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Disgusting or delicious? Predatory behavior of the hylid frog *Phyllodytes luteolus* on sympatric ants

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ABSTRACT. The phytotelm-dwelling frogs from the genus *Phyllodytes* Wagler, 1830 have been characterized as specialist frogs regarding their diet strategy which is mainly composed by colonial insects. Herein, we used two species of ants (*Camponotus* sp. and *Gnamptogenys* sp.) with distinct defensive mechanisms to test the predatory behavior of *Phyllodytes luteolus* Wied, 1824. The experiment was conducted with frogs inhabiting a patch of 20 bromeliads (*Aechmea* **cf.** *blanchetiana*). Ants were offered randomly to the frogs until we obtained ten observations of predation of each ant species. We observed and recorded the time that *P. luteolus* needed to keep each ant species inside its mouth before it could ingest it. Predatory behavior was highly distinct. While *Camponotus* were caught and swallowed within six seconds and without apparent discomfort, individuals of *P. luteolus* had more difficulty in swallowing *Gnamptogenys* individuals, the time of manipulation ranging from 57 to 177 seconds. The mean values of time of predation observed in each treatment was highly significant ($p<0.001$). We conclude that differences found in the time of manipulation are highly correlated with defense mechanisms of each species of ants.

KEYWORDS. Behavior, *Camponotus*, *Gnamptogenys*, bromeliads, predation.

RESUMO. Nojento ou delicioso? Comportamento predatório da perereca *Phyllodytes luteolus* sobre formigas simpátricas. As pererecas que habitam fitotelmatas do gênero *Phyllodytes* Wagler, 1830 têm sido caracterizadas como especialistas em relação à sua estratégia de dieta, que é composta principalmente por insetos coloniais. Neste trabalho, usamos duas espécies de formigas (*Camponotus* sp. e *Gnamptogenys* sp.) com mecanismos de defesa diferentes para testar o comportamento predatório de *Phyllodytes luteolus* Wied, 1824. O experimento foi conduzido com pererecas que habitavam uma mancha de 20 bromélias (*Aechmea* **cf.** *blanchetiana*). As formigas foram oferecidas aleatoriamente para as pererecas até que obtivemos dez observações de predação para cada espécie de formiga. Observamos e registramos o tempo que *P. luteolus* precisou manter cada espécie de formiga dentro da boca antes da mesma poder ser ingerida. O comportamento de predação foi altamente distinto. Enquanto *Camponotus* foram capturadas e engolidas dentro de seis segundos e sem desconforto aparente, indivíduos de *P. luteolus* tiveram maiores dificuldades em engolir indivíduos de *Gnamptogenys*, com tempo de manipulação variando de 57 a 177 segundos. Os valores médios do tempo de predação em cada tratamento foram altamente significativos ($p<0.001$). Concluímos que as diferenças encontradas no tempo de manipulação estão altamente correlacionadas com os mecanismos de defesa de cada espécie de formiga.

PALAVRAS-CHAVE. Comportamento, *Camponotus*, *Gnamptogenys*, bromélias, predação.

The Yellow Heart-tongued Frog *Phyllodytes luteolus* Wied, 1824 is distributed along the Atlantic Forest of Brazil, from the state of Paraíba to the north of the state of Rio de Janeiro (Vrcibradic *et al*., 2006; Haddad *et al*., 2013). Individuals are commonly found inside bromeliads thriving in open areas, in axils usually containing at least 100 ml of water (Teixeira *et al.*, 1997). Reproduction also takes place in bromeliad axils where each female may lay up to three eggs and where tadpoles develop feeding on debris (Peixoto, 1995; Giaretta, 1996). Although its diet is diversified, *P. luteolus* has been considered a specialist regarding its foraging strategy once its diet is mainly composed by colonial insects (Ferreira *et al*., 2012). Feeding on ants and termites seems to be the common share for several bromeligenous and bromelicolous frog species as e.g. *Thoropa miliaris* (Spix, 1824) and *Scinax arduous* Peixoto, 2002 (Pertel *et al*., 2010). However, Motta-Tavares *et al*. (2016) argued that it is not possible to assume diet strategy of species if no studies evaluate whether frogs select prey items or if they consume them according to prey availability inside bromeliads. Moreover, ants possess a very large arsenal of defense strategies involving chemical defenses as formic acid (Falótico *et al*., 2007), stinging (Haddad Jr & Larsson, 2015) and biting (Peeters & Ito, 2015). As amphibians from several species have been reported to sequester alkaloids from dietary arthropods as ants and mites (Hantak *et al*., 2013) they should be able to deal with these defense strategies to overwhelm their prey. In order to aid to elucidate this dilemma

