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A CASE OF SUSPECTED CORAL SNAKE (*HEMIBUNGARUS CALLIGASTER*) MIMICRY BY LEPIDOPTERAN LARVAE (*BRACCA* SP.) FROM LUZON ISLAND, PHILIPPINES

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***ABSTRACT.* –** I report on a suspected case of coral snake color pattern mimicry by moth larvae of the genus *Bracca* (Geometridae; Tribe Boarmiini) from Luzon Island, Philippines. Although the proposed model (the coral snake *Hemibungarus calligaster*) is four to five times the total length of the proposed mimic (*Bracca* sp.), the two are strikingly similar in regards to relative lengths of white, black, and red banding patterns and body width. The two distantly related species exist sympatrically on the Bicol Peninsula of Luzon Island, they inhabit the same forested habitats, have similar microhabitats preferences and defensive behavior, and presumably encounter the same avian predators. If this example truly represents a case of coral snake mimicry by the larvae of a lepidopteran species, it would be the first such instance reported in Asia.

INTRODUCTION

The evolution of warning coloration is a topic that has piqued the interest of natural historians for more than a century and a half. Poulton (1890) defined aposematic coloration as an appearance that warns off enemies because it denotes something unpleasant or dangerous. The hypothesis that coloration in a harmless mimic species may evolve to resemble that of a venomous or toxic model species (Batesian Mimicy: Bates, 1862) has been supported by many observations of proposed model-and-mimic systems (Greene and McDiarmid, 1981, 2005; Pough, 1988; Brodie and Brodie, 2004) and a variety of recent experimental evidence (Smith, 1975, 1977; Brodie, 1993; Pfennig et al., 2001) from snakes. Müllerian mimicry, in which two noxious, venomous, or unpalatable types converge on a similar pattern (gaining a selective advantage by sharing the burden of predator education; Müller, 1879) is rare in vertebrates, although somewhat more common in invertebrates (Kaplan, 2001; Symula et al. 2001).

Although there are documented cases of generalized snake mimics among Old World lepidopteran larvae (Greene and McDiarmid, 2005), I am aware of no previously published accounts of proposed mimicry systems involving lepidopteran larvae and Asian coral snakes. In this note, I report on a probable case of Philippine coral snake mimicry by the larvae of a species of moth (genus *Bracca*) from Luzon Island.

MATERIALS AND METHODS

I conducted herpetological field surveys on Mt. Malinao (Albay Province) and Mt. Isarog (Camarines Sur Province) of the Bicol Peninsula of Luzon Island, Philippines between the years 2002 and 2004. Herpetological specimens were deposited in the National Museum of the Philippines and the Texas Memorial Museum; lepidopteran specimens were measured with a plastic ruler (to the nearest 0.1 mm), photographed and released. Relative lengths of the color bands of the *Bracca* larvae were calculated from photographs corrected for total body length measurements taken from larvae in life; lengths of colored bands of the snakes were measured directly from preserved specimens (at midbody) with digital calipers. I identified coral snakes with the key provided by Leviton (1963) and identification of the moth larvae was provided by consultation with specialists (see acknowledgements) and clarification by Holloway (1991, 1993).

RESULTS

On Mt. Malinao and Mt. Isarog, I frequently encountered conspicuously colored caterpillars of a moth species (genus *Bracca*) that perfectly resembled the color and pattern of the sympatric elapid *Hemibungarus* (formerly *Calliophis*) *calligaster calligaster* (Leviton, 1963). Five specimens of

the *Bracca* sp. (Geometridae; Tribe Boarmiini) larvae were observed in life, measured, photographed, and released. Based on photographs of larvae only, specimens could not be positively identified, but possibilities include *B. georgiata* (known from the Philippines, the Molukus, and Sulawesi), *B. rotundata* (a more widespread Australasian species), or a currently unrecognized species. Brief descriptions of larvae for these species suggest that the color pattern observed here may better match that of *B. rotundata* (Holloway 1991, 1993) but definitive identification of the species will require future collections of adults and larvae.

One individual was observed on the leaf of a low branch (1.1 m from the ground) of an sapling, three individuals were observed on the ground in moss and leaf litter between dipterocarp tree buttresses, and one specimen was observed suspended from a thread of silk (hanging 1.3 m below an under story tree branch on which the silk was anchored; 0.3 m from the ground).

Four specimens of *Hemibungarus calligaster* were encountered in similar habitats. One was observed crawling on a path in sunlight, two were found coiled in between the same dipterocarp buttresses where *Bracca* larvae were encountered, and one was found 1.3 m above the ground as it climbed a partially suspended fallen tree. Thus, the limited observations available suggest that the microhabitats of the two unrelated species coincide fairly well.

Fig. 1. *Hemibungarus calligaster calligaster* (Texas Natural History Collections 62483): A, in life; B, an unidentified *Bracca* sp. moth larvae (not collected) observed sympatrically on Mt. Isarog, Camarines Sur Province, Luzon Island, Philippines.

