/arachnids, nutrition, fatty acids, arachidonic acid, eicosanoids, molting, and feeder insects. Additional sources were identified by screening reference lists of relevant articles.

Eligibility criteria and synthesis approach

Peer-reviewed articles were prioritized when they provided quantitative lipid/fatty-acid data, controlled feeding comparisons, or mechanistic discussion relevant to arthropod eicosanoid biology. Evidence was synthesized narratively to identify convergent findings, knowledge gaps, and practical implications for captive husbandry.

The husbandry of spiders in captivity spans a broad range of contexts, from highly regulated laboratory settings to public zoological exhibits and private arachnid collections. In these environments, feeding regimens are often formulated based on practical considerations, such as prey accessibility, ease of maintenance, and feeding frequency, rather than on a comprehensive understanding of species-specific nutritional or biochemical requirements. Frequently used prey include *Drosophila* spp., *Acheta domesticus* (house crickets), and *Tenebrio molitor* (mealworms), among other commercially available arthropods. While these prey items provide baseline macronutrient support, they may not replicate nutrient composition typical of spiders' natural diets, particularly with regard to essential fatty acids, vitamins, and trace micronutrients. This mismatch may exert cumulative physiological effects, influencing metabolism, development, and reproductive performance.

Empirical literature documents a range of challenges reported for spiders maintained in captivity, including irregular molting, reduced longevity, and variable reproductive performance. However, attributing these outcomes to specific dietary inadequacies is often difficult because captive studies frequently differ in enclosure design, microclimate, prey type, and husbandry routines. Trabalon (2022), for example, demonstrated that captive conditions (space and substrate) can rapidly alter behavior and body mass in a wolf spider, underscoring that non-dietary husbandry factors can also contribute to observed differences in condition.

Nutritional ecology provides a perspective for interpreting these deficiencies. It examines how dietary choice and nutrient availability relate to physiological function and provides models for how predators, including spiders, respond to variation in prey nutrient composition (Cuff et al., 2025).

These differences vary with the origin and rearing conditions of prey. Insects raised on standard commercial or laboratory substrates (e.g., cornmeal-, yeast-, or bran-based media) often contain lower concentrations of long-chain polyunsaturated fatty acids (LC-PUFAs), including arachidonic acid and eicosapentaenoic acid (EPA). In contrast, prey derived from aquatic or nutrient-enriched environments can accumulate higher levels of LC-PUFAs, yielding a profile closer to that of emergent aquatic insects. Comparative analyses have reported higher LC-PUFA concentrations in emergent aquatic insects than in terrestrial insects in the same systems (Parmar et al., 2022), which is relevant when selecting prey for captive diets.

Available evidence indicates that dietary composition, rather than caloric sufficiency alone, is associated with health, development, and survival in captive spiders. This pattern supports closer attention to prey nutrient profiles, including essential fatty acids such as arachidonic acid. Integrating lipid biochemistry, nutritional ecology, and applied husbandry helps evaluate dietary adequacy and reduce avoidable nutritional variation in captive settings.

Evaluating captive diets requires attention to the nutritional composition of commonly used prey items. As summarized in Table 1, the feeder insects compared here differ in total lipid content and in key fatty acids, including linoleic acid, arachidonic acid, eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA). These profiles show differences in the availability of essential fatty acids across prey species (Pérez-Santaescolástica et al., 2023; Udomsil et al., 2019; Wen et al., 2025). Such comparisons can guide prey selection and, when appropriate, supplementation strategies in captive settings.

Table 1. Comparative fatty acid profiles of commonly used captive prey items.

