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The suitability of select ferns as hosts for *Archips machlopis* (Lepidoptera: Tortricidae)

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Lygodium microphyllum (Cav.) R. Br. (Old World climbing fern; Lygodiaceae) is native to the tropics of Africa, Asia, Australia, and the Pacific Islands. Since its naturalization in Florida (Beckner 1968), the exotic fern has spread rapidly across southern Florida and damages plant communities by blanketing vegetation in wetland habitats (Pemberton et al. 2002). *Lygodium microphyllum* is difficult to manage using controlled burns, mechanical removal, or herbicide applications due to the plant's ability to regenerate from underground rhizomes (Goolsby et al. 2003; Stocker et al. 2008). A biological control program was initiated in 1998 with the expectation that introduced herbivores would provide a long-term, environmentally safe solution to the management of *L. microphyllum* in Florida (Pemberton 1998). This program has resulted in several surveys for host-specific natural enemies in the plant's native range (Goolsby et al. 2003).

On 9 Jun 2014, 36 larvae of a tortricid species were observed binding foliage with silk and feeding in a communal group on *L. microphyllum* stems near Ban Bo Lo (8.0890667°N, 100.0864167°E) in Chian Yai District, Nakhon Si Thammarat Province, Thailand. Stems supporting the larvae were excised from the plant, placed in a plastic container (10 × 5 × 5 cm) with additional *L. microphyllum* vegetation and shipped to the quarantine facility at the United States Department of Agriculture (USDA), Agricultural Research Service (ARS), Invasive Plant Research Laboratory (IPRL) in Fort Lauderdale, Florida, USA, under permit # P-13-03151. Upon arrival, larvae were distributed among 3 ventilated clear plastic containers (10 × 10 × 10 cm) and provisioned exclusively with *L. microphyllum* foliage until pupation. The resulting adults were transferred to a new cage, where they mated and oviposited on cut *L. microphyllum* foliage; dead adults were submitted to the USDA's Systematic Entomology Laboratory (SEL) for identification. Eggs were deposited on the vegetation but also on the walls of the enclosure; neonates (F1) were collected following emergence and reared as described above. The following generation (F2) consisted of >100 adults and their progeny (F3) were used in the following experiment.

An experiment was designed to quantify the host use patterns of the moth in relation to select fern species. Test plant species used in this study 1) represented a range of fern genera, 2) occur sympatricly with the exotic weed (target), or 3) are of particular concern for horticultural or conservation reasons. Test plants consisted of 6 *Lygodium* species, including the only North American native *Lygodium*, *L. palmatum* (Bernh.) Sw., as well as 3 species native to the Caribbean or South America: *L. oligostachyum* (Willd.) Desv., *L. venustum* Sw., and *L. volubile* Sw. The test also included the exotic species *L. microphyllum* and *L. japonicum* (Thunb.) Sw., the latter considered particularly invasive in the northern half of Florida (Langeland & Craddock-Burks 1998). Six Florida native species were tested: *Blechnum serrulatum* Richard (Blechnaceae), *Ctenitis sloanei* (Poeppig ex Sprengel) C. V. Morton (Dryopteridaceae), *Osmunda regalis* L. (Osmundaceae), *Platycerium bifurcatum* (Cav.) C.Chr. (Polypodiaceae), *Thelypteris kunthii* (Desvaux) C.V. Morton (Thelypteridacaea), and *Woodwardia virginica* (L.) Smith (Blechnaceae). The exotic and widely distributed *Pteris vittata* L. (Pteridaceae) and *Nephrolepis cordifolia* (L.) C. Presl (Nephrolepidaeceae) were tested as well as the Australian tree fern *Cyathea cooperi* (Hook. ex F. Muell.) Domin (Cyatheaceae), which is an important ornamental.

A no-choice host specificity and development test was conducted in a single controlled environmental chamber set at 25 °C, 75% RH, and a 14:10 h L:D photoperiod. Six hundred and fifty neonate larvae (<24 h old) were collected from the adult oviposition enclosures and randomly assigned, in groups of 10 individual larvae (pseudoreplicates), to 1 of 65 Petri dishes (90 mm diameter, 15 mm tall). Generally, 5 replicate potted plants per species were maintained at the IPRL, but select species had fewer replicates available for testing (Table 1). Vegetation from each replicate plant for each test species was also randomly assigned to 1 of the 65 dishes for the duration of the test. Each dish was lined with a slightly moistened filter paper (VWR #413), on which was placed excised foliage in excess of the daily consumption by the 10 larvae. Dishes were sealed with parafilm, creating internal conditions of 25 °C and 90% RH when measured with a data logger (Hygrochron iButton, Maxim Integrated, San Jose, California). Analysis of variance (ANOVA) was used to compare larval survivorship and development times among test plant species (PROC GLM, SAS Version 9.1, SAS Institute, Cary, North Carolina) and Tukey's HSD test was used for mean separation.

