Cricket species vary in gut loading capacity: Implications for delivery of carotenoids to amphibians

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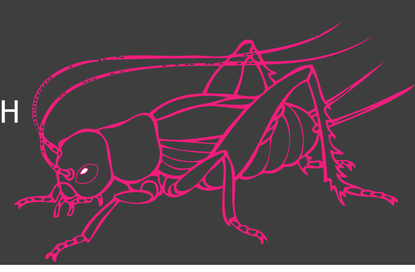


Introduction

Captive insectivore nutrition

There are a very limited number of commercially available invertebrates used as prey items for captive insectivores. Furthermore, previous studies have shown that most feeder invertebrates are of poor nutritional quality. Captive insectivores may therefore be prone to diseases related to nutritional inadequacies. Prey species may be fed on specific nutrients that are required in the insectivore diet. This is termed 'Gut-loading', and is often used to improve the quality of feeder invertebrates.

Carotenoids

Why are we interested in carotenoids?

Carotenoid pigments have roles in antioxidant systems, cell signalling pathways, immune systems, reproduction and colouration in several vertebrate tax*a*.

Carotenoid pigments are obtainable by vertebrates exclusively from the diet.

Sources include plants, bacteria, fungi, and prey animals that have themselves fed on carotenoid producing organisms.

Captive insectivores, particularly amphibians, often display sub-optimal colouration. This may be caused by dietary carotenoid deficiencies, which may have implications for animal health. Changes in colour may also affect behaviour, and may reduce suitability for re-introduction to the wild. Frogs feed on motile prey, therefore invertebrates must be gut-loaded in order to incorporate carotenoids into the frog diet.

Aims

To examine factors that influence gut-loading in commonly used feeder invertebrates to optimise carotenoid delivery to captive insectivores.

Factors examined included:

Are all species equal?
Interspecific variation in gut-loading capacity and nutrient retention

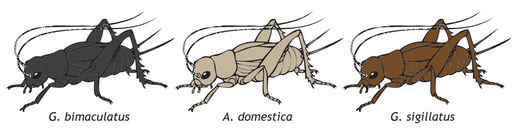
Are all diets equal?
Variation in carotenoid composition among standard cricket diets

Are all ages equal?
Ontogenetic variation in gut-loading capacity within one species

Methods

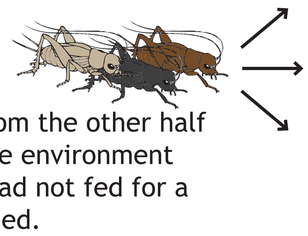
Are all species equal? Are all diets equal?

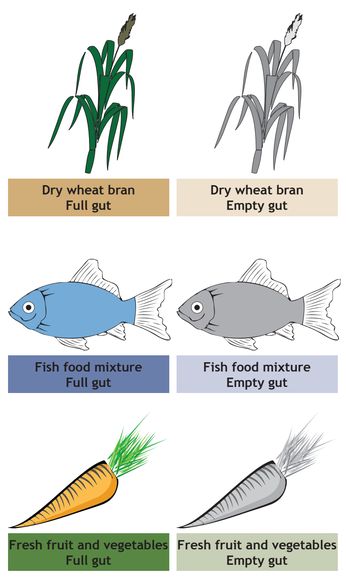
Prey survey
A survey was conducted across European institutions to establish which species of feeder insectivores are most commonly used. *Gryllus bimaculatus*, *Gryllodes sigillatus* and *Acheta domestica* were favoured so were used in our experiments.



Dietary manipulation
3rd instar crickets were separated into 54 plastic faunaria with approximately 100 individuals in each.

All were maintained for four days on one of three diets.





Crickets from half of the containers had access to food for a further 48 hours (full gut). Crickets from the other half of the containers were starved for 48 hours (empty gut). This was to simulate feeding in the captive environment so that the nutritional quality of freshly gut-loaded crickets could be compared with crickets that had not fed for a number of days i.e. those that remain temporarily in insectivore enclosures before they are consumed.

There were three repeats of each feeding block per species.

Carotenoid composition and concentration were analysed by HPLC.

Are all ages equal?

