TRANSACTIONS AMERICAN ENTOMOLOGICAL SOCIETY

RESEARCH ARTICLE

TAES 140: 237-244
ISSO 0002-8320
http://taes.entomology-aes.org/

Curculionidae (Coleoptera) Species within Geographically Isolated Wetlands of the Gulf Coastal Plain in Southwestern Georgia

Nathalie Smith and Stephen Golladay

Joseph W. Jones Ecological Research Center, 3988 Jones Center Drive, Newton, GA 39870, USA.
Correspondence: nsmith@jones.ctr.org [NS] and sgollada@jonesctr.org [SG]
Keywords: indicator species, wetland ecotones, weevils

ABSTRACT

Curculionidae (weevils) frequently are recognized as favoring moist environments and wetland vegetation. To better understand the relationship between wetland type and the presence of curculionid species, twenty-four isolated wetlands (previously characterized as marshes, savannas or forested swamps) were sampled. Seventeen genera and 27 species were identified. Indicator species analysis revealed an association between the genus Dirabius and marsh habitat. NMS (Non-Metric Multidimensional Scaling Ordination) found a significant 2-dimensional solution to abundance data. *Auleutes nebulosus, Lissorhoptrus simplex*, *Notiodes laticollis*, *Rhinoncus longulus*, *Sphenophorus minimus*, and an unidentified species of Dirabius and Listronotus were associated with marshes. Swamps were characterized by their absence of Curculionidae. Savannas were intermediate between marshes and swamps. Marshes, with their diversity of vascular plants, appear to provide more suitable habitat and possess characteristics that allow curculionid populations to persist in the landscape.

INTRODUCTION

Within the southeastern coastal plain of the United States, geographically isolated wetlands are an important landscape feature. These seasonally flooded wetlands provide ecosystem services by providing wildlife habitat, improving water quality, removing excess sedimentation and nutrient loads, controlling floodwater, and facilitating groundwater recharge (NRCS, 2007). Compared to perennial wetlands, these isolated ecosystems have a higher risk of degradation due to their small size and lack of legal protection (Kirkman et al., 2000). Invertebrates are often the dominant faunal group in small isolated wetlands but only recently have received attention from ecologists (Cooper et. al, 2009). Little research has been directed toward examining terrestrial species that transition into wetlands during periodic drying, i.e., loss of pooled surface water. A basic understanding of this tendency is important in that nearly all invertebrates occupy intermediate positions in food webs and some serve as a link between wetland productivity and terrestrial ecosystems. Battle and Golladay (2003) observed that the beetle fauna (larvae and adults) of isolated wetlands, particularly marshes, is the most diverse faunal group during the aquatic phase. The highly specific habitat requirements of some beetle species provide a valuable tool for assessing environmental conditions of terrestrial and freshwater ecosystems (New, 2010). A recent severe and extended drought in the southeastern US (2010-2012, www.drought.gov) provided an opportunity to look at the beetle fauna of isolated wetlands during abnormal climatic conditions.

Coleopteran species have a wide variety of associations with aquatic habitats, but often it is difficult to determine aquatic versus terrestrial habitat preferences (White, 2009). Curculionidae are among the most speciose group of animals with more than 60,000 described species (Arnett, 2002). They are found in almost every habitat and often

Publication date: 15 May 2014 urn:lsid:zoobank.org:pub:51AC5007-9D7E-4A38-9482-ABBB505B8316

have the ability to transition into and out of aquatic ecosystems. Some species have the ability to alternate between plastron respiration while in water and resume terrestrial respiration during periods of dry down and/or anoxic conditions (McCafferty, 1983). Nearly all curculionids are herbivores and many species have narrow host plant requirements. Kirkman et al. (2000) assessed plant diversity of isolated wetlands noting peaks in diversity occurring in marshes and in wetland ecotones. The host specificity of weevils makes it likely that their diversity would show a similar pattern. To understand the suitability of seasonal wetlands for aquatic Coleoptera, specifically Curculionidae, variation in hydrologic conditions and climatic variation must be considered. We hypothesized that the diversity of curculionids would reflect their tolerance to both wet and dry habitats and the differing plant diversity of wetland types.

