First Report of an Egg Parasitoid Reared from *Neomusotima conspurcatalis* (Lepidoptera: Crambidae), A Biological Control Agent of *Lygodium microphyllum* (Schizaeales: Lygodiaceae)

Author(s): Ellen C. Lake, Michael W. Gates, Melissa C. Smith, Gloria L. Witkus and Paul D. Pratt
Source: Florida Entomologist, 98(4):1244-1246.
Published By: Florida Entomological Society
DOI: [http://dx.doi.org/10.1653/024.098.0436](http://dx.doi.org/10.1653/024.098.0436)
URL: [http://www.bioone.org/doi/full/10.1653/024.098.0436](http://www.bioone.org/doi/full/10.1653/024.098.0436)

BioOne ([www.bioone.org](http://www.bioone.org)) is a nonprofit, online aggregation of core research in the biological, ecological, and environmental sciences. BioOne provides a sustainable online platform for over 170 journals and books published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Web site, and all posted and associated content indicates your acceptance of BioOne’s Terms of Use, available at [www.bioone.org/page/terms_of_use](http://www.bioone.org/page/terms_of_use).

Usage of BioOne content is strictly limited to personal, educational, and non-commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.
First report of an egg parasitoid reared from *Neomusotima conspurcatalis* (Lepidoptera: Crambidae), a biological control agent of *Lygodium microphyllum* (Schizaeales: Lygodiaceae)

Ellen C. Lake\(^1\), Michael W. Gates\(^2\), Melissa C. Smith\(^1\), Gloria L. Witkus, and Paul D. Pratt\(^3\)

Native predators and parasitoids within the introduced range of a biological control agent often find and attack the agent, a novel resource (Hill & Hulley 1995; Paynter et al. 2010; Christensen et al. 2011). Biotic interference or resistance can decrease the efficacy of a biological control agent, and may even prevent biological control agents from establishing in the introduced range (Goeden & Louda 1976; Van Driesche et al. 2008 and references therein; Paynter et al. 2010). For example, predation by the generalist *Plagiognathus politis* Uhler (Hemiptera: Miridae) decreased the effectiveness of *Galerucella calmariaensis* L. (Coleoptera: Chrysomelidae), on *Lythrum salicaria* L. (Myrtales: Lythraceae), purple loosestrife, and predation by spiders, fire ants, and birds contributed to the failure of *Spodoptera pectinicornis* Hampson (Lepidoptera: Noctuidae) to establish on *Pistia stratiotes* L. (Alismatales: Araceae), waterlettuce (Dray et al. 2001; Hunt-Joshi & Blossey 2005).

Old World climbing fern, *Lygodium microphyllum* (Cavanilles) R. Brown (Schizaeales: Lygodiaceae), is native to tropical and subtropical regions of the Old World (Pemberton 1998; Smith et al. 2006). It escaped cultivation in Florida and was first reported as naturalized in 1965 (Beckner 1968; Pemberton & Ferriter 1998). *Lygodium microphyllum* is now widespread in wetland and mesic habitats in south and central Florida, with several isolated populations in north Florida (EDMaps 2015). This aggressive indeterminate vine can climb 20 m or more into trees and can extend horizontally, smothering native vegetation and reducing plant diversity and ecosystem services (Gordon 1998; Pemberton & Ferriter 1998). *Lygodium microphyllum* produces vast numbers of spores that are windborne and opportunistically self-compatible (Lott et al. 2003; Volin et al. 2004).

The rapid spread of *L. microphyllum*, its impact on native communities, and the lack of effective long-term control using conventional management techniques prompted the start of a classical biological control program in 1997 (Goolsby et al. 2003; Hutchinson et al. 2006). The ongoing search for potential biological control agents has focused on Asia and Australia (Pemberton 1998; Goolsby et al. 2003).

The moth *Neomusotima conspurcatalis* Warren (Lepidoptera: Crambidae) was approved for release as a biological control agent of *L. microphyllum* in 2007 (Boughton & Pemberton 2009). Field releases began in 2008 and large populations developed quickly at some sites causing “brown out” events where heavy defoliation by the larvae caused large areas of *L. microphyllum* to turn brown (Boughton & Pemberton 2009). Field collections of *N. conspurcatalis* larvae to check for parasitism began approximately 8 mo after the first release (Boughton et al. 2012). In total, 1,100 *N. conspurcatalis* larvae were collected from Jonathan Dickinson State Park, Hobe Sound, Florida, USA, between 2008 and 2010 (Boughton et al. 2012). Four species of hymenopteran and one species of dipteran parasitoids were reared from these larvae (Kula et al. 2010; Boughton et al. 2012).

