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Habitat Associations of Macro-Staphylinids (Coleoptera: Staphylinidae) at Alice L. Kibbe Life Science Station, Hancock County, Illinois

Kenneth W. McCravy¹ and Jason E. Willand²

Abstract

Habitat associations of size-selected (≥ 5 mm length) rove beetles (Coleoptera: Staphylinidae), hereafter referred to as "macro-staphylinids," were studied in west-central Illinois forest and prairie habitats in 2005 using pitfall traps. Habitats sampled included oak-hickory forest last burned in spring 2004, oak-hickory forest burned in spring 2005, oak-hickory forest unburned for 5+ years, unburned early successional forest, reconstructed prairie last burned in spring 2004, and reconstructed prairie burned in spring 2005. A total of 361 macro-staphylinids, representing 12 species, were collected, with *Philonthus caerulipennis* (Mannerheim), *Platydracus maculosus* (Gravenhorst), *Platydracus fossator* Gravenhorst, *Platydracus zonatus* (Gravenhorst), and *Tachinus fimbriatus* Gravenhorst comprising 94% of all macro-staphylinids collected. Fewest numbers of macro-staphylinids were collected in prairie habitats, particularly the prairie burned in spring 2005. A multi-response permutation procedure revealed significant variation in species composition among habitats, with relatively large differences between burned and unburned forest habitats and between forest and prairie habitats. Within-habitat variation in species composition was relatively high in the prairie and recently burned forest habitats. Indicator species analysis revealed a significant association of *Philonthus asper* Horn with the early successional forest, and four species had relatively high indicator values for multiple forest habitats, with fire playing a potentially important role in some cases. More intensive sampling and larger sample sizes are needed to clarify these potential habitat associations.

The rove beetles (Coleoptera: Staphylinidae) are one of the most diverse metazoan families, with over 46,200 known species worldwide and over 4,100 known species in North America north of Mexico (Newton et al. 2001). Most rove beetles are generalist predators, but other feeding types, such as fungivory (Thayer 1987), parasitoidism (Walsh and Posse 2003) and saprophagy (Newton et al. 2001) are also present in the family. In North America, rove beetles occur and are often very abundant in virtually every habitat type except for the driest regions (Newton et al. 2001). Larval rove beetles are poorly studied, but are generally found in similar habitats as the adults and appear to have similar feeding habits (Newton et al. 2001).

Despite their great diversity, rove beetles have received relatively little attention as potential ecological indicators compared with other species-rich coleopteran families, such as the ground beetles (Carabidae) (Bohac 1999, Martins da Silva et al. 2009). In the Midwestern United States a large proportion of the original forest and prairie has been eliminated or fragmented by cultivation

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and other disturbances (Parker 1989, Corbett and Anderson 2006). Rove beetle communities are potentially useful indicators of anthropogenic environmental influences. In our study, pitfall traps were used to investigate habitat associations of epigeic rove beetles ≥ 5 mm in length (hereafter referred to as "macro-staphylinids") in a Midwestern forest/prairie habitat mosaic.

Materials and Methods

Macro-staphylinids were collected from June to October 2005 at Western Illinois University's Alice L. Kibbe Life Science Station (40.365° N, 91.406° W) and adjacent Illinois Department of Natural Resources land in Hancock County, Illinois. Six habitats were sampled: three oak-hickory forest stands, early successional forest, and two reconstructed prairies. One oak-hickory forest stand was last treated with prescribed fire in spring 2004, one was treated with prescribed fire in spring 2005, and one had not been burned for 5+ years (hereafter referred to as burned forest-2004, burned forest-2005 and unburned forest, respectively). Total contiguous area of the oak-hickory forests was at least 200 ha, and burn units were ca. 3.0 ha each. The burned forest-2004 and the unburned forest had an easterly aspect and the burned forest-2005 had a southerly aspect. Slope ranged from 7-9° for these forests plots. The early successional forest consisted of two fragments, and had not been burned. One fragment was ca. 0.3 ha with a length of ca. 75 m and width of ca. 40 m, and the other was ca. 0.1 ha with a length of ca. 40 m and width of ca. 25 m. One prairie had last been treated with prescribed fire in spring 2004, and the other in spring 2005 (hereafter referred to as burned prairie-2004 and burned prairie-2005, respectively). The burned prairie-2004 was irregular in shape and ca. 2.5 ha. The burned prairie-2005 was ca. 3.0 ha and linear, with a length of ca. 500 m and width of ca. 60 m.

