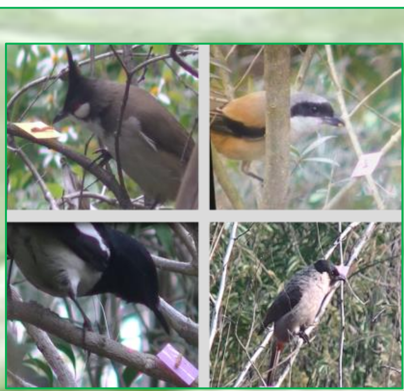
The effect of mimicry frequency on natural predation in a Batesian mimicry system



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Introduction

Batesian mimicry, in which palatable species resemble unpalatable ones in order to avoid predation, is a classic example of natural selection. In Batesian mimicry system, mimics are costly to models because their presence increases predation.

- **How does mimic frequency affect predation?**
  - Predator psychology models predict a linear relationship between mimic frequency and predation (e.g., Ihalainen et al. 2007; **I A**)
  - Laboratory studies show concave-up curvilinear relationship (**I B**), suggesting a threshold, over which predators switch strategies.
- **How do predators adjust their attack strategies to respond to mimicry frequency?**
  - Studies have shown that avian predators use taste-rejection (i.e., they reject prey if it is bad taste) attack strategy to respond the chemical defense of unpalatable prey (e.g., Guilford 1994).
  - Taste-rejection can stabilize the investment of chemical defense, since unpalatable prey may survive at high rates if only attacked, and not killed (e.g., Gamberale-Stille and Guilford 2004).

However, how mimic frequency affects predation and taste-rejection in nature is poorly understood, since most of studies have been conducted under lab conditions, and only in single species. Here we studied how mimic frequency affects predation and taste-rejection, in a wild bird community of an urban tropical city.

Methods

- **Study sites**: six parks 2 km apart (**Figure II A**). Each has different mimic frequency (0%, 20%, 40%, 60%, 80%, 100%)
- **Prey**: mealworm stapled to bright colored background. Prey of 2 types:
  - **Control**: injected with 0.02 ml water
  - **Model-mimic complex:** mimics injected with 0.02 ml 3% quinine sulfate, models with water. Mimic and models appear identical. The frequency of mimics varies by park.
- Color of background (pink or yellow) systematically assigned to one type of prey, with the other type having the opposite color.
- **Field work**: For 4 days, undefended worms on blue background make birds accustomed to this novel prey type. Then in next 4 days we present the two types of prey described above.
  - Prey are placed in 10 subsites of the park (**Figure II B**), at least 15 m apart. In each subsite, 10 control worms are placed in a cluster (1.5 m^2) and another cluster of 10 model-mimic complex worms are nearby (1 m; **Figure II C**).
  - Prey are presented in morning, and reassessed 2 hours later. If some of worm remained, we scored it as "no head", "no tail", or "half left".

