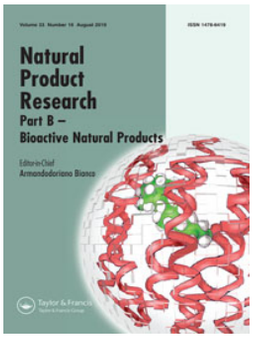


Natural Product Research
Formerly Natural Product Letters

ISSN: 1478-6419 (Print) 1478-6427 (Online) Journal homepage: https://www.tandfonline.com/loi/gnpl20

Extracts of the unripe fruit of *Ilex paraguariensis* as a potential chemical control against the golden apple snail *Pomacea canaliculata* (Gastropoda, Ampullariidae)

Fabiano Carvalho de Brito, Grace Gosmann & Guendalina Turcato Oliveira

To cite this article: Fabiano Carvalho de Brito, Grace Gosmann & Guendalina Turcato Oliveira (2019) Extracts of the unripe fruit of *Ilex paraguariensis* as a potential chemical control against the golden apple snail *Pomacea canaliculata* (Gastropoda, Ampullariidae) , Natural Product Research, 33:16, 2379-2382, DOI: 10.1080/14786419.2018.1443084

To link to this article: https://doi.org/10.1080/14786419.2018.1443084

NATURAL PRODUCT RESEARCH
2019, VOL. 33, NO. 16, 2379–2382
https://doi.org/10.1080/14786419.2018.1443084

Taylor & Francis
Taylor & Francis Group

SHORT COMMUNICATION

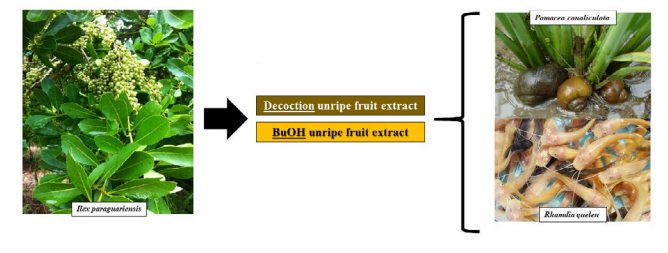
Extracts of the unripe fruit of *Ilex paraguariensis* as a potential chemical control against the golden apple snail *Pomacea canaliculata* (Gastropoda, Ampullariidae)

Fabiano Carvalho de Brito[a], Grace Gosmann[b] and Guendalina Turcato Oliveira[a]

[a]Conservation Physiology Laboratory. Av. Ipiranga, Faculty of Life Sciences, Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS), Porto Alegre/RS, Brazil; [b]Faculty of Pharmacy, Universidade Federal do Rio Grande do Sul (UFRGS), Porto Alegre, Brazil

ABSTRACT

Plant extracts can provide a viable alternative to controlling many crop pests. This study sought to assess the efficacy of vegetable extracts of the unripe fruits of *Ilex paraguariensis* (yerba maté) for chemical control of the channeled apple snail (*Pomacea canaliculata*) and of non-target species as the South American catfish (*Rhamdia quelen*) under laboratory conditions. In *P. canaliculata*, the LC_{50} of the decoction extract was 31.39 $mg.L^{-1}$ and the LT_{50} was over 26 h. The LC_{50} of the butanol extract was 24.75 $mg.L^{-1}$ and the LT_{50} was in the range of 28 to 32 h. In juvenile *R. quelen*, the LC_{50} of the decoction was 17.98 $mg.L^{-1}$ and the LT_{50} was in the range of 10–12 h. These extracts are particularly attractive considering the source of compounds and their effectiveness as molluscicides.



ARTICLE HISTORY
Received 10 September 2017
Accepted 12 February 2018

KEYWORDS
Chemical control; maté; molluscicide; rice pest

1. Introduction

The South American ampullarid, *Pomacea canaliculata*, is a freshwater gastropod which has been ranked among the 100 worst world's invasive alien species (Lowe et al. 2000) and considered one of the most harmful pests of rice in many Asian countries, including China, the Philippines, and Malaysia Recently, in Ecuador, crops have been continuously affected

CONTACT Fabiano Carvalho de Brito me.fabianobrito@gmail.com, guendato@pucrs.br
Supplemental data for this article can be accessed at https://doi.org/10.1080/14786419.2018.1443084.