The dominant vegetation of the oak-hickory forests included white oak (*Quercus alba* L.), northern red oak (*Quercus rubra* L.), shagbark hickory [*Carya ovata* (P. Mill) K. Koch], black cherry (*Prunus serotina* Ehrh.), bramble (*Rubus* spp. L.), prickly ash [*Zanthoxylum americanum* P. Mill.], fragrant sumac (*Rhus aromatica* Ait.), pointedleaf ticktrefoil [*Desmodium glutinosum* (Muhl. ex Willd.) Wood], Virginia creeper [*Parthenocissus quinquefolia* (L.) Planch.] and sedges (*Carex* spp. L.). The early successional forest contained primarily black locust (*Robinia pseudoacacia* L.), Canada goldenrod (*Solidago canadensis* L.), garlic mustard [*Alliaria petiolata* (M. Bieb.) Cavara and Grande], white avens (*Geum canadense* Jacq.) and white snakeroot [*Ageratina altissima* (L.) King & H.E. Robins.]. Dominant vegetation in the prairies included Indian grass [*Sorghastrum nutans* (L.) Nash], big bluestem (*Andropogon gerardii* Vitman), goldenrod (*Solidago* spp. L.), partridge pea [*Chamaecrista fasciculata* (Michx.) Greene], roundhead lespedeza (*Lepedeza capitata* Michx.), ticktrefoil (*Desmodium* spp. Desv.) and woody vegetation such as roughleaf dogwood (*Cornus drummondii* C. A. Mey.) and smooth sumac (*Rhus glabra* L.). Plant nomenclature follows that of Gleason and Cronquist (1991), with verification of recent nomenclature using <http://www.wildflower.org/plants/> and <http://plants.usda.gov/> (both accessed 25 May 2010).

A total of 162 pitfall traps were used to collect rove beetles. Three plots were placed in each habitat, with each plot consisting of nine traps, arranged in a 3 x 3 grid, with 5 m between traps. The study plots were arranged in transects 75 m apart in the oak-hickory forests and burned prairie-2005. Due to fragmentation and size irregularity, the burned prairie-2004 and early successional forest plots were each separated into two different areas. Within each of the larger patches of habitat two plots were established ~ 40 m apart; in the smaller patch a third plot was established. Plots in the prairie habitats were located 30 to 40 m from the nearest prairie/forest interface, and plots in the early successional forest were located 15 to 20 m from the nearest forest/prairie

interface. Plots in the oak-hickory forests were located 50 to 100 m from the nearest forest/prairie interface, and at least 30 m inside the prescribed burn boundary. Each pitfall trap consisted of two 473 ml plastic cups (Solo[®], Urbana, IL) one nested inside the other, and buried in the ground to the top rim. Traps were filled with approximately 150 ml of a 50/50 mixture of propylene glycol antifreeze and water, which acted as a killing agent and preservative. Rove beetles were trapped for seven consecutive days each month (4-11 June, 9-16 July, 6-13 August, 10-17 September and 8-15 October). Because of some loss of very small specimens which could negatively affect data analysis, only macrostaphylinids (≥ 5 mm in length) were collected from the traps and included in the analyses. All collected macro-staphylinids were identified by Richard Hoebeke, Senior Extension Associate and Assistant Curator, Department of Entomology, Cornell University.

Differences in macro-staphylinid abundance among habitats were compared using the chi-square test for goodness of fit. Macro-staphylinid species composition was compared among habitats using a multi-response permutation procedure (MRPP), a nonparametric statistical technique for testing the hypothesis of no difference in species composition/relative abundance between two or more habitats. MRPP provides a measure of within-habitat homogeneity (A), which increases as the communities in different habitats deviate, to a maximum of 1. In community ecology analyses, values of A are generally below 0.1, and an A value greater than 0.3 is considered to be relatively high (McCune and Grace 2002). The Sørensen (Bray & Curtis) distance measure was used to calculate the A values because it is less likely to exaggerate the effects of outliers (McCune and Grace 2002). Distance measures range from 0 to 1, increasing with greater heterogeneity of species composition among plots within a habitat.