METHODS

Study Site

We sampled 24 geographically isolated wetlands situated throughout the Ichauway Ecological Reserve, an 11,800 ha longleaf pine ecosystem located in the Dougherty Plain of Baker County, Georgia. These wetlands were classified as marshes, savannas or forested swamps on the basis of soil characteristics and vegetation (Kirkman et al., 2000). Marshes contain sandy soils with panic grasses (*Panicum* spp.) and cutgrass (*Leersia hexandra*) dominating their ground-flora. Savannas have clayey soils with a sparse distribution of pond cypress (*Taxodium ascendens*) and ground-flora consisting of panic grasses and broomsedge (Andropogon virginicus). Swamps are characterized by organic soils with pond cypress and swamp tupelo (*Nyssa biflora*) canopies. Sparse midstory and ground-flora of various species also are present in swamp wetlands (Battle and Golladay, 2003). Overall, marshes contain greater species diversity than savannas or forested swamps (Kirkman et al., 2000).

Beetle collections

Wetlands were sampled in November 2010, and January, March, and April of 2011 during an extended severe drought in the southeastern US (2010-2012, www.drought.gov). Water depth at permanent staff gauges (located within the deepest depression of each wetland) were recorded at the time of sampling. Five methods were used to capture beetles: sweep netting, tree beating, flight intercept traps, pitfall traps and yellow bowls (described below).

Understory vegetation, i.e., vegetation immediately above the forest floor and reachable by the observer (Charles and Basset, 2005), was sampled by sweep netting and tree beating during daylight hours. Beetles were dislodged with 5 strokes of an aluminum baseball bat and captured with a beating sheet of 18,810 cm^2 surface area. Sweep net samples were collected by sweeping wetland vegetation within four 10 m transects at each staff gauge. Flight intercept traps ($1m^2$) were placed overnight in each wetland and positioned within 10 m of the staff gauge. One meter troughs filled with soapy water were positioned directly below each net to capture any falling beetles (Catanach, 2012).

Pitfall trapping was our standard method for collecting ground-dwelling beetles. Traps consisted of 2 L bottles, whose necks were cut and inverted to create a funnel with an entrance diameter of 20 mm. Traps were buried with their rims flush with the soil surface. Three pitfall traps were deployed within each of our study sites: two baited with fish or dry cat food, and one unbaited trap which served as a control. Once deployed, traps were left for three days and then retrieved. Within each wetland, one 354 mL yellow plastic bowl was filled with soapy water and placed within 1 m of the staff gauge. Captured specimens were preserved in 70% EtOH, and identified to the lowest possible taxonomic level by taxonomic specialists at the Louisiana State University, Arthropod Museum.

Statistical analyses

Nonmetric multidimensional scaling (NMS) ordination was used to evaluate the association between curculionid taxa and wetland type. Analysis was done using PC-ORD for Windows, Version 5.10 (McCune and Mefford 2006). Single individual captures were not included in the analysis. An initial run was made using 6 dimensional space, Sorensen distance, and 250 iterations. A 2 dimensional solution was suggested and a final run of 250 iterations was made using 2 axes with a randomly selected starting configuration. A Monte Carlo analysis using randomized data was performed to determine whether the preferred solution is significantly different from chance.

PC-ORD Indicator Species Analysis (using the Sorenson distance measure and 1000 randomizations in the Monte Carlo Test) was used to determine indicator taxa associated with wetland type and the presence or absence of water. This method measures affinity based on abundance, presence, and frequency of a particular taxa for a group of sites. A perfect indicator species will always be present and exclusive to a group (receiving an indicator value of 100).

RESULTS

Seventeen genera and twenty-seven species were identified from the family Curculionidae. Weevils were collected at 20/24 wetlands sampled (Table 1). Indicator species analysis revealed an association between the genus *Dirabius* (indicator value of 50) and marsh habitat. The randomization test showed that the probability of an indicator value of 50 or higher, given this species' distribution of abundance, was 0.0318. No indicator taxa were associated with the presence or absence of water within a wetland. NMS found a significant 2 dimensional solution with a stress value of 10.08084 and a Monte Carlo p-value of .0040.

Auleutes nebulosus, Lissorhoptrus simplex, Notiodes laticollis, Rhinoncus longulus, Sphenophorus minimus, and unidentified species of *Dirabius and Listronotus* were associated with marshes; swamps were characterized by the absence of curculionids. Savannas were intermediate between marshes and swamps. Eleven taxa (44%) were represented by single individuals captured. Sweep netting yielded 14 taxa, tree beating yielded 2 taxa, flight intercept traps yielded 1 taxon (exclusively *Aulobaris anthracina*) and yellow bowls yielded two taxa. Pitfalls baited with catfood, fish and those that served as a control yielded 6, 2 and 7 taxa respectively. The abundance and diversity of curculionid taxa were greatest during April (n=22) collections (Figure 3). January had the lowest abundance and diversity of specimens (n=1).