Prey Item	Total Lipid (% DW)	Linoleic (18:2 n-6), % total fatty acids	Arachidonic (20:4 n-6), % total fatty acids	EPA (20:5 n-3), % total fatty acids	DHA (22:6 n-3), % total fatty acids
<i>Acheta domesticus</i> (House cricket)	14.6 ± 0.7	17.3 ± 1.2	0.21 ± 0.04	0.05 ± 0.01	0.02 ± 0.01
<i>Blaptica dubia</i> (Dubia roach)	15.8 ± 0.9	12.4 ± 1.1	0.36 ± 0.05	0.08 ± 0.02	0.03 ± 0.01
<i>Tenebrio molitor</i> (Mealworm larvae)	28.1 ± 1.5	20.8 ± 2.0	0.18 ± 0.02	0.04 ± 0.01	0.01 ± 0.00
<i>Zophobas morio</i> (Superworm larvae)	27.3 ± 1.8	19.2 ± 1.4	0.25 ± 0.03	0.06 ± 0.01	0.02 ± 0.01

<i>Gryllus bimaculatus</i> (Field cricket)	13.9 ± 0.5	15.1 ± 1.0	0.41 ± 0.06	0.07 ± 0.02	0.03 ± 0.01
<i>Musca domestica</i> (Housefly larvae)	20.4 ± 1.3	10.7 ± 0.8	0.32 ± 0.05	0.09 ± 0.02	0.02 ± 0.01

Note. Total lipid is reported as percent dry weight (% DW). Individual fatty acids (linoleic acid, arachidonic acid, EPA, DHA) are reported as percent of total fatty acids. Values are shown as mean ± dispersion measure as reported (e.g., SD or SE). Abbreviations: ARA, arachidonic acid; DHA, docosahexaenoic acid; DW, dry weight; EPA, eicosapentaenoic acid; LA, linoleic acid.

Results: Evidence Synthesis

Arachidonic acid: biochemistry and relevance

Arachidonic acid (ARA; 20:4 n-6) is a long-chain polyunsaturated fatty acid with biochemical and physiological relevance. It functions as a structural component of cellular membranes and as a precursor in the biosynthesis of bioactive eicosanoids, including prostaglandins, leukotrienes, and thromboxanes. Across animal taxa, eicosanoids are lipid-derived signaling mediators with roles that vary by taxon and context. In vertebrates, ARA is synthesized from linoleic acid (18:2 n-6) through desaturation and elongation reactions catalyzed by Δ 6- and Δ 5-desaturases. In insects, evidence indicates that linoleic acid can be desaturated and elongated to ARA as part of eicosanoid biosynthesis, and that insect eicosanoid pathways differ in key enzymatic steps from vertebrate pathways (Stanley, 2006; Stanley & Kim, 2018). In spiders, the extent of endogenous ARA synthesis from shorter-chain precursors has not been established, and dietary ARA availability is a candidate determinant of development under captive conditions (Wen et al., 2025). As a result, discussions of ARA in spider nutrition focus on dietary acquisition as a contributor to physiological requirements.

Research attention to ARA in spiders has increased, particularly with respect to molting, a physiologically demanding phase of arachnid development. Molting involves coordinated cuticular synthesis, lipid mobilization, and hormone-mediated regulation (including via ecdysteroids). Wen et al. (2025) reported that juvenile *Pardosa pseudoannulata* deprived of ARA exhibited high mortality associated with failed ecdysis, whereas those supplied with ARA-enriched prey showed high survival to adulthood. In that study, ARA deficiency was associated with “Molting Death Syndrome” (MDS), characterized by incomplete or failed ecdysis and subsequent mortality. Beyond molting, ARA-derived eicosanoids have established roles in reproduction in other arthropods (e.g., oocyte maturation, sperm differentiation, fertilization), but spider-specific evidence remains limited. Work in other arthropods links inadequate dietary ARA with reduced fecundity, embryonic viability, and offspring development, outcomes that can destabilize captive populations.

Dietary sources of ARA vary according to the ecological origins of prey. Aquatic insects and certain dipteran species can accumulate relatively high levels of long-chain polyunsaturated fatty acids, including ARA, due to the fatty acid composition of their food sources and environments (Kowarik et al., 2021).

In contrast, terrestrial insects cultivated on standard laboratory or commercial media (typically cornmeal, yeast, or bran-based substrates) often contain comparatively low concentrations of arachidonic acid and related fatty acids. Differences in prey nutritional ecology may therefore correspond to differences in physiological outcomes for arachnid predators. Consistent with this possibility, experimental evidence indicates that including ARA-rich prey or ARA-enriched prey in captive feeding regimes has been associated with higher juvenile survival and successful molting under some conditions (Wen et al., 2025). More broadly across arthropods, dietary ARA supplementation has been associated with improved reproductive performance in controlled feeding studies (Ginjupalli et al., 2015; Kangpanich et al., 2016).

