Frequency-dependent Batesian mimicry

Predators avoid look-alikes of venomous snakes only when the real thing is around.

Batesian mimicry holds that palatable species look like dangerous species because both are then protected from predation1–3. But this protection should break down where the dangerous model is absent, when predators would not be under selection to recognize the model or any other species resembling it as dangerous2,4,5. Here we provide experimental evidence to support this critical prediction of Batesian mimicry by demonstrating that predators avoid harmless look-alikes of venomous coral snakes only in areas that are inhabited by these deadly snakes.

Ringed replicas and non-venomous kingsnakes possess red, yellow (or white), and black ringed markings6, which predators avoid7, though often without prior experience8. To determine whether this avoidance depends on the model’s presence in the vicinity, we constructed snake replicas9 (1.5 cm × 18 cm cylinders of pre-coloured, non-toxic plasticine threaded onto an S-shaped wire) with a tricolour ringed pattern, a striped pattern with identical colours and proportions as the ringed replicas, or a plain brown pattern.

Ringed replicas conformed to the local mimic: scarlet kingsnakes (Lampropeltis triangulum elapsoides), which resemble eastern coral snakes (Micrurus fulvius)10, or sonoran mountain kingsnakes (L. pyromelana), which resemble western coral snakes (Microurides euryxanthus)6; striped and brown replicas served as controls. We arranged three different replicas (triplets) 2 m apart in natural habitat (each was used once only). At each site, 10 triplets were placed 75 m apart in a line. After collection, 49 (6.8%) replicas had been attacked by carnivores.

We next investigated whether predators avoid L. l. elapsoides only in areas inhabited by Micrurus by placing 10 triplets at eight sympatric sites (sites with mimic and model) and eight allopatric sites (sites with only the mimic) in North and South Carolina, USA (480 replicas; allopatric sites were more than 80 km outside Micrurus’s range6,11; sites were 16–420 km apart). After 4 weeks, 25 (5.2%) replicas had been attacked by carnivores. The mean (± s.e.m.) proportion of ringed replicas attacked was significantly greater in allopatry (0.046 ± 0.078) than in sympatry (0.138 ± 0.060; P = 0.006). Moreover, in sympatry, the proportion of ringed replicas attacked (0.138) was significantly less than random (0.33; P = 0.010, 2-tailed Wilcoxon signed-rank test). By contrast, attacks were random in allopatry (P = 0.188).

Thus, predators avoid coral snake mimics only in sympathy with the model.

Coral snakes become increasingly rare with increasing latitude (Spearman ρ = −0.57, P = 0.01411 and elevation (ρ = −0.77, P = 0.026; our unpublished results). Consequently, selection to avoid ringed patterns should weaken with increasing latitude and elevation. As expected, the proportion of ringed replicas attacked increased gradually with latitude and elevation (Fig. 1), suggesting that selection to avoid ringed patterns is indeed sensitive to the abundance of coral snakes.

Our results do not fully resolve why mimetic patterns occur where models are absent6–8,9,12. Possibly selection for mimicry in sympathy, coupled with gene flow between sympatric and allopatric populations12, maintains mimetic patterns in both regions. Nevertheless, our results verify the critical prediction of Batesian mimicry and demonstrate that the benefits of mimicry depend on abundance of the model.

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