by this species (Cowie 2002; Horgan et al. 2014). Currently, synthetic molluscicides (niclosamide and metaldehyde) are widely used for the chemical control of this pest (Schnorbach et al. 2006). Synthetic molluscicides could vary from moderately hazardous to unlikely to present acute hazard in normal use for human, moreover their negative impact on the environment and the high costs of application are known. So, these facts have stimulated the search for molluscicidal plant extracts that could be environmentally safe (Duke et al. 2010; WHO 2010). The search for alternatives has led to investigation of saponins and other compounds as candidate molecules for the management of pest molluscs (Singh et al. 2010). The Yerba mate (*Ilex paraguariensis* A.St.-Hil 1822) is a tropical tree species of South America, widely cultivated in South Brazil, Argentina, and Uruguay for its leaves, which are commercially valuable a traditional beverage known as maté or *chimarrão*. High saponin content has been reported in the leaves (5–10%) (Gosmann et al. 1995), and, especially, in the unripe fruits (12%) (Pires et al. 2002; Taketa et al. 2004; Pavei et al. 2007; Borré et al. 2010). These fruits are considered waste byproducts of commercial mate processing, and are thus discarded by the beverage industry. The present study investigated under laboratory conditions the efficacy of two extracts (decoction and butanol extract) of unripe fruits of *Ilex paraguariensis* for chemical control of the channeled apple snail *P. canaliculata*, as well as the toxicity of these extracts in a non-target organism, the South American catfish *Rhamdia quelen*. In both animal species, median lethal concentration (LC_{50}) and median lethal time (LT_{50}) for each extract were determined.

2. Results and discussion

In *P. canaliculata* the LC_{50} of decoction was 31.39 ± 1.4 mg.L^{-1} and its LT_{50} was over 26 h as it was not achieved in a 26-h monitoring period. The LC_{50} of unripe fruit butanol extract in *P. canaliculata* was 24.75 ± 1.3 mg.L^{-1} and the LT_{50} was in the range of 28 to 32 h with 32-h monitoring period. In *R. quelen* the LC_{50} was 17.98 ± 1.2 mg.L^{-1} and the LT_{50} was in the range of 10–12 h with 12-h monitoring period. All results are presented in Figures 1S, 2S and Table 1S. According to our review of the literature, this is the first report demonstrating that extracts of the unripe fruit of *I. paraguariensis* have molluscicidal activity. Both the decoction and butanol extracts of unripe *I. paraguariensis* fruits had some behavioral effects on *P. canaliculata*. In order to assayed in a non-target organism, it was used only the extract presenting the lower toxicity to the snails. The decoction extract presented LC_{50} and a LT_{50} values lower by twofold to *R. quelen* than to the snails. In snails, both extracts caused marked slime secretion and a similar behavioral pattern of rigidity, immediate retraction, drifting, and death in the experimental groups. Also, juveniles of *R. quelen* treated with the decoction extract exhibited hyperventilation and drifting before death. In unexposed (control) fish, this behavior was not observed. It is known that the chemical affinity of saponins, previously detected in maté fruits (Taketa et al. 2004), (and, possibly, of other molecules contained in the tested extracts) for complex formation with phospholipids, cholesterol, and epithelial proteins may lead to pore formation in the cell membrane, thus increasing ion outflow from cells to the aqueous medium, with subsequent loss of homeostasis and death (Melzig et al. 2001; Augustin et al. 2011). The application of these extracts in the field environment may has an acute effect on related organisms. For example, Joshi et al. (2008) verified extracts of quinoa saponins did not affect the germination in rice seedlings. The toxic effects of common synthetic molluscicides are well known (WHO. World Health Organization 2010). The LC_{50} of

niclosamide was reported as 0.1 to 0.5 mg.L^{-1} for *P. canaliculata* and, having a LC_{50} of 0.03 to 0.23 mg.L^{-1} for fishes (WHO 2002; Schnorbach et al. 2006, 2010). Although the maté extracts presented lower efficacy to kill snails in comparison to commercial molluscicides, plant extracts generally have a much smaller range of environmental damage (Horgan 2017). In this sense, further experiments should be conducted to assess the impact of these extracts to the environment and the mechanisms and sites of action of the compounds present in *I. paraguariensis* extracts, both in *P. canaliculata* and in non-target species. Our findings suggest that the decoction and butanol extracts obtained from the unripe fruits of *I. paraguariensis* are effective and promising molluscicides for chemical control of the channeled apple snail, *P. canaliculata*. As the unripe fruits are considered industrial waste, this provides an abundant source of material for production of the aforementioned extracts, thus creating a new use for plant matter that would otherwise be discarded.

Supplementary material

Supplementary material related to this article is available online, alongside Figure 1S, Figure 2S and Table 1S.