These findings are consistent with a nutrient-informed approach to arachnid husbandry. Prey selection based on lipid and fatty acid profiles, together with supplementation of arachidonic acid when natural sources are limited, may help address potential gaps in captive diets. Aligning husbandry practices with hypothesized metabolic requirements may also support interpretability of captive studies and guide further research on arachnid nutritional physiology.

Evidence for arachidonic acid in spiders

The empirical basis for considering arachidonic acid (ARA; 20:4 n-6) in spider nutrition has expanded through recent experimental work examining associations with survival, molting, and developmental physiology under captive conditions. Wen et al. (2025) provided a detailed evaluation of ARA-related outcomes in arachnids using *Pardosa pseudoannulata* as a model organism. The authors conducted two complementary experiments that examined how dietary ARA influences molting success and juvenile survivorship. In the first experiment, juvenile spiders were assigned to three diet groups: midges, naturally rich in ARA; fruit flies reared on conventional laboratory media; and fruit flies experimentally enriched with ARA. Spiders consuming either ARA-rich midges or ARA-supplemented fruit flies exhibited high survival to maturity, whereas those maintained on unmodified fruit fly diets showed mortality rates exceeding 90%. These findings suggest that dietary ARA availability may be associated with successful development under captive conditions.

In the second phase of the study, Wen et al. analyzed the fatty acid composition of the prey items to identify biochemical constituents associated with the observed survival differences. Among the thirty-five fatty acids examined, arachidonic acid showed a

statistically significant positive correlation with survival and molting success. This result is consistent with an association between ARA availability and ecdysial success under the study conditions. The authors linked ARA deficiency to MDS (i.e., incomplete or failed ecdysis followed by mortality). These observations are consistent with a role for ARA in metabolic and hormonal processes involved in exoskeletal regeneration and cuticle synthesis.

The implications of these findings beyond *P. pseudoannulata* remain uncertain because the Wen et al. (2025) experiments were conducted in a single species under controlled conditions. The study provides proof-of-concept that a specific long-chain PUFA (ARA) can be limiting for successful molting and survival when spiders are maintained on an ARA-deficient monotypic prey diet. Comparative work across taxa and husbandry contexts is needed before thresholds or sensitivities are generalized across spider lineages.

Limitations of spider-specific evidence. Direct experimental evidence linking dietary arachidonic acid (ARA) to physiological outcomes in spiders remains limited. At present, the clearest controlled evidence is from a single-species juvenile model (*Pardosa pseudoannulata*) under defined prey conditions (Wen et al., 2025). Accordingly, proposed roles for ARA in adult performance and reproduction in spiders should be treated as hypotheses and interpreted cautiously; where discussed, they are informed primarily by broader arthropod eicosanoid and nutrition literature rather than spider-specific trials.

Experimental and comparative findings support arachidonic acid as a relevant dietary component in captive spider husbandry. In particular, low ARA availability in commonly used feeder insects may be associated with adverse outcomes reported under captive conditions, including molting failure. Potential links to reproductive output in spiders remain plausible but are not yet well established, and much of the direct experimental evidence currently pertains to juvenile survival and molting in *Pardosa pseudoannulata* (Wen et al., 2025). Future work that quantifies ARA requirements across taxa and life stages and evaluates practical supplementation strategies would help refine husbandry protocols and improve interpretability of captive studies.

Findings from Wen et al. (2025) support an association between dietary arachidonic acid availability and molting success in juvenile spiders under the study conditions. Broader arthropod literature on eicosanoid biology is consistent with the interpretation that ARA can function as both a nutrient and a signaling precursor with relevance for arachnid physiology.

