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Does body size reflect foraging ability in post-metamorphic marine toads?

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Abstract. The Marine Toad (*Rhinella marina*) is an invasive exotic species found in the southern United States. We observed the feeding behaviour of post-metamorphic Marine Toads in order to ascertain whether body size was related to foraging ability. We offered the toadlets pinhead crickets as prey and tallied the results of each predatory encounter. We also tabulated the number of tongue flicks each toad needed to capture its prey. Small toadlets did not catch crickets as frequently as other size classes. Our data suggest that post-metamorphic body size may be related to prey capture ability in Marine Toads.

Keywords. *Rhinella marina*, predatory behavior, prey capture, predation, behavior.

Introduction

Natural history information provides us with an important understanding of species that can be useful for management activities (Bury, 2006). Unfortunately, we lack much natural history data on many species, even those which are common (Green, 2005). Amphibians as a group are both critically imperilled and understudied (Mendelson, 2006; McCallum and McCallum, 2006; McCallum, 2007). Foraging ability is an important natural history trait having serious repercussions for an individual's life (Stephens and Krebs, 1987). Better nutrition due to foraging ability can lead to larger body size at a younger age (McCallum and Trauth, 2002) potentially leading to earlier maturity (Jurgens, 1988; Blackenhorn and Heyland, 2004). Larger metamorphs are less susceptible to predation (Clarke, 1977) and able to utilize a larger prey base (McCallum and Trauth, 2002). Early maturation will provide an individual with more opportunities for reproduction over its life time (Leskovar et al., 2006). Larger body size also imparts greater mating success in male (Arak, 1988) and larger clutch size in female (McCallum, 2003; McCallum et al., 2011) amphibians. Growth and ultimate attainment of body size is tantamount to reproductive success and survival (McCallum, 2011). Foraging ability can be learned (Stull and Gruberg, 1998), but in lower vertebrates much of this may be genetically predetermined (Stirling and Roff, 2000). Understanding a species' variability in foraging ability and its relationship to body size can be important for understanding how an organism, especially an exotic invasive one like the Marine Toad (*Rhinella marina*), succeeds or comes to dominate local habitats.

The Marine Toad is one of the more extensively studied amphibians because of its historical use as biological control (Bailey, 1976) and its status as an exotic invasive species (Greenlees et al., 2006; Meshaka, Devane and Marshall, 2006; Phillips and Shine, 2006; Meshaka, 2011), and its noxious and poisonous glandular defences (Catling et al., 1999; Uvari and Madsen, 2009). The broad diet of the Marine Toad is well documented (Strussmann et al., 1984). Our study is an attempt to understand if body size relates to foraging ability in recently metamorphosed Marine Toads. We hypothesized that larger toadlets have better foraging skills than smaller toadlets explaining the noncongruity in body size among post-metamorphic *R. marina* of similar ages. We predicted that if this was true, small toadlets should be less successful at capturing prey and larger toadlets should be more effective at prey capture.

Materials and Methods

Toadlets (N = 51, est. age = 28 days) were housed in a 90 x 30 cm glass aquarium at 23° C and a 12/12 hr lighting regiment. The aquarium was tilted slightly to allow 0.5 L of water to pool at one end. Live Sphagnum Moss was kept in the water so toadlets could easily climb out. Crickets (SVL = 2 mm; *Acheta domesticus*; New York Worms, Inc. Long Island, New York) served as prey targets during this study. We released crickets into the aquarium and then we randomly selected a toadlet to observe. We watched each toadlet until it began stalking a cricket. We observed each toadlet for a single predation event. We recorded whether or not the toadlet was successful in eating a cricket and the number of tongue flicks

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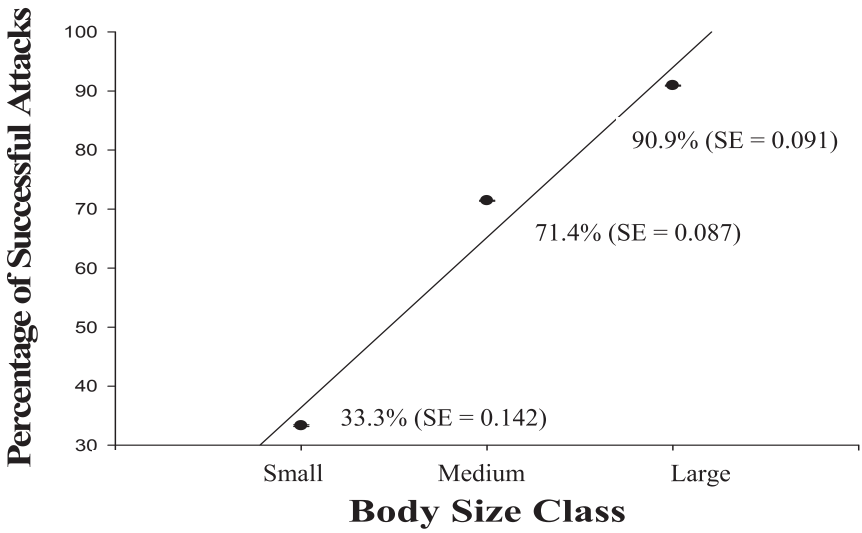