Indicator species analysis (ISA) was used to examine the extent to which individual macro-staphylinid species were *exclusive* (never occurring elsewhere) and *faithful* (always present) to particular habitats (Dufrene and Legendre 1997, McCune and Grace 2002). Indicator values for a particular habitat can range from 0 to 100, with higher values indicating stronger associations with a given habitat. The maximum indicator value for each species was tested for statistical significance using a Monte Carlo technique based on 1000 randomizations. Both MRPP and ISA were performed using PC-Ord Version 4.25 software.

Results and Discussion

A total of 361 macro-staphylinids, representing 12 species, were collected (Table 1). The five most common species, *Philonthus caerulipennis* (Mannerheim), *Platydracus maculosus* (Gravenhorst), *Platydracus fossator* Gravenhorst, *Platydracus zonatus* (Gravenhorst), and *Tachinus fimbriatus* Gravenhorst, comprised 94% of all captures. Numbers of macro-staphylinids collected varied significantly among habitats ($\chi^2 = 86.08$, $df = 5$, $P < 0.001$) compared to the null prediction of equal distribution of macro-staphylinids over all habitats. We collected the fewest numbers of macro-staphylinids in the burned prairie-2005 (Table 1). This habitat contributed over half (45.23) of the above chi-square value. The lower numbers of macro-staphylinids collected in the burned prairie-2005 vs. the burned prairie-2004 were primarily due to the relatively low numbers of *P. fossator* in the burned prairie-2005 (Table 1). This species is often associated with carrion (Byrd and Castner 2001), probably as a predator of other carrion-feeding insects. Changes in vegetation structure caused by recent fire may affect this species by altering microclimatic conditions or availability of carrion and associated insect prey.

Rove beetles have received little attention as potential bioindicators, probably because of taxonomic constraints and lack of ecological information (Bohac 1999, Martins da Silva et al. 2009). Buse (1988) has also suggested that rove beetles are habitat generalists relative to other beetle groups. However,

Table 1. Numbers of macro-staphylinids (rove beetles ≥ 5 mm in length) collected in pitfall traps in six habitats (BF-04 = oak-hickory forest burned in spring 2004, BF-05 = oak-hickory forest burned in spring 2005, UF = oak-hickory forest unburned for 5+ years, ESF = unburned early successional forest, BP-04 = prairie burned in spring 2004, and BP-05 = prairie burned in spring 2005). Trapping was done for five 7-day trapping periods from 4 June to 15 October 2005 in Hancock County, Illinois USA.

| Species | BF-04 | BF-05 | UF | ESF | BP-04 | BP-05 | Total | % of Total |
|--|-------|-------|----|-----|-------|-------|-------|------------|
| <i>Hesperus baltimorensis</i> (Gravenhorst) | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0.3 |
| <i>Homaeotarsus</i> sp. | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0.3 |
| <i>Ontholestes cingulatus</i> Gravenhorst | 0 | 0 | 0 | 5 | 1 | 0 | 6 | 1.7 |
| <i>Philonthus asper</i> Horn | 1 | 0 | 0 | 7 | 0 | 0 | 8 | 2.2 |
| <i>Philonthus caerulipennis</i> (Mannerheim) | 61 | 60 | 19 | 14 | 1 | 0 | 155 | 42.9 |
| <i>Platydracus cupripennis</i> (Melsheimer) | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0.3 |
| <i>Platydracus fossator</i> Gravenhorst | 2 | 2 | 7 | 4 | 30 | 5 | 50 | 13.9 |
| <i>Platydracus maculosus</i> (Gravenhorst) | 22 | 10 | 16 | 31 | 6 | 2 | 87 | 24.1 |
| <i>Platydracus zonatus</i> (Gravenhorst) | 5 | 1 | 11 | 9 | 1 | 0 | 27 | 7.5 |
| <i>Que dius neomolochinus</i> Korge | 1 | 0 | 1 | 0 | 1 | 0 | 3 | 0.8 |
| <i>Que dius peregrinus</i> (Gravenhorst) | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0.3 |
| <i>Tachinus fimbriatus</i> Gravenhorst | 9 | 1 | 9 | 0 | 1 | 1 | 21 | 5.8 |
| Total | 102 | 75 | 65 | 70 | 41 | 8 | 361 | 100.1 |