Acknowledgements

We thank Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS) and Universidade Federal do Rio Grande do Sul (UFRGS) for providing infrastructure and funding for the present study; the Brazilian National Council of Scientific and Technological Development (CNPq) for providing financial support, including a Master's scholarship grant; and Ximango Indústria de Erva-mate (Ilópolis, Rio Grande do Sul) for their kind donation of the plant material used in the experiments. We thank MSc. P. J. S. Silva Filho from the Botany Department/UFRGS for identifying the plant material. We thank Profª Drª. Jandira Fachel from UFRGS/Brazil, Statistician, for the help and guidance in all statistical analyzes.

Funding

This work was supported by Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS); Universidade Federal do Rio Grande do Sul (UFRGS); the Brazilian National Council of Scientific and Technological Development (CNPq) (Master's scholarship grant); Conselho Nacional de Desenvolvimento Científico e Tecnológico.

ORCID

Fabiano Carvalho de Brito http://orcid.org/0000-0003-0687-8060
Grace Gosmann http://orcid.org/0000-0001-6823-8312
Guendalina Turcato Oliveira http://orcid.org/0000-0001-7929-917X

References

Augustin JM, Kuzina V, Andersen SB, Bak S. 2011. Molecular activities, biosynthesis and evolution of triterpenoid saponins. Phytochem. 72:435–457.

Borré G, Kaiser S, Pavei C, da Silva F, Bassani V, Ortega G. 2010. Comparison of methylxanthine, phenolics and saponin contents in leaves, branches and unripe fruits from *Ilex paraguariensis* A. St.-Hil (mate). J Liq Chromatogr Related Technol. 33:362–374.

Cowie RH. 2002. Apple snails (Ampullariidae) as agricultural pests: their biology, impacts and management. In: Baker GM, editor. Molluscs as crop pests. CABI; p. 145–192.
Duke SO, Cantrell CL, Meepagala KM, Wedge DE, Tabanca N, Schrader KK. 2010. Natural toxins for use in pest management. Toxins. 2:1943–1962.
Gosmann G, Guillaume D, Taketa ATC, Schenkel EP. 1995. Triterpenoid saponins from *Ilex paraguariensis*. J Nat Prod. 58(3):438–441.
Horgan FG. 2017. Ecology and management of apple snails in rice. In: Chauhan BS, Jabran K, Mahajan G, editors. Rice Production Worldwide. Cham (CH): Springer, p. 409. doi: 10.1007/978-3-319-47516-5_15
Horgan FG, Stuart AM, Kudavidanage EP. 2014. Impact of invasive apple snails on the functioning and services of natural and managed wetlands. Acta Oecol. 54:90–100.
Joshi RC, San Martín R, Saez-Navarrete C, Alarcon J, Sainz J, Antolin MM, Martin AR, Sebastian LS. 2008. Efficacy of quinoa (*Chenopodium quinoa*) saponins against golden apple snail (*Pomacea canaliculata*) in the Philippines under laboratory conditions. Crop Prot. 27:553–557.
Lowe S, Browne M, Boudjelas S, De Poorter M. 2000. 100 of the World's worst invasive alien species. The Invasive Species Specialist Group, IUCN: Auckland; p. 12.
Melzig M, Bader G, Loose R. 2001. Investigations of the mechanism of membrane activity of selected triterpenoid saponins. Plant Med. 67:43–48.
Pavei C, Guzatto P, Petrovick PR, Gosmann G, Ortega G. 2007. Development and validation of an HPLC method for the caracterization and assay of the saponins from *Ilex paraguariensis* A.St.-Hil (mate) Fruits. J Liq Chromatogr Related Technol. 30:87–95.
Pires V, Gosmann G, Guillaume D, Schenkel E. 2002. Triterpenes and saponins from *Ilex psammophila*. Nat Prod Let. 16 (6): 401–406.
Schnorbach HJ, Rauen HW, Bieri M, 2006. Chemical control of the golden apple snail, *Pomacea canaliculata*. In: Joshi RC, Sebastian LS (ed), Global advances in ecology and management of golden apple snails, Los Baños: Philippine Rice Research Institute (PhilRice), 419–438.
Singh SK, Yadav RP, Singh A. 2010. Molluscicides from some common medicinal plants of eastern Uttar Pradesh. India J Appl Toxicol. 30(1):1–7.
Taketa ATC, Breitmaier E, Schenkel EP. 2004. Triterpenes and triterpenoidal glycosides from the fruits of *Ilex paraguariensis* (Maté). J Braz Chem Soc. 15:205–211.
WHO. World Health Organization. 2002. Specifications and Evaluations for Public Health pesticides. Niclosamide. Geneva: WHO/599/EC.
WHO. World Health Organization. 2010. Recommended classification of pesticides by hazard and guidelines to classification: 2009. Geneva: WHO/PCS/01.