Figure I

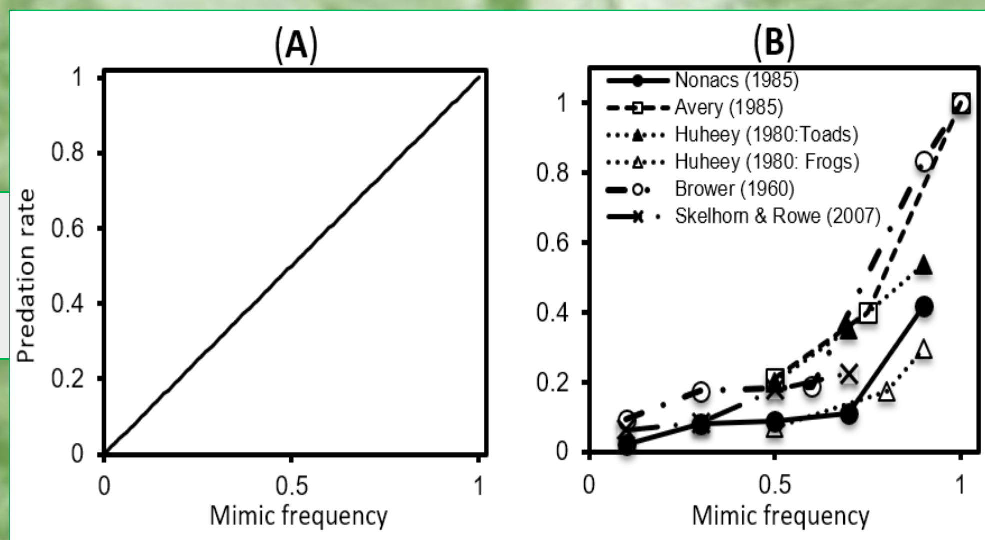


Figure II

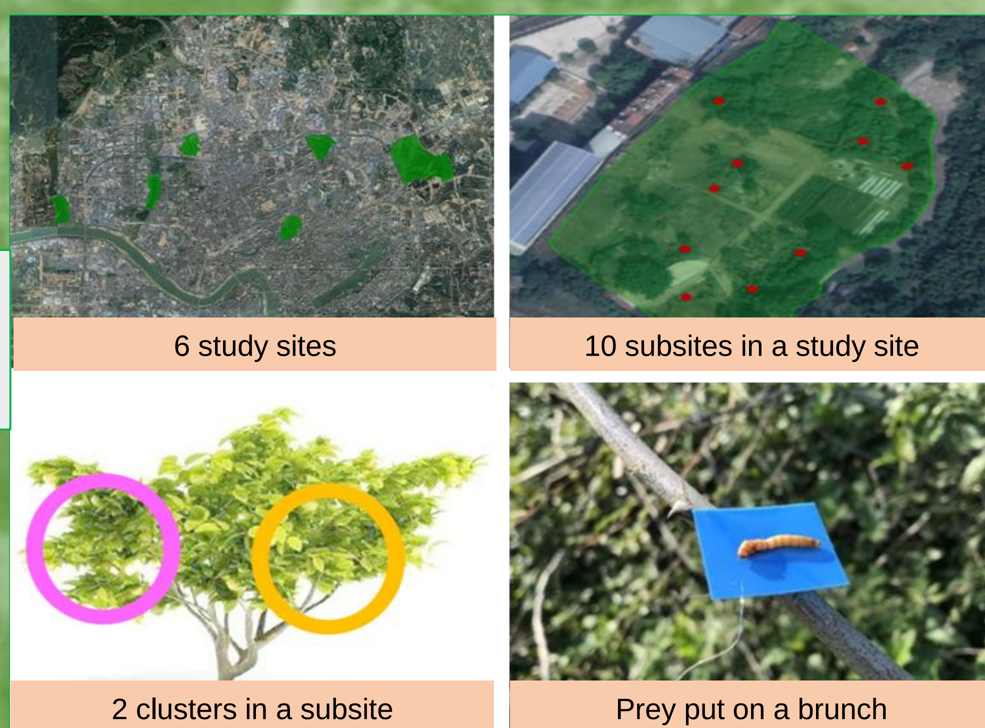


Figure III

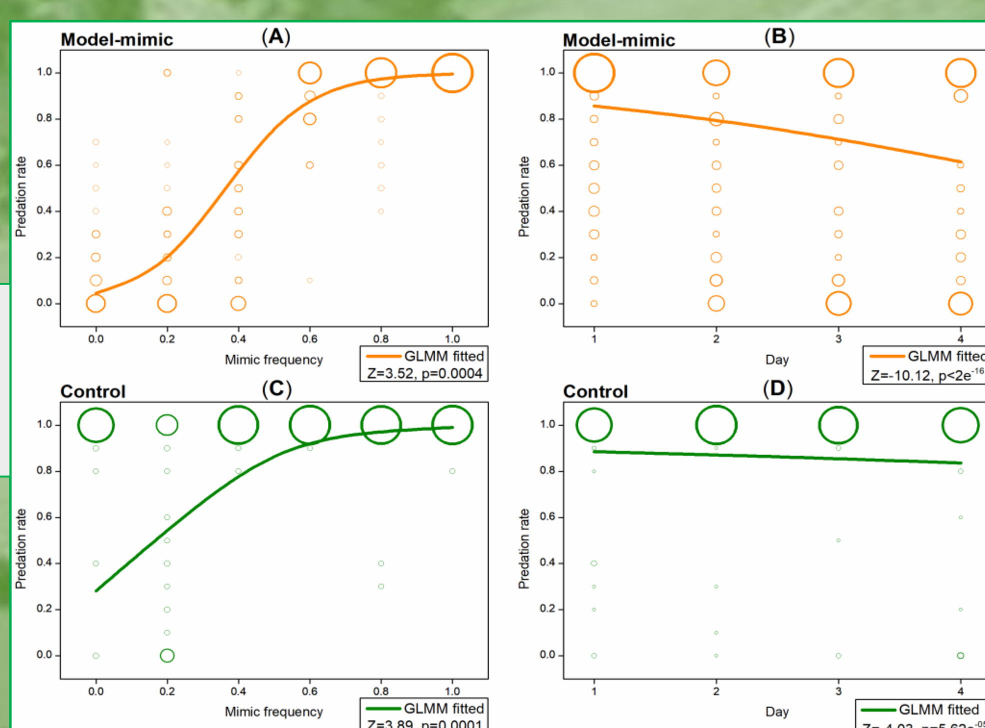
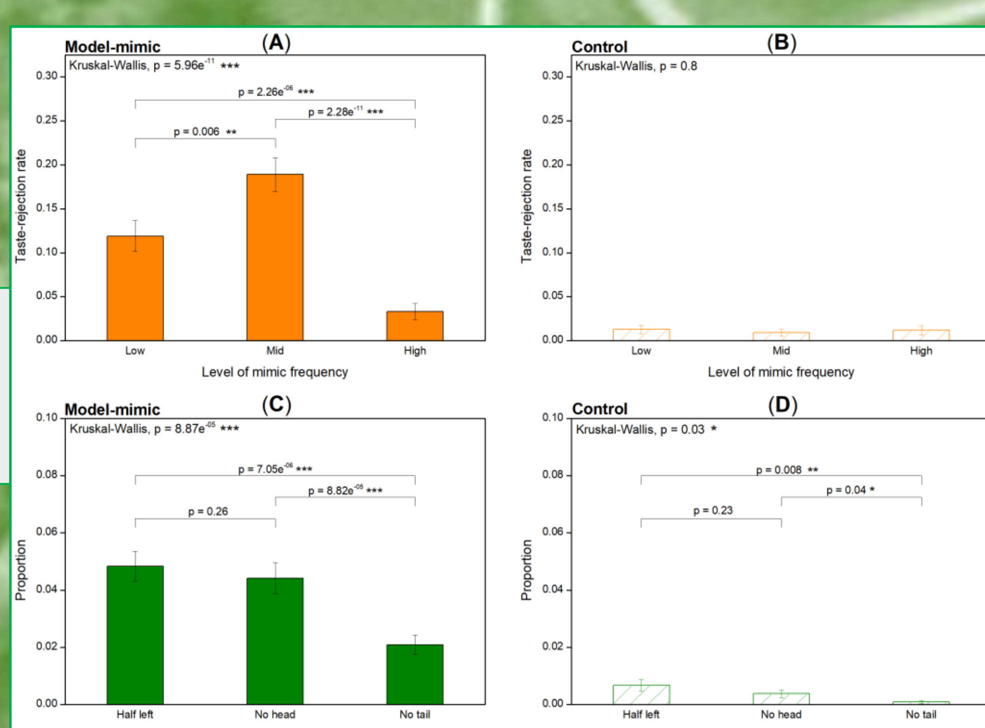


Figure IV



Results

Mimic frequency and predation

- Found a S-shape relationship between mimic frequency and predation (**Figure III A**). Predators showed low attack rate when mimics represented < 20% and high attack rate when mimics represented > 60% of the population.
- Strong evidence of learning showed at low mimic densities, as predation drops day-by-day over the 4 days (**Figure III B**).
- Similar trends in control (**Figure III C** and **D**): some "spill-over" where when models present, birds reject all mealworms.

Mimic frequency and taste-rejection

- Partially consumed worms were most often seen at intermediate levels of mimic frequency (40, 60%), see **Figure IV A**.
- There were more "half left" and "no head" than "no tail". **Figure IV C**.

Discussion

Mimic frequency and predation

- Different from previous lab studies (e.g., **Figure I**), our result showed a S-shape relationship, with predation increasing with increasing mimic frequency. The threshold is also lower than that in the lab, being somewhere between 0.2 and 0.6.
- Although we do have evidence of learning (see **Figure III B**), the wild populations in these parks are quite large and so some birds may not resample many prey. If mimic frequency is high (e.g. 0.8), such a bird may not ever encounter an unpalatable prey, leading to high predation.
- Another possibility is that some wild bird species also may accept a few unpalatable prey that may still be potentially nutritious (Barnett et al. 2007; Skelhorn and Rowe 2007).
- The result of the control, supports the hypothesis that palatable prey benefit from aposematic neighbors (Mappes et al. 1999).

Mimic frequency and taste-Rejection

- Our result basically supports the hypothesis that predators adjust their taste-rejection rate to respond to different mimic frequencies (e.g., Gamberale-Stille and Guilford 2004).Taste-rejection attack behavior rises in situations of high uncertainty (intermediate mimic frequencies).
- Previous studies showed a high survival rate for prey taste-rejected by avian predators (ref). However, the result that there were more "half left" and "no heads" than "no tails" suggests that taste-rejection may not maintain the efficiency of chemical defense in Batesian mimicry system, since many of the unpalatable prey are killed immediately by the birds.

In conclusion, as mimic frequency rises, birds switch strategies from avoiding most prey to eating most. Intermediate mimic frequencies bring high uncertainty, and hence high taste-rejection.

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