Bohac (1999) and Markgraf and Basedow (2002) found that rove beetles can be heavily influenced by landscape structure and land management practices. Buse and Good (1993) found substantial habitat specificity among rove beetles inhabiting plantation forests and associated habitats in northeast England, and Caballero et al. (2009) found that habitat changes probably altered rove beetle diversity and species composition in southern Mexico. In our study, the overall MRPP analysis indicated significant differences in macro-staphylinid species composition among habitats ($A = 0.215$, $P = 0.0004$). Pairwise MRPP comparisons (Table 2) between the two burned forest habitats, between the unburned forest and early successional forest (the two unburned forest habitats), and between the two prairie habitats, produced relatively small A -values. Pairwise comparisons between burned and unburned forest habitats produced larger A -values, suggesting greater divergence in species composition. These results suggest that recent burning can affect species composition of forest macro-staphylinid assemblages, perhaps through changes in microclimate and leaf litter structure. Variation in litter layer and in soil moisture has been found to be associated with variation in rove beetle species composition (Bohac 1999). Prairie macro-staphylinid species composition was substantially different from that of the forest habitats in our study, but showed the least divergence from the burned forest-2005 (Table 2). Removal of large amounts of litter and understory vegetation by recent fire in this forest habitat may have resulted in microclimatic conditions more similar to those of the prairies. We limited our trapping to one week per month due to concerns about potential effects of removal on rove beetle populations, but this resulted in restricted sample sizes and species richness. Future studies employing more intensive trapping, as well as other collection techniques, are needed to further clarify the effects of fire on rove beetle abundance and diversity.

MRPP distance measures for the six habitats were: 0.351 for the burned forest-2004, 0.603 for the burned forest-2005, 0.307 for the unburned forest, 0.367 for the early successional forest, 0.784 for the burned prairie-2004, and 0.833 for the burned prairie-2005. The relatively high distance measures in the burned forest-2005 and the prairies reflect greater variation in species composition among plots within those habitats. This could reflect more patchy and variable ground level microclimatic conditions related to recent fire in this forest habitat and to lack of a canopy and periodic complete removal of vegetation by fire in the prairies.

Philonthus asper Horn was the only species that produced a significant indicator value for a particular habitat, the early successional forest (Table 3). This habitat also produced the largest number of indicator species in a study of ground beetle diversity and habitat associations (Willand 2006). Early successional habitats have diverse structure and composition of plant and animal species, but are declining in the eastern United States (Askins 2001, Gobster 2001, DeGraaf and Yamasaki 2003). Our results suggest that these habitats can be important for certain macro-staphylinid species as well. Several other species had relatively high indicator values for multiple forest habitats, including *P. maculosus* (all four forest habitats), *P. caerulipennis* (the two burned forest habitats), *P. zonatus* (forest habitats not burned the preceding spring), and *T. fimbriatus* (oak-hickory forest habitats not burned the preceding spring) (Table 3). Hunter et al. (1991) also found *P. maculosus* to be strongly associated with wooded habitats, collecting all 19 specimens in wooded vs. open pasture. In a comparison of epigeic beetles inhabiting fragmented and relatively undisturbed continuous hardwood forests, Jennings and Tallamy (2006) found *P. maculosus* and *P. caerulipennis* to be most abundant in continuous forest. The relatively large continuous forests of Kibbe Field Station and adjacent public lands appear to provide suitable habitat for these species, and forest management using prescribed fire may affect certain macro-staphylinid species as well. Many species of *Philonthus*, *Platydracus* and *Tachinus* are associated with carrion

Table 2. Multi-response permutation procedure *A*-values (with associated *P*-values in parentheses) for macro-staphylinids (rove beetles ≥ 5 mm in length) collected in pitfall traps in six habitats (BF-04 = oak-hickory forest burned in spring 2004, BF-05 = oak-hickory forest burned in spring 2005, UF = oak-hickory forest unburned for 5+ years, ESF = unburned early successional forest, BP-04 = prairie burned in spring 2004, and BP-05 = prairie burned in spring 2005). Trapping was done for five 7-day trapping periods from 4 June to 15 October 2005 in Hancock County, Illinois USA.