Here we report the first egg parasitoid reared from *N. conspurcatalis* in its introduced range. This is the first recorded egg parasitoid for *Neomusotima* at the generic level (Noyes 2015). *Neomusotima conspurcatalis* females lay eggs singly or in clutches of 20 or more eggs, usually on the underside of *L. microphyllum* foliage (Solis et al. 2004; Boughton & Pemberton 2012; personal observation). The eggs are relatively flat, may overlap like shingles, and are translucent pale yellow in color (Solis et al. 2004; Boughton & Pemberton 2012; personal observation). The egg turns more yellow as the larva develops, and the dark head capsule becomes visible before the 2 mm long larva emerges. Healthy egg masses are difficult to see with the naked eye due to their color and small size. In contrast, parasitized egg masses are more visible because the chorion of parasitized eggs turns a grayish color with black spots, making these egg masses stand out against the *L. microphyllum* foliage. In March 2013, a dark *N. conspurcatalis* egg mass was observed on *L. microphyllum* collected from a field site in Martin County, Florida, USA. This egg mass was held in the laboratory and microhymenopterans emerged.

Parasitized egg masses have since been recovered at multiple sites located up to 125 km apart in southeast Florida. These egg masses were found by observers searching foliage in the field or were detected in the laboratory on field-collected *L. microphyllum* that was examined visually prior to use in the *N. conspurcatalis* mass rearing operation. Individual parasitized egg masses were left in situ on foliage of *L. microphyllum* and held in a plastic vial (Thorton Plastics CO, Salt Lake City, Utah, USA) at approximately 24 °C until parasitoids emerged. The microhymenopterans and remains of the egg mass were then preserved in 95% ethanol and sent to the U.S. Department of Agriculture, Agricultural Research Service, Systematic Entomology Labora-
ology for identification. Males were identified by antennal features, and slide mounts were made using the methods outlined by Platner et al. (1999). Specimens collected from 2 sites in south Florida (26.070815°N, 80.277655°W; 25.958249°N, 80.340957°W) were identified as *Trichogramma* sp. (Hymenoptera: Trichogrammatidae) using Pinto (1997).

Subsequently, specimens were keyed through the revision of North American species of *Trichogramma* (Pinto 1999), but a satisfactory result was not obtained. Additional males are needed, particularly larger specimens, in order to observe the ridges and processes of the genital capsule (via scanning electron microscopy) that are difficult to discern with slide mounted material (Pinto 1999). Further, additional slide mounts will allow for accurate determination of the presence of bac- isonic egg sensilla on the flagellum (Pinto 1999). With the continued efforts outlined above, we hope to arrive at a positive identification. However, it may be that this species is extralimital or, possibly, new. In either case, the results would be reported separately.

*Trichogrammatid wasps are egg parasitoids and the genus *Trichogramma* includes numerous biological control agents (Triplehorn & Johnson 2005). Multiple eggs within a single *N. conspurcatalis* egg mass are often parasitized and parasitism rates can reach 100%. Parasitism rates by *Trichogramma* species can vary depending on environmental conditions, such as temperature and humidity, and by host density (Bourchier & Smith 1996; Quayle et al. 2003; Kalyebi et al. 2005). Ro- meis et al. (2005) reviewed additional factors that can alter parasitism rates by *Trichogramma*, including habitat type and host food plant species and structure. Further research is needed to determine how these factors influence the interaction between *N. conspurcatalis* and its *Trichogramma* sp. parasitoid. It also remains unclear how parasitism affects the population dynamics of *N. conspurcatalis* and its efficacy as a biological control agent of *L. microphyllum*.

We thank the many land managers who permitted us to conduct research on their *L. microphyllum* populations. Tracey Wasyllyk, Alex Chapman, and Cristina Martinez provided assistance in the field and laboratory. Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture (USDA). USDA is an equal opportunity provider and employer. Funding was provided by the South Florida Water Management District and the U.S. Army Corps of Engineers as part of the Comprehensive Everglades Restoration Plan (CERP).