DISCUSSION

Our results indicate that marshes are the most important geographically isolated wetland habitat for curculionid diversity and abundance. Characterized by a species-rich herbaceous flora (Kirkman, Smith, and Golladay, 2012), marshes provide habitat and food needed for these phytophagous insects. Adult weevils typically feed on a narrow range of host plant foliage and/or reproductive structures. In comparison, larvae are known to feed within the tissues of congeneric plant taxa (Arnett et al., 2002). Certain species have the capacity to live under water and feed on aquatic vegetation (Arnett, 2000). Oviposition occurs within or on a host plant (McCafferty, W.P., 1983). Currently, little or no life history information is available on many curculionid species, including the genus *Dirabius*, which was abundant in the wetlands we sampled. Examining weevil to plant species relationships would further our understanding of the role curculionids play within wetland ecosystems. It seems likely that these weevils require host plants that are specific to marshes, but additional study is needed to elucidate this relationship.

The absence of curculionid beetles in swamps was unexpected, given the diversity of species in this family of beetles. Sparse emergent vegetation, lower plant diversity, and longer inundation might contribute to the limited number of curculionids found within swamps. However, previous sweep sampling also noted an absence of curculionids in swamps. While previous samples were collected during the inundation phase, they included emergent vegetation and dead wood (Battle and Golladay, 2001).

Many variables can influence the capture success of beetles. These include, but are not limited to, the presence or absence of water in the wetlands, temperature and various other environmental factors such as rain, mammalian disturbance, fire ant infestation, cold tolerance and variation in the dispersal abilities of individual taxa. Noctural sweep netting and tree beating would likely influence capture richness and abundance. For future studies, comparing these diurnal captures to specimens captured at night would better illustrate the relationship curculionids play within geographically isolated wetlands.

When comparing collecting methods, sweep netting was most effective in our wetlands, resulting in not only more individuals, but a richer diversity of taxa. Sweep net capture illustrates the close association curculionids have with emergent wetland vegetation. Our results suggest that curculionids seldom move far from their host plants or dispersal did not occur during the periods when we sampled. Alternate collection techniques such as tree beating and pitfall trapping also proved of importance as they allowed for a more complete assessment of curculionid diversity (Table 1) providing for the collection of rare taxa.

The lack of association between taxa and the presence or absence of water, suggests that curculionids can inhabit wetlands throughout varying hydroperiods. This would be a useful adaptation in isolated systems that undergo frequent and unpredictable hydrologic changes. Transitioning between these hydroperiods is likely to have no constraint on the physiological requirements of these beetles.

These findings bring attention to a group of insects that are largely overlooked. Given their strong association with plants, curculionids provide important ecological services as control agents for noxious weeds (Bloem et al., 2002), pollination and nutrient cycling. The majority of curculionid research has focused on destructive species that impact agriculture and crops. Little has been done to examine curculionids that inhabit natural ecosystems (Ciegler, 2010). More research about their biology and patterns of in-site diversity is needed (Jones et al., 2008). Given their host specificity and ease of collection, they may represent useful indicators of restoration and conservation strategies. Understanding the natural history and ecological function of curculionids is an essential component to wetland conservation and management.

ACKNOWLEDGEMENTS

This project was supported by the Joseph W. Jones Ecological Research Center. We thank Dr. Michael Ferro for identifications and Dr. Charles O'Brien and Dr. Mark Blackmore for reviewing earlier versions of the manuscript. We are grateful for field and laboratory assistance from Kyle Hodgson and Bryan Cloninger. We also thank the associate editor and 2 anonymous reviewers.

WORKS CITED

Anderson,R.S., Pages [722-724] in Arnett, R.H. Jr., M.C. Thomas, P.E. Skelley, and J.H. Frank (eds.) 2002. American Beetles, vol. 2. NewYork: CRC Press.

Arnett, R.H. Jr. 2000. American Insects: A Handbook of the Insects of America North of Mexico. CRC Press LLC.

Battle, J., and S.W. Golladay. 2001. Water quality and macroinvertebrate assemblages in three types of seasonally inundated limesink wetlands in southwest Georgia. Journal of Freshwater Ecology, Vol. 16, No.2.

Battle, J., and S.W. Golladay. 2003. Prescribed fire's impact on water quality of depressional wetlands in southwestern Georgia. American Midland Naturalist 150:15-25.

Bloem, S., R.F. Mizell, and C.W. O'Brien. 2002. Old Traps for New Weevils: New Records for Curculionids (Coleoptera: Curculionidae), Brentids (Coleoptera: Brendidae) and Anthribids (Coleoptera: Anthribidae) from Jefferson Co., Florida. The Florida Entomologist, Vol. 85, No.4, pp.632-644.