Larval survivorship from neonate to the pupal stage varied widely among the fern species tested ($F_{14,64} = 7.46$; $P < 0001$; Table 1). Larvae failed to complete development on *L. oligostachyum*, *L. venustum*, and *P. bifurcatum*, although caution should be used when drawing inferences of host suitability with these *Lygodium* species because limited replicates were available for testing. Survivorship was generally low when larvae were held with the remaining 12 species; the highest level observed was 32% when larvae were feeding on the Florida native *O. regalis* and the lowest was found for *B. serrulatum* and *C. cooperi* with the remaining species intermediate. Plant species also influenced larval ($F_{11,50} = 3.74$; $P < 0.001$) and neonate-to-adult ($F_{11,42} = 3.69$; $P < 0.002$) development rates. Complete development was observed on Florida native and exotic species, including the target weed *L. microphyllum*. Shortest larval development rates were observed for the Florida native

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Table 1. Mean (± SE) survival and development of *Archips machlopis* larvae when held with fern species as hosts. Larval development was monitored from neonate through last larval instar whereas total development terminates with the emergence of the adult. Replicate number refers to the Petri dishes that each housed 10 larvae (considered here as pseudoreplicates).

Plant species	Replicates	Larval survivorship (%)	Larval development time (d)	Total development time (d)
Blechnum serrulatum	5	2.0 (0.02)	28.0 (0.0)	38.0 (0.0)
Ctenitis sloanei	5	24.0 (0.04)	23.4 (1.2)	31.3 (1.6)
Cyathea cooperi	5	8.0 (0.02)	47.0 (10.2)	48.0 (8.7)
Lygodium japonicum	5	20.0 (0.03)	36.0 (1.5)	43.0 (1.5)
Lygodium microphyllum	5	24.0 (0.02)	28.0 (1.6)	34.0 (2.2)
Lygodium oligostachyum	1	0.0 (0.00)	—	—
Lygodium palmatum	5	14.0 (0.04)	42.5 (3.9)	50.0 (5.0)
Lygodium venustum	2	0.0 (0.00)	—	—
Lygodium volubile	3	16.7 (0.07)	47.0 (6.8)	52.7 (9.4)
Nephrolepis cordifolia	5	22.0 (0.05)	31.4 (2.0)	36.5 (1.5)
Osmunda regalis	5	32.0 (0.04)	28.0 (1.9)	36.0 (2.4)
Platycerium bifurcatum	5	0.0 (0.00)	—	—
Pteris vittata	4	18.0 (0.03)	22.3 (0.3)	28.0 (0.0)
Thelypteris kunthii	5	14.0 (0.04)	33.6 (4.6)	39.0 (1.0)
Woodwardia virginica	5	1.04 (0.05)	35.0 (4.6)	44.4 (3.9)

C. sloanei and the exotic *P. vittata* whereas the longest were observed when larvae were feeding on *L. volubile* and *C. cooperi*, with the remaining species intermediate.

Adult moths collected at the inception of the study and submitted for identification were determined as *Archips machlopis* Meyrick (Lepidoptera: Tortricidae) by John W. Brown of the SEL, where voucher specimens are lodged. These data clearly demonstrate that multiple fern species are developmental hosts of *A. machlopis* and lend evidence that the species is a broad generalist, feeding on species across vascular and spore-bearing plants. Although the species was recognized by Goolsby et al. (2003) as a generalist, these data appear to be the first record in the scientific literature to assess the suitability of ferns as hosts for *A. machlopis* (see Robinson et al. 2010 for host list). These data also confirm that *A. machlopis* is not sufficiently host specific to be considered for biological control of *L. microphyllum*.

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Summary

Surveys for natural enemies of *Lygodium microphyllum* (Cav.) R. Br. (Lygodiaceae) in Thailand resulted in the collection of *Archips machlopis* Meyrick (Lepidoptera: Tortricidae). Multiple generations of the tortricid were reared on *L. microphyllum* in a quarantine laboratory, demonstrating that the plant is a developmental host. Further host specificity testing indicated that *A. machlopis* is able to complete development on 12 of the 15 fern species tested, confirming that the polyphagous herbivore's diet includes Pteridophyta. These data also confirm that *A. machlopis* is not sufficiently host specific to be considered for biological control of *L. microphyllum*.

Key Words: Old World climbing fern; exotic; invasive; Florida

Sumario

Los sondeos para los enemigos naturales de *Lygodium microphyllum* (Cav.) R. Br. (Lygodiaceae) en Tailandia resultaron en la colección de *Archips machlopis* Meyrick (Lepidoptera: Tortricidae). Varias generaciones del tortrícido fueron criadas sobre *L. microphyllum* en un laboratorio de cuarentena, lo que demuestra que la planta es un hospedero para su desarrollo. Pruebas adicionales de especificidad de hospedero indicaron que *A. machlopis* puede completar el desarrollo en 12 de las 15 especies de helechos probados, confirmando que la dieta del herbívoro polífago incluye Pteridophyta. Estos datos también confirman que *A. machlopis* no es suficientemente específico a los hospederos para ser considerado para el control biológico de *L. microphyllum.*

Palabras Clave: Helecho Trepador del Viejo Mundo; exótico; invasor; Florida

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