**Summary**

*Neomusotima conspurcatalis* Warren (Lepidoptera: Crambidae) was first released in Florida, USA, as a biological control agent of *Lygodium microphyllum* (Cavanilles) R. Brown (Schizaeas: Lygodiaceae), Old World climbing fern, in 2008. The first egg parasitoid, a *Trichogramma* sp. (Hymenoptera: Trichogrammatidae), was reared from *N. conspurcatalis* in 2013. The parasitoid is widely distributed in south Florida, where its egg mass parasitism rates can reach 100%.

Key Words: egg parasitism; *Trichogramma*; Old World climbing fern; weed biological control

**References Cited**

Beckner J. 1968. *Lygodium microphyllum*, another fern escaped in Florida. American Fern Journal 55: 93-94.

Boughton AJ, Pemberton RW. 2009. Establishment of an imported natural enemy, *Neomusotima conspurcatalis* (Lepidoptera: Crambidae) against an invasive weed, Old World climbing fern, *Lygodium microphyllum*, in Florida. Biological Control Science and Technology 19: 769-772.

Boughton AJ, Pemberton RW. 2012. Biology and reproductive parameters of the brown lygodium moth, *Neomusotima conspurcatalis*—a new biological control agent of Old World climbing fern in Florida. Environmental Entomology 41: 301-316.

Boughton AJ, Kula RR, Gates M, Zhang Y, Nunez M, O’Connor J, Whitfield JB, Center TD. 2012. Parasitoids attacking larvae of a recently introduced weed biological control agent, *Neomusotima conspurcatalis* (Lepidoptera: Crambidae): key to species, natural history, and integrative taxonomy. Annals of the Entomological Society of America 105: 753-767.

Bourchier RS, Smith SM. 1996. Influence of environmental conditions and parasitoid quality on field performance of *Trichogramma minutum*. Entomologia Experimentalis et Applicata 80: 461-468.

Christensen RM, Pratt PD, Costello SL, Rayamajhi MB, Center TD. 2011. Acquired natural enemies of the weed biological control agent *Oxyops vitiosa* (Coleoptera: Curculionidae). Florida Entomologist 94: 1-8.

Dray Jr. FA, Center TD, Wheeler GS. 2001. Lessons from unsuccessful attempts to establish *Spodoptera pectinicornis* (Lepidoptera: Noctuidae), a biological control agent of waterlettuce. Biocontrol Science and Technology 11: 301-316.

EDDMaps. 2015. Center for Invasive Species and Ecosystem Health: Early Detection and Distribution Mapping System, University of Georgia, https://www.eddmaps.org/distribution/viewmap.cfm?sub=3046 (last accessed 29 Jun 2015).

Goeden RD, Louda SM. 1976. Biotic interference with insects imported for weed control. Annual Review of Entomology 21: 325-342.

Goosby JA, Wright AD, Pemberton RW. 2003. Exploratory surveys in Australia and Asia for natural enemies of Old World climbing fern, *Lygodium microphyllum*: Lygodiaceae. Biological Control 28: 33-46.

Gordon DR. 1998. Effects of invasive, non-indigenous plant species on ecosystem processes: lessons from Florida. Ecological Applications 8: 975-989.

Hill MP, Hulley PE. 1995. Host-range extension by native parasitoids to weed biocontrol agents introduced to South Africa. Biological Control 5: 297-302.

Hunt-Joshi TR, Bloxsey B. 2005. Interactions of root and leaf herbivores on pur- ple loosestrife (*Lythrum salicaria*). Oecologia 142: 554-563.

Hutchinson JA, Ferriter A, Serbesoff-King K, Langeland K, Rodgers L [eds.]. 2006. Old World Climbing Fern (*Lygodium microphyllum*) Management Plan for Florida, 2nd edition. Florida Exotic Pest Plant Council Lygodium Task Force, Florida, USA.

Kalyebi A, Overholt WA, Schulthesis F, Mueke JM, Hassan SA, Sitananthan S. 2005. Functional response of six indigenous *Trichogrammatid* egg parasit- oids (Hymenoptera: Trichogrammatidae) in Kenya: the influence of temperature and relative humidity. Biological Control 32: 164-171.