Catanach, T.A. 2012. Invertebrate sampling methods for use in wildlife studies. Pages 336-343 in N.J. Silvy (ed). The Wildlife Techniques Manual. John Hopkins University Press.

Charles, E. & Basset, Y. 2005 Vertical stratification of leaf beetle assemblages (Coleoptera: Chrysomelidae) in two forest types in Panama. J. Trop. Ecol. 21, 329–336.

Ciegler, J.C. 2010. Weevils of South Carolina (Coleoptera: Nemonychidae, Attelabidae, Brentidae, Ithyceridae, and Curculionidae). Biota of South Carolina. Vol. 6. Clemson University, Clemson, S.C. 276 pp.

Cooper, M.J., D.G. Uzarski, and T.M. Burton. 2009. Benthic Invertebrate Fauna, Wetland Ecosystems. Pages 232-241 in Mitsch et al. Wetland Ecosystems: John Wiley and Sons, Inc.

Jones, R.W., C.W. O'Brien, L. Ruiz-Montoya, and B. Gomez-Gomez. 2008. Insect Diversity of Tropical Montane Forests: Diversity and Spatial Distribution of Weevils (Coleoptera: Curculionidae) Inhabiting Leaf Litter in Southern Mexico. Annals of the Entomological Society of America, 101(1):128-139.

Kirkman, L.K., L.L Smith, and S.W. Golladay. 2012. Southeastern depressional wetlands. Pages 203-216 in D. Batzer, and A. Baldwin (eds.). Wetland Habitats of North America: Ecology and Conservation Concerns. University of California Press.

Kirkman, L.K., P.C. Goebel, L. West, M.B. Drew, and B.J. Palik. 2000. Depressional wetland vegetation types: a question of plant community development. Wetlands 20:373-385.

McCafferty, W.P. 1983. Aquatic Entomology. Pages 234-235. Jones and Bartlett Publishers, Inc.

McCune, B. and J.B. Grace. 2002. Analysis of Ecological Communities. MjM Software Design. Gleneden Beach, OR.

New, T.R. 2010. Beetles in Conservation: Blackwell Publishing

NRCS, Natural Resources Conservation Service. 2007. Temporarily Flooded Wetlands. Fish and Wildlife Habitat Leaflet: 47.

White, D.S. 2009. Coleoptera (Beetles) in aquatic ecosystems. Pages 144-156 in G.E. Likens (ed.). Encyclopedia of Inland Waters: Academic Press.

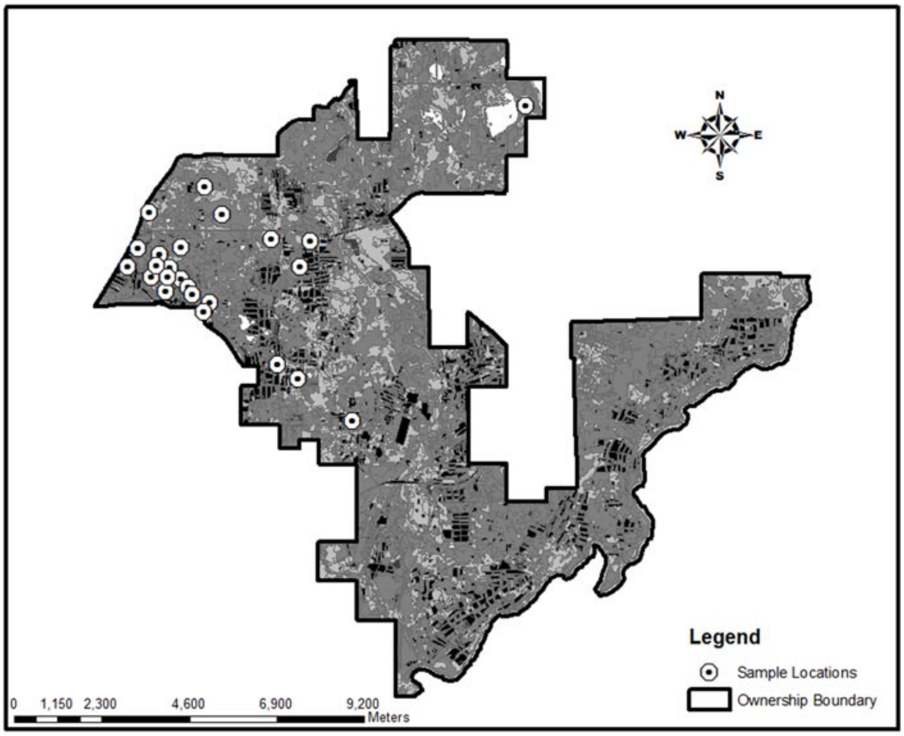

Figure 1. Wetland sample sites on the Ichauway Ecological Reserve, Newton, Georgia.