Discussion

Interpretation and practical implications

Evidence that arachidonic acid (ARA; 20:4 n-6) is relevant to spider development suggests that common feeding practices in research, zoological, and private settings may not fully account for prey lipid composition. Captive diets often emphasize prey availability and general macronutrient content, with less attention to fatty acid profiles. Gut-loading and other enrichment approaches have been proposed as strategies to modify the nutritional composition of feeder insects. In experimental work by Wen et al., juvenile *Pardosa pseudoannulata* maintained on ARA-deficient prey experienced high mortality associated with failed ecdysis, whereas juveniles provided ARA-enriched prey showed high survival. These results indicate that targeted modification of prey fatty acid composition can influence developmental outcomes under captive conditions.

Potential husbandry approaches include (a) increasing prey diversity and incorporating prey types with higher long-chain polyunsaturated fatty acid content when feasible, (b) enriching commonly used prey via gut-loading or direct fortification to increase ARA availability, and (c) tracking outcome measures that may be sensitive to lipid adequacy (e.g., molting success, juvenile survival, growth trajectories, and reproductive output). These approaches are presented as practical options derived from the available evidence base and may require validation across taxa and husbandry contexts.

These husbandry considerations apply across captive contexts. In research laboratories, standardized prey selection and enrichment protocols can improve reproducibility by reducing nutritional variability as a confound. Within zoological collections, diet composition contributes to maintaining display and breeding populations, although spider-specific evidence linking ARA to reproductive outcomes remains limited. For private keepers, attention to the lipid composition of cultured or commercially sourced prey, combined with feasible enrichment practices, is associated with fewer chronic husbandry issues, including molting complications; claims regarding improved reproductive success remain tentative pending controlled spider studies.

Lipid-informed feeding practices shift emphasis from prey quantity to prey composition. Aligning prey selection and enrichment with hypothesized physiological requirements reduces nutritional variability in captive studies and supports refinement of feeding protocols across captive contexts.

Recommendations for practice

This conceptual workflow outlines one approach for implementing arachidonic acid (ARA) considerations within captive spider husbandry. The steps integrate nutritional

assessment, biochemical monitoring, and adaptive management within a cyclical framework aligned with common practices in invertebrate physiology and nutritional ecology. The approach emphasizes iterative evaluation and documentation through controlled supplementation and outcome tracking:

- Prey lipid profiling: Conduct biochemical analyses of feeder insects to determine baseline fatty acid composition, emphasizing arachidonic and linoleic acid content.
- Nutritional assessment: Evaluate prey profiles against established or hypothesized arachnid requirements to identify deficiencies.
- Controlled feeding trials: Introduce diet variations under standardized conditions to assess outcomes such as molting success, reproduction, and survivorship.
- Physiological and biochemical monitoring: Track metrics such as hemolymph composition, molting interval, and brood viability.
- Data integration and adjustment: Refine diets based on outcomes and analyses.
- Protocol documentation and sharing: Record feeding protocols and outcome measures and, where appropriate, share methods and results through institutional channels or the research literature.

Limitations and future directions

Despite recent findings reported by Wen et al. and related investigations, gaps remain in understanding the physiological and ecological functions of arachidonic acid (ARA; 20:4 n-6) across spider taxa. Although *Pardosa pseudoannulata* appears sensitive to low ARA availability, interspecific variation in ARA requirements is plausible (Wen et al., 2025). Comparative studies of prey fatty acid profiles provide additional context for these dietary considerations (Parmar et al., 2022). Ecological specialization, prey preference, and habitat type may contribute to variation in both quantitative requirements and biochemical utilization. Accordingly, determining taxon-specific thresholds for ARA sufficiency and deficiency remains an important objective for future research.

A second unresolved question concerns life-stage-specific differences in ARA requirements. Current evidence indicates that juvenile spiders are particularly vulnerable to ARA deficiency, which can manifest as molting failure and decreased survivorship (Wen et al., 2025). However, the nutritional needs of adult spiders, particularly with respect to reproduction, immune function, and longevity, remain insufficiently characterized. In other arthropods, eicosanoid signaling has been linked to both reproduction and immune responses (Stanley, 2006; Stanley & Miller, 2006; Stanley &

Kim, 2018), and dietary ARA availability has been associated with reproductive outcomes in controlled studies (Ginjupalli et al., 2015; Kangpanich et al., 2016). Establishing whether analogous relationships apply in adult spiders is essential for designing dietary models that accurately reflect physiological requirements across the life cycle.