Kula RR, Boughton AJ, Pemberton RW. 2010. *Stantonia pallida* (Ashmead) (Hymenoptera: Braconidae) reared from *Neomusotima conspurcatalis* Warren (Lepidoptera: Crambidae), a classical biological control agent of *Lygodium microphyllum* (Cav.) R. Br. (Polypodiales: Lygodiaceae). Proceedings of the Entomological Society of Washington 112: 61-68.

Lott MS, Volin JC, Pemberton RW, Austin DF. 2003. The reproductive biology of the invasive ferns *Lygodium microphyllum* and *L. japonicum* (Schizaeaceae): implications for invasive potential. American Journal of Botany 90: 1144-1152.

Noyes JS. 2015. Universal Chalcidoidea Database, http://www.nhm.ac.uk/chal- cidoidea (last accessed 7 Jul 2015).

Paynter Q, Fowler SV, Gourlay AI, Groeneman R, Peterson PG, Smith L, Winks CJ. 2010. Predicting parasitoid accumulation on biological control agents of weeds. Journal of Applied Ecology 47: 575-582.

Pemberton RW. 1998. The potential of biological control to manage Old World climbing fern (*Lygodium microphyllum*), an invasive weed in Florida. American Fern Journal 88: 176-182.

**Sumario**

*Neomusotima conspurcatalis* Warren (Lepidoptera: Crambidae) fue liberado por primera vez en la Florida, EE.UU., como un agente de control biológico de *Lygodium microphyllum* (Cavanilles) R. Brown (Polypodiales: Lygodiaceae), el helecho trepador del Viejo Mundo, en 2008. El primer parasitoide de huevos, un *Trichogramma* sp., fue cria-
Pemberton RW, Ferriter AP. 1998. Old World climbing fern (Lygodium microphyllum), a dangerous invasive weed in Florida. American Fern Journal 88: 165-175.

Pinto JD. 1997. Trichogrammatidae, pp. 726-752 In Gibson GAP, Huber JT, Woolley JB [eds.], Annotated Keys to the Genera of Nearctic Chalcidoidea (Hymenoptera). National Research Council Canada, NRC Research Press, Ottawa, Ontario, Canada.

Pinto JD. 1999. Systematics of the North American species of Trichogramma Westwood (Hymenoptera: Trichogrammatidae). Memoirs of the Entomological Society of Washington 22: 287.

Platner GR, Velten RK, Planoutene M, Pinto JD. 1999. Slide-mounting techniques for Trichogramma (Trichogrammatidae) and other minute parasitic Hymenoptera. Entomological News 110: 56-64.

Quayle D, Régnière J, Cappuccino N, Dupont A. 2003. Forest composition, host-population density, and parasitism of spruce budworm Choristoneura fumiferana eggs by Trichogramma minutum. Entomologia Experimentalis et Applicata 107: 215-227.

Romeis J, Babendreier D, Wäcker Fl, Shanower TG. 2005. Habitat and plant specificity of Trichogramma egg parasitoids—underlying mechanisms and implications. Basic and Applied Ecology 6: 215-236.

Smith AR, Pryer KM, Schuettpele E, Korall P, Schneider H, Wolf PG. 2006. A classification for extant ferns. Taxon 55: 705-731.

Solis MA, Yen S, Gooldsby JH. 2004. Species of Lygomusotima new genus and Neomusotima Yoshiyasu (Lepidoptera: Crambidae) from Australia and southeastern Asia feeding on Lygodium microphyllum (Schizaeaeaceae). Annals of the Entomological Society of America 97: 64-76.

Triplehorn CA, Johnson NF. 2005. Borror and DeLong’s Introduction to the Study of Insects, 7th edition. Thomson Brooks/Cole, Belmont, California, USA.

Van Driesche R, Hoddle M, Center T. 2008. Control of Pests and Weeds by Natural Enemies: An Introduction to biological control. Blackwell Publishing Ltd., Malden, Massachusetts, USA.

Volin JC, Lott MS, Muss JD, Owen D. 2004. Predicting rapid invasion of the Florida Everglades by Old World climbing fern (Lygodium microphyllum). Diversity and Distributions 10: 439-446.