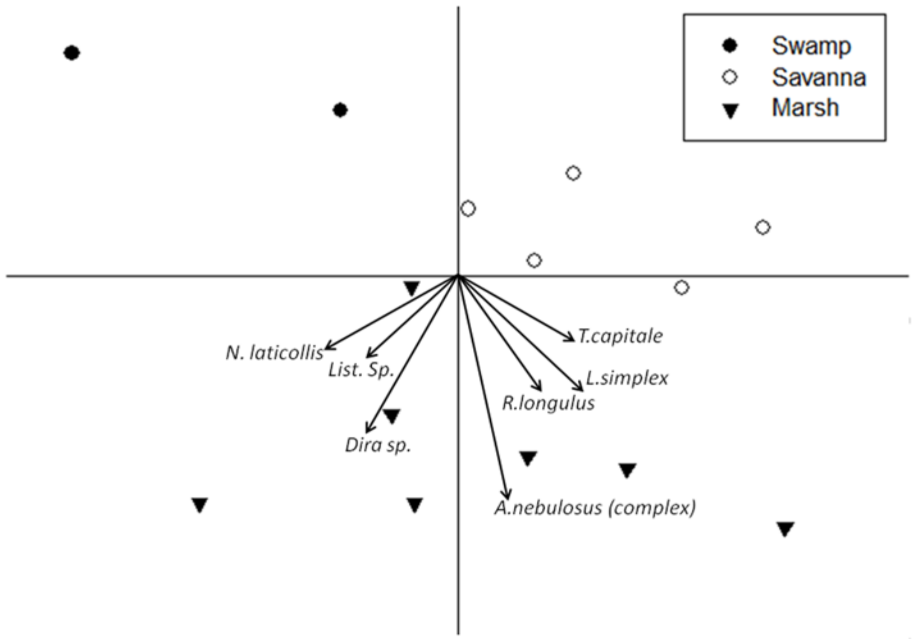

Figure 2. NMS found a significant 2 dimensional association between curculionid species and wetland ecotones.

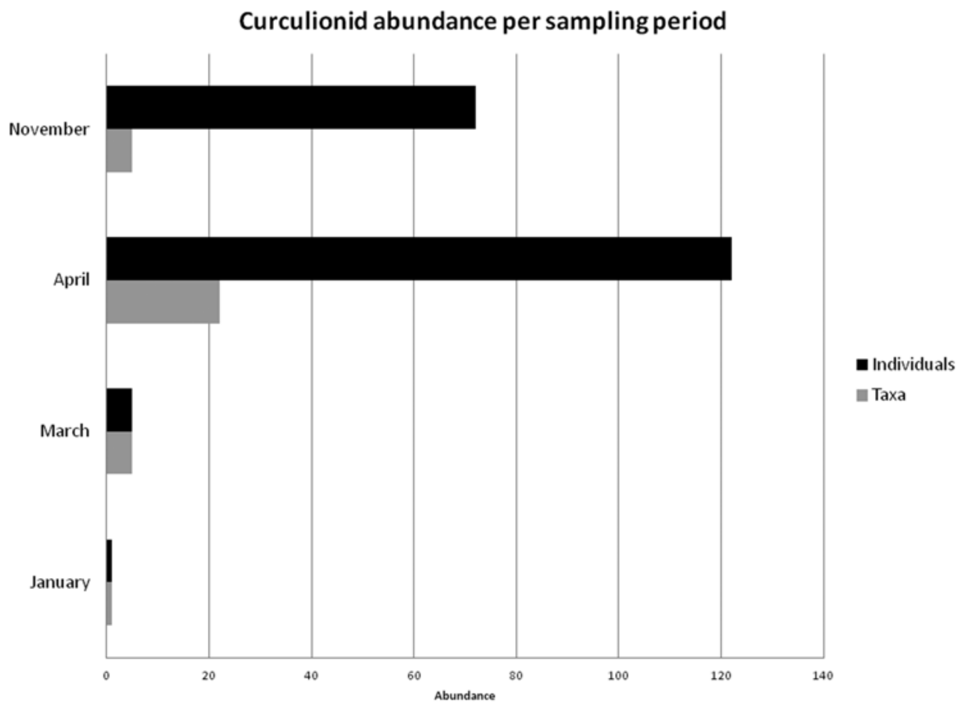

Figure 3. Curculionid abundance by sampling period. Bars indicate total collected (# individuals or # species).