Figure 1. Percentage of attacks resulting in successful capture of prey in each of three size classes of post-metamorphic Marine Toad (*Rhinella marina*).

each toadlet used to capture its prey, or before the cricket escaped. A cricket was tallied as an escape at the point where the toad ceased pursuit. We placed toadlets into three groups for comparison: (1) small (*N* = 12; SVL: mean = 13.1 mm, SE = 0.824), (2) medium (*N* = 28; SVL: mean = 17.3 mm, SE = 0.182), and (3) large (*N* = 11; SVL: mean = 20.3 mm, SE = 0.523).

Binary logistic regression served to analyze the influence of body size and the number of tongue flicks on capture success. Linear regression allowed us to infer the influence of body size on the number of tongue flicks required to catch prey. Decision theory used $\alpha = 0.05$ to indicate significance. We used MiniTab 13.0 (MiniTab, Inc., State Park, PA) to calculate all statistical tests.

Results

Post-metamorphic Marine Toads captured prey in 66% (17/51) of encounters. Only 13.7% (7/51) encounters involved more than a single tongue flick to capture prey. Toadlets averaged 1.31 (SE = 0.141) tongue flicks per prey encounter. Body size was a significant predictor of prey capture success in post-metamorphic Marine Toads (Fig. 1; Table 1A). Success rate followed body size in that small toadlets were the least successful at prey capture (4/12, 33.3%, SE = 0.142), large toadlets had the highest success rate (10/11, 90.9%, SE = 0.091), and medium-sized toadlets fell in between (20/28, 71.4%, SE = 0.087). The number of tongue flicks needed did not influence prey capture success (Table 1B). The number of tongue flicks required to catch prey did not significantly vary ($r^2 = 0.038$, $df = 50$, $P = 0.170$) among Small (mean = 1.58, SE = 0.288), medium (mean = 1.32, SE = 0.225), and large (mean = 1.00, SE < 0.001) toadlets.

Discussion

The number of tongue flicks required to capture prey did not reveal trends in relation to prey capture success. This may be an artefact of the small number of individuals that required multiple flicks to capture crickets. Dean (1980) found that the speed of prey capture by Marine Toads did not affect their capture success. Our data suggest that the number of tongue flicks does not effectively influence success either. Repetition of tongue flicks probably require less effort or energy to implement than lunging, making accuracy less critical unless the animal is exposed to immediate competition during a predation event. If tongue flick success was prominent in determining prey capture and ultimately nutrition acquisition, then size biases related to tongue flick accuracy should exist in a group of toads of similar ages. This was not the case.

Table 1. Logistic regression tables.

A. Are larger toads more successful at capturing prey?

Predictor	Coefficient	SE Coefficient	*Z*	*P*
Constant	-2.193	1.065	-2.06	0.040
Body Size	1.537	0.564	2.73	0.006

Test that all slopes are zero: $G = 9.420$, $df = 1$, $P = 0.002$

B. Does the number of tongue flicks needed influence success in catching crickets?

Constant	0.3570	0.5710	0.63	0.532
Flicks	0.2665	0.4026	0.66	0.508

Test that all slopes are zero: $G = 0.559$, $df = 1$, $P = 0.455$.

Body size was a good predictor of ultimate prey capture success. Large toadlets captured prey much more effectively than smaller individuals. This may explain why differences in body size exist. Metamorph size differences were not likely due to larval nutrition (McCallum and Trauth 2002, Nicieza, Alvarez and Atienza, 2006;) or environmental stress (Edwards et al., 2006) because all of the toadlets developed in almost identical captive conditions. Whether large toadlets were genetically predisposed to better capture success is unknown, likewise we cannot be completely certain whether body size resulted from or caused variation in feeding success. Consequently, we believe that differences in prey capture success may explain differences in body size.

This was a structured laboratory experiment, but it seems plausible that similar results would occur in the field. In the field, all kinds of avenues for escape are possible. It is unlikely that an encounter between a cricket and a toadlet would involve more than one or two tongue flicks before the prey escaped. Wild toadlets that miss insects on the first attempt will undoubtedly cause that prey to flee for cover. These components of a predator prey encounter may be under-estimated in our laboratory study because we observed encounters on the bare glass bottom of an aquarium. The only avenue for escape in our laboratory study was for the prey to distance itself from the predator because no shelter was available. Certainly poor predators would be even less successful in the wild due to the more complex habitat structure. This wild habitat structure provides many abodes for escape (McCallum, 1999; McCallum 2011), likely leading to less efficient prey capture, smaller toadlet body sizes, and possibly even near starvation.

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