Third, interactions between ARA and other nutritional constituents require systematic investigation. Polyunsaturated fatty acids (PUFAs) operate within metabolic networks involving sterols, proteins, and carbohydrates, each of which can modulate ARA bioavailability and utilization. Although Wen et al. controlled for several macronutrients, they noted that broader nutritional interactions might amplify or offset the effects of ARA supplementation. Investigating these relationships, particularly among ARA, linoleic acid (LA; 18:2 n-6), and eicosapentaenoic acid (EPA; 20:5 n-3), may help clarify the integrated lipid physiology underlying arachnid development and homeostasis.

Fourth, applied methodologies for ARA supplementation in captivity remain limited and under-standardized. Strategies such as gut-loading prey with nutrient-enriched substrates, directly fortifying prey tissues with ARA, or routinely monitoring prey lipid profiles appear promising, but protocols are not yet methodologically consistent. Developing reproducible, cost-effective, and scalable supplementation approaches suitable for research, zoological, and private husbandry contexts would improve the reliability of nutrient management across captive spider populations.

Finally, the ecological relevance of ARA in natural diets warrants focused investigation. Establishing how ARA availability varies across prey communities in the wild would provide essential context for interpreting laboratory results and refining captive feeding regimes, particularly for species with narrow trophic specialization or habitat restriction. Addressing these questions will likely require multidisciplinary research that integrates lipidomics, behavioral ecology, and experimental husbandry, including quantitative profiling of prey and spider tissues, and controlled manipulations of dietary ARA to evaluate outcomes such as survival, molting efficiency, and reproduction.

Conclusion

Recent arachnid nutrition research identifies arachidonic acid (ARA; 20:4 n-6) as a candidate dietary component for spiders, particularly in captive environments where commonly used prey species do not match the fatty acid profiles of natural prey. Wen et al. (2025) reported associations between dietary ARA availability and outcomes including juvenile survival and successful molting in *Pardosa pseudoannulata* under a monotypic prey regime. These findings indicate that prey composition, in addition to prey availability, warrants consideration in captive feeding protocols. Integrating lipidomic approaches with applied husbandry provides a practical basis for evaluating diet

composition and supporting evidence-informed management across institutional and private settings.

Arachidonic acid can be treated as a focal variable linking mechanistic research with husbandry practice. Evidence summarized here, including findings from Wen et al. (2025) and related work on eicosanoid biology in arthropods, supports the interpretation that low dietary ARA availability can be associated with molting failure and reduced juvenile survivorship under some captive conditions. Potential associations with reproduction in spiders remain a hypothesis rather than an established conclusion. These uncertainties motivate nutritional interventions designed as controlled tests. Further work assessing ARA-informed diet design across research laboratories and zoological facilities may clarify effects on health outcomes and improve consistency in captive management.

Limitations. Spider-specific experimental evidence on dietary arachidonic acid remains limited, and the strongest controlled data currently derive from a juvenile single-species model (*Pardosa pseudoannulata*) under defined prey conditions (Wen et al., 2025). Accordingly, broader inferences about adult outcomes, including reproduction, should be interpreted cautiously until replicated across additional taxa, life stages, and husbandry contexts.

Integrating biochemical measures, including lipid profiling, with husbandry practice can advance understanding of spider nutritional physiology and inform captive feeding protocols. Collaborative work spanning laboratory, zoological, and private settings supports rigorous evaluation of dietary requirements across taxa and life stages.

Ethics Statement

This study involved no live experimentation. All information derives exclusively from published literature and standard husbandry practices. No institutional animal care approval was required.

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Competing Interests

The author declares no competing interests.

Author Contributions

Luis A. Roque: Conceptualization; Investigation; Writing - original draft; Writing - review & editing.

Data Availability

No new data were generated for this review. Data sharing is not applicable to this article.

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