| | BF-04 | BF-05 | UF | ESF | BP-04 | BP-05 |
|--------------|-------------------|-------------------|------------------|------------------|-------------------|-------------------|
| BF-04 | --- | -0.072 (0.802) | 0.181 (0.050) | 0.229 (0.036) | 0.231 (0.024) | 0.250 (0.025) |
| BF-05 | -0.072 (0.802) | --- | 0.158 (0.075) | 0.162 (0.090) | 0.126 (0.077) | 0.139 (0.055) |
| UF | 0.181 (0.050) | 0.158 (0.075) | --- | 0.085 (0.054) | 0.184 (0.025) | 0.207 (0.023) |
| ESF | 0.229 (0.036) | 0.162 (0.090) | 0.085 (0.054) | --- | 0.186 (0.025) | 0.217 (0.026) |
| BP-04 | 0.231 (0.024) | 0.126 (0.077) | 0.184 (0.025) | 0.186 (0.025) | --- | -0.005 (0.516) |
| BP-05 | 0.250 (0.025) | 0.139 (0.055) | 0.207 (0.023) | 0.217 (0.026) | -0.005 (0.516) | --- |

and other decaying organic matter, or potential prey associated with these food sources (Newton et al. 2001). Interactions among habitat conditions and availability of or access to these food sources may be important factors in rove beetle abundance and diversity.

In summary, with the exception of *P. fossator*, macro-staphylinid species collected in this study were most abundant and most strongly associated with forest habitats. Within-habitat variation in species composition was relatively high in the prairie and recently burned forest habitats. Species composition varied among habitats, with fire potentially playing a role in affecting species/habitat associations, at least in the short term. More large-scale studies with larger sample sizes are needed to further clarify these patterns.

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Table 3. Indicator values, *P*-values, and habitat affinities for macro-staphylinids (rove beetles ≥ 5 mm in length) collected in pitfall traps in six habitats (BF-04 = oak-hickory forest burned in spring 2004, BF-05 = oak-hickory forest burned in spring 2005, UF = oak-hickory forest unburned for 5+ years, ESF = unburned early successional forest, BP-04 = prairie burned in spring 2004, and BP-05 = prairie burned in spring 2005). Trapping was done for five 7-day trapping periods from 4 June to 15 October 2005 in Hancock County, Illinois USA.

| Species | Indicator Value | <i>P</i> -value | BF-04 | BF-05 | UF | ESF | BP-04 | BP-05 |
|---------------------------------|-----------------|-----------------|-------|-------|----|-----|-------|-------|
| <i>Hesperus baltimorensis</i> | 33.3 | 1.000 | 33 | 0 | 0 | 0 | 0 | 0 |
| <i>Homacotarsus</i> sp. | 33.3 | 1.000 | 0 | 33 | 0 | 0 | 0 | 0 |
| <i>Ontholestes cingulatus</i> | 55.6 | 0.108 | 0 | 0 | 0 | 56 | 6 | 0 |
| <i>Philonthus asper</i> | 87.5 | 0.012 | 4 | 0 | 0 | 88 | 0 | 0 |
| <i>Philonthus caerulipennis</i> | 39.4 | 0.216 | 39 | 39 | 12 | 9 | 0 | 0 |
| <i>Platydracus cupripennis</i> | 33.3 | 1.000 | 0 | 0 | 33 | 0 | 0 | 0 |
| <i>Platydracus fossator</i> | 60.0 | 0.071 | 3 | 3 | 14 | 5 | 60 | 7 |
| <i>Platydracus maculosus</i> | 35.6 | 0.201 | 25 | 11 | 18 | 36 | 2 | 1 |
| <i>Platydracus zonatus</i> | 40.7 | 0.069 | 19 | 1 | 41 | 33 | 1 | 0 |
| <i>Quedius neomolochinus</i> | 11.1 | 1.000 | 11 | 0 | 11 | 0 | 11 | 0 |
| <i>Quedius peregrinus</i> | 33.3 | 1.000 | 0 | 0 | 33 | 0 | 0 | 0 |
| <i>Tachinus fimbriatus</i> | 42.9 | 0.168 | 43 | 2 | 29 | 0 | 2 | 2 |

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