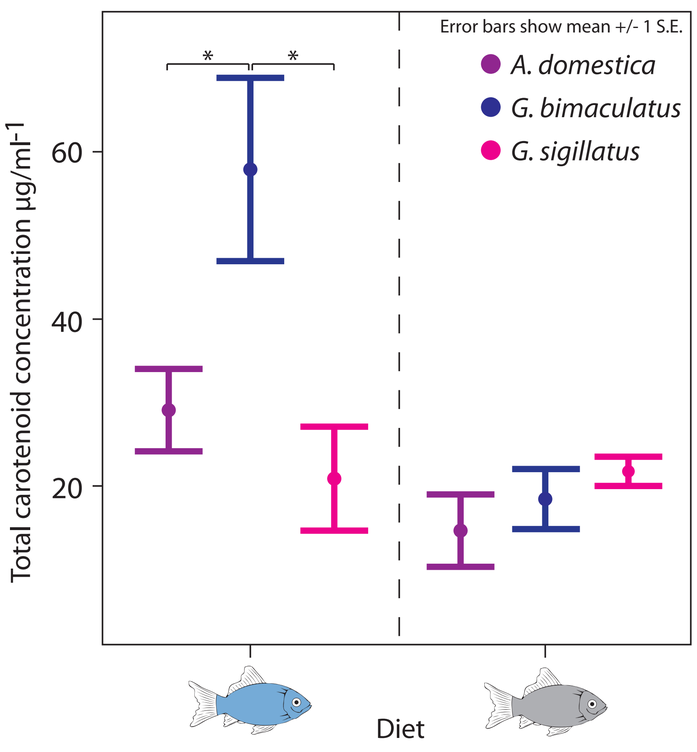
Dietary manipulation
1st, 2nd, 3rd, 4th, and 5th instar *G. bimaculatus* crickets were separated into 18 plastic faunaria with approximately equal overall mass in each. (There were 3 repeats per instar)

Crickets were fed *ad libitum* on a fish food mixture diet for four days.

Approximately equal mass of crickets from each container were used in subsequent carotenoid analysis.

Results and Conclusions

Are all species equal?



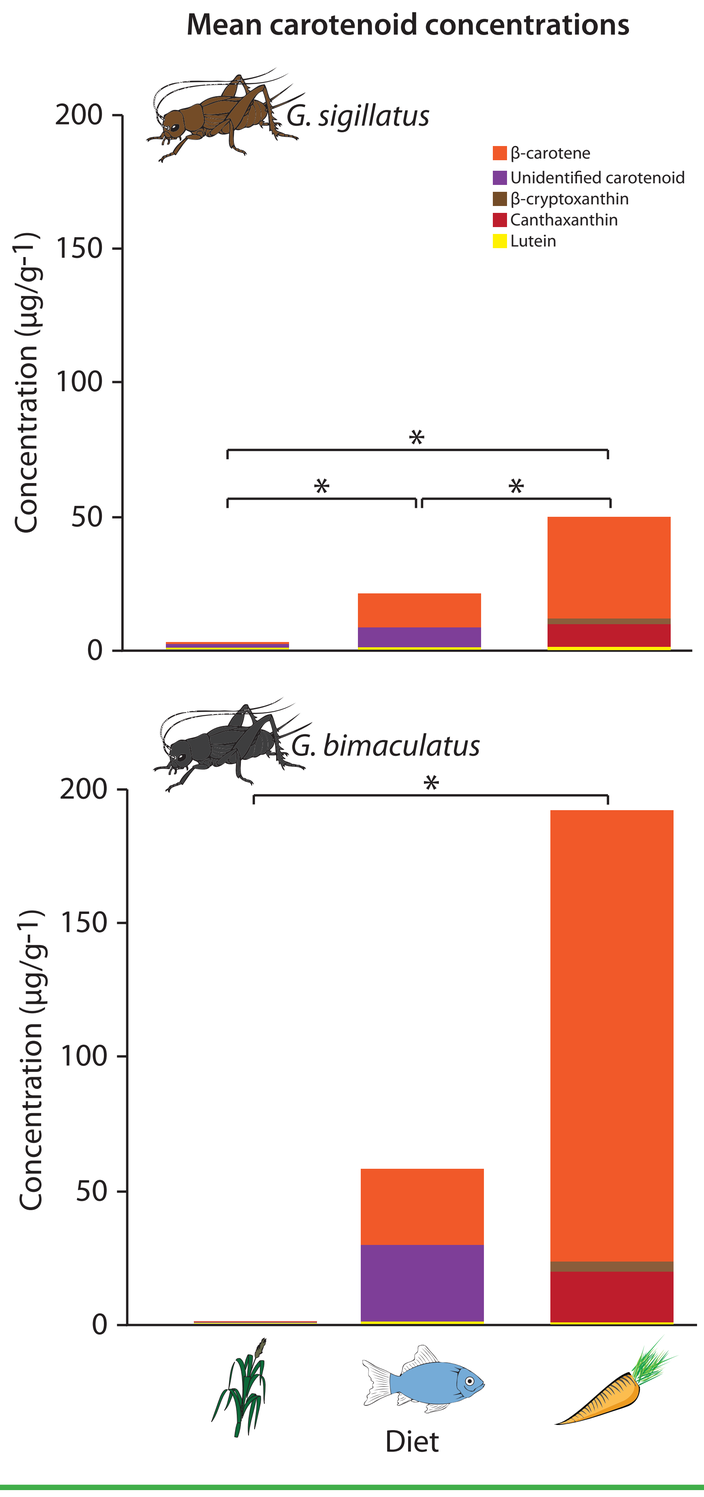
No, not all species are equal.
There were significant species differences in gut-loading capacity: *G. bimaculatus* had a greater capacity than *A. domestica* or *G. sigillatus*.

