



Testing macronutrient imbalance as a key factor limiting range expansion in herbivores



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OVERVIEW

The South American Locust (*Schistocerca gregaria*) is experiencing the greatest population upsurge in 60 years. In 2017, large swarms left their small permanent breeding zone in NW Argentina and invaded Bolivia and Paraguay, and expanded throughout Argentina. The RAPID grant allowed researchers to collect time-sensitive data on locust macronutrient balancing in the field, which has emerged as a key factor in regulating insect behavior, physiology, and performance. We tested the hypothesis that *S. gregaria* in their expansion zones are unable to obtain food of sufficiently high carbohydrate:protein ratio to maximize their fitness.



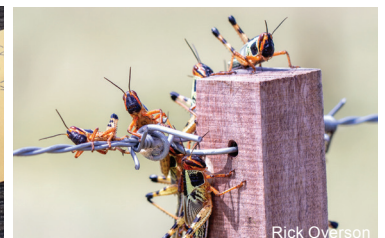
Jon Harrison



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OBJECTIVE 1

What are the nutrient landscapes available to locusts in the outbreaking regions?

OBJECTIVE 2

How does the nutrient landscape affect the behavioral and physiological responses of the locusts?

OBJECTIVE 3

How does dietary protein:carbohydrate ratio affect migratory capacities?

OBJECTIVE 4

How does temperature affect locust performance and distribution?



Jon Harrison

FIELD WORK IN GRAN CHACO PARAGUAY APRIL 2019

The field team gathered data on nutritional physiology and thermal biology with collaborators from Argentina, Bolivia, and Paraguay during continuing locust outbreaks in Paraguay.



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NUTRITIONAL ECOLOGY

Most organisms have an ideal balanced diet (e.g. protein to carbohydrate ratio) that allows them to function optimally. Performance (survival and reproductive success) increases when an organism consumes close to the preferred protein to carbohydrate ratio.

INVOLVEMENT

This RAPID supported postdoctoral, graduate and undergraduate student training, including providing the opportunity for one postdoc and one graduate student to work internationally during a locust plague.

OUTCOMES

In central Argentina and the edge of the locust's range in Bolivia and Paraguay, most of the plants we sampled were protein biased with protein:carbohydrate ratios greater than 1. During the Paraguayan field trip, we studied the behavioral and physiological responses in juvenile locusts collected from outbreak

populations. Marching locust bands ate readily from dishes of carbohydrate-rich, but not protein-rich, diets. When given a choice, locusts selected a carbohydrate-rich diet with a protein:carbohydrate ratio of 1:2, grew and survived better on diets with higher carbohydrate content, and ate more of carbohydrate-rich plants. We confirmed these findings for lab-reared *S. cancellata*, enabling us to control for many environmental factors that may have occurred in the field. Plants or diets high in carbohydrate were necessary for locusts to accumulate sufficient fat to migrate.

S. cancellata selected microsites that allowed them to maintain body temperatures near 40°C that maximized digestive performance, and modeling suggests that temperature affects the southern but not northern range limits of this species.



Jon Harrison

BIG PICTURE

Our results have informed pest management strategies by showing how different crops and/or natural vegetation assemblages affect locust performance. This information will allow managers to better target pesticides for specific locust populations. For example, locusts eating crops containing insufficient carbohydrate will be less viable, less able to migrate, and potentially more susceptible to pathogens, making fungal biopesticides a more feasible treatment option. Locusts are a major challenge for food security globally, with outbreaks causing up to 80-100% crop losses. By working with national plant protection organizations, this research can be directly applied to strategies to improve livelihoods, human and environmental health, and global food security.