Although no data were collected on activity patterns of the unrelated forms, it is noteworthy that all caterpillars and coral snakes were encountered in the late morning, between 10:30 and 11:45 hr. Although *H. calligaster* was encountered in this study between 450 and 700 m above sea level, Taylor (1922) and Leviton (1963) report specimens from at or near sea level. The *Bracca* sp. larvae were observed between 500 and 735 m above sea level. Additionally, the proposed model and mimic share similar movement patterns: both crawl slowly when undisturbed and jerk, twist, and thrash erratically when disturbed.

The general resemblance between the proposed model and mimic is striking with respect to the precise colors, order of colored bands, and relative width of respective bands (Fig. 1). Both share thin white annuli, broader black bands, and broad red bands. Although *H. calligaster* is substantially longer in total body length (479–510; $\bar{x}$ = 498.5 ± 14.5 mm; n = 4; Leviton, 1963, reports total length as 504–515 for two individuals) than *Bracca* larvae (71–92; $\bar{x}$ = 78.8 ± 8.1 mm; n = 5) the banding pattern, relative lengths of the banding elements, and order of bands are strikingly similar. The white annuli, black bands, and red bands measured 0.7–1.1 ($\bar{x}$ = 0.9 ± 0.2; n= 5), 6.0–10.3 ($\bar{x}$ = 7.5 ± 0.2; n = 5), and 7.4–11.5 ($\bar{x}$ = 9.2 ± 1.3; n = 5) mm respectively in the *Bracca* larvae and 0.9–1.3 ($\bar{x}$ = 1.1 ± 0.2 SD; n = 4), 13.1–18.2 ($\bar{x}$ = 15.8 ± 0.9; n = 4), and 13.8–17.0 ($\bar{x}$ = 15.8 ± 1.7; n = 4) mm respectively in *H. calligaster*. Most significantly, the *relative* lengths of the banding segments were comparable, with very thin white annuli coupled with thick black bands and equally thick or thicker red bands.

The proposed model and mimic have reasonably similar body widths. *Hemibungarus calligaster* specimens were 0.9–1.7 ($\bar{x}$ = 1.4; ± 0.2 SD; n = 4) mm wide at midbody and *Bracca* specimens were 0.7–1.1 ($\bar{x}$ = 0.9 ± 0.2 SD; n = 5) mm wide. Similarly, although *H. calligaster* possesses these red bands only on its ventral surface, coral snakes are well known to present their ventral surfaces to predators during attacks (Pough, 1988; Brodie and Brodie, 2004; Greene and McDiarmid, 2005). Thus, the overall appearance that would be observed by an attacking avian predator when snake or caterpillar begins defensive thrashing is expected to be quite similar (Fig. 1).

DISCUSSION

The question of whether the *Bracca*/*Hemibungarus* example represents Müllerian or Batesian mimicry cannot be determined at present. It is clear that our understanding of this system would improve with a further taxonomic review of Philippine *Bracca* species diversity and a comprehensive descriptive review of their larvae. Our ability to distinguish between hypotheses concerning the selective advantage of aposematic coloration in *Bracca* moth larvae would also improve with determination of relative toxicity or unpalatability of the species, identification of potential predators, observations of bird foraging behavior in natural habitats on Mts. Isarog and Malinao, and experimental trials

aimed at determining whether predators avoid attacking the *Bracca* larvae.

Examples of Asian snakes proposed as mimic/model systems (Greene & McDiarmid, 2005) include several similarly colored (colubrid/elapid) pairs of species in the following genera: *Lycodon*/*Bungarus*, *Oligodon*/*Sinomicrurus*, and *Calamaria*/*Calliophis* (= *Hemibungarus*). Examples of snake mimicry by non-squamate taxa are far rarer, but a few have been reported. Greene & McDiarmid (2005) discussed a number of cases in which invertebrates (e.g., several banded species of unpalatable/toxic planarians) may be the noxious models mimicked by Asian snakes (see also Brodie and Moore, 1995). The geographically concurrent presence of brightly colored banding patterns in sympatric invertebrates, non-venomous snakes, and venomous snakes suggests the possibility of an extremely complex evolutionary interaction with multiple models and mimics, numerous species involved, and the possible simultaneous evolution of both Batesian and Müllerian mimics.

It is possible that the variation observed here in *Bracca* sp. larvae of S. Luzon represents a case of generalized mimicry or a generic aposematic color pattern that coincidentally resembles the coloration of *H. calligaster*. However, the near perfect correspondence between the color patterns of *H. calligaster* and *Bracca* sp. larvae, coupled with their sympatry and ecological co-occurrence, are compelling observations which, taken together, support the hypothesis of mimicry. It will be interesting to determine whether banding patterns in the proposed invertebrate mimics correspond to geographic variation in banding patterns in the presumed vertebrate models and whether each recognized subspecies of Philippine coral snake (*H. c. mcclungi* from Polillo Island; *H. c. gemiannulis* of Panay, Negros, Cebu; and *H. c. calligaster* of Luzon Island; Leviton, 1963) has a corresponding local caterpillar mimic.

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