Conclusion: Nutrient delivery to captive insectivores could be optimised by selecting species with high gut-loading capacity.

Starvation significantly reduced carotenoid concentration in *G. bimaculatus* crickets. Starvation did not significantly reduce carotenoid concentration in *A. domestica* or *G. sigillatus*.

Conclusion: Feeder invertebrates should have continuous access to food until they are fed to insectivores. Invertebrates that remain uneaten in insectivore enclosures for 48 hours or more may be of poor nutritional quality in terms of carotenoids unless they have access to carotenoid rich foods within the enclosure.

Are all diets equal?



All diets are not equal.
There was a significant difference in total carotenoid concentration between the three diets for *G. sigillatus* and *G. bimaculatus*.
(*G. sigillatus*: GLM: F2,8=38.073, p=<0.001) (*G. bimaculatus*: GLM: F2,8=6.306, p=0.034)

There was no significant difference in total carotenoid concentration between the three diets for *A. domestica*.
(GLM: F2,8=1.699, p=0.260)

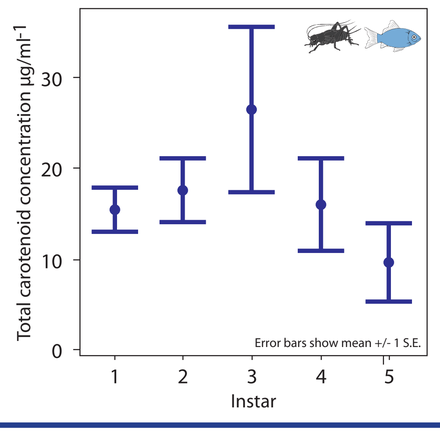
Conclusions: Crickets fed on a diet of fresh fruit and vegetables will deliver the greatest concentration of carotenoids to captive insectivores.

Commercially available invertebrates are usually despatched with bran as food. We found that crickets fed on bran had very low carotenoid concentrations. Therefore, invertebrates that are fed to captive insectivores without being gut loaded will deliver almost no carotenoids.

Are all ages equal?

All ages are equal for *G. bimaculatus*.
There was no significant difference in total carotenoid concentration between different instars of *G. bimaculatus* crickets.
(GLM: F4,14=1.259, p=0.348)

Conclusion: This suggests that, for *G. bimaculatus*, carotenoid delivery to captive insectivores may be boosted through gut-loading irrespective of the size used.



Main conclusion

Cricket **species** and **diet** should be taken into consideration in order to optimise carotenoid delivery to captive insectivores.