we set up an experiment offering two sympatric species of ants with distinct defense mechanisms (chemical and stinging) to specimen of *P. luteolus* inside bromeliad axils. We wanted to find out if there would be differences on the time of prey processing in relation to the defense mechanism of the ant. As no previous behavioral information on how bromeliad frogs deal with ants exist we hypothesize that both species possess attributes that may delay or accelerate their ingestion. On one hand frogs may try to swallow ants with a sting rapidly, thus neutralizing the risk of being stung. On the other hand they may delay the ingestion in order to avoid being stung while the ant is still alive inside their stomach.

MATERIALS AND METHODS

To carry out the experiment we used individuals of *Phyllodytes luteolus* as predators and two species of ants of similar size — *Camponotus* sp. and *Gnamptogenys* sp. — as target species. Both ants occur in syntopy with the frogs and were chosen based on previous *ad libitum* observations performed by MS which revealed that *P. luteolus* were able to prey on them. Individuals of *P. luteolus* used in the experiment inhabited a patch of 20 bromeliads (*Aechmea* **cf.** *blanchetiana*), which were cultivated by MS since 2010 in the municipality of Ilhéus, state of Bahia, Brazil (14°54'44.3"S, 39°01'27.8"W). This population of *P. luteolus* comprised around 80 individuals. The experiment was conducted on October 1st 2014 between 22:00h and 24:00h until we obtained ten observations of predation of each ant species. Ants, which had been previously collected in activity during the same night at the study site, were gently placed manually inside bromeliad axils containing a randomly chosen frog. For each ant offered we observed and recorded the manipulation time in the mouth that *P. luteolus* needed to ingest each one. To compare the time of predation between each treatment (prey models) we performed a t-test ($p<0.05$).

RESULTS

Predatory behavior was highly distinct between both ant species. While *Camponotus* sp. were caught and swallowed in up to six seconds (mean = 2.4 ± 2.27; n = 10) and without apparent distress, those individuals of *Phyllodytes luteolus* that tried to feed on *Gnamptogenys* sp. showed more difficulty in swallowing them. Frogs manipulated individuals of *Gnamptogenys* sp. with their mouth, keeping the abdomen of the prey outside for 57 to 177 seconds (mean = 108.3 ± 48.52; n = 10), in order to avoid injuries due to the ant's sting (Fig. 1). The mean values observed among the time of predation in each treatment were highly significant ($p<0.001$). We also noted that for *Gnamptogenys* sp., amphibians opened their mouth several times until they finally managed to swallow their prey.

Fig. 1. *Phyllodytes luteolus* Wied, 1824 manipulating its prey, an ant of the genus *Gnamptogenys*. Note that the frog has kept the abdominal region of the ant outside of the mouth in order to prevent injuries caused by its sting.

DISCUSSION

Defensive tactics in prey forced predators to coevolve simultaneously generating a predator-prey arms race (Brodie & Brodie, 1999a,b; Geffeney *et al*., 2002). Results provided by our experiment demonstrated that *Camponotus* sp. and *Gnamptogenys* sp. can be consumed by *Phyllodytes luteolus*, but with distinct behaviors for each ant species. As both ant species are similar in size this result can be explained due to the distinct defense mechanisms against predators of those ant species. While *Camponotus* sp. can use its well-developed jaws as a defense mechanism *Gnamptogenys* sp. injects formic acid through its stinger located at the final portion of its abdomen. Although *P. luteolus* showed ability to withstand the discomfort caused by the defense mechanisms of both ants, the pain caused by *Gnamptogenys* stinging seemed to be much more uncomfortable than the bites inflicted by *Camponotus* sp. (authors pers. obs.). We conclude that individuals of *P. luteolus* are adapted to eat both targeted species of ants. Future studies using simultaneously both ant species to test prey preferences would be useful to determine the capacity of prey selection in *P. luteolus*.

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