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Title: Insect Visitors of *Phemeranthus calycinus* (Raf.) Kiger (Montiaceae, large-flowered rockpink) in Illinois

Running head: Insect Visitors of *Phemeranthus calycinus*

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ABSTRACT

Thirty-nine insect visitors were collected from blossoms of large-flowered rockpink (*Phemeranthus calycinus* (Raf.) Kiger Montiaceae), representing three orders, thirteen genera, and eighteen species. Native solitary bees of the genera *Adrena*, *Augochlorella*, *Calliopsis*, *Ceratina*, *Halictus*, *Lasioglossum*, *Megachile*, *Melissodes*, and *Pseudopanurgus* were the most frequent visitors, followed by the hoverflies *Hemipenthes sinuosa* and *Allograpta obliqua*. Butterflies, *Asterocampus celtis* and *Nathalis iole*, were rare visitors to rockpink flowers. Early afternoon flowering coincided with peak insect activity, and flower numbers were greatest during June. All insects identified in this study were generalists known to gather pollen from several unrelated plant species. Maintaining a sparsely vegetated outcrop appears essential for high flower visibility to foraging insects, and rockpink/insect visitor interactions.

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INTRODUCTION

The plant genus *Phemeranthus* (Raf.) Kiger (rockpink, Montiaceae) is represented by 16 species in the Flora of North America, including three taxa native to Illinois (Gleason and Cronquist 1991; Kiger 2003; Mohlenbrock 2014). *Phemeranthus parviflorus* (Nutt.) Kiger (small-flowered rockpink), present in four southern counties, is state endangered; *Phemeranthus rugospermus* (Holz.) Kiger (wrinkle-seeded rockpink), currently unlisted, has a scattered distribution in 12 northern counties; and *Phemeranthus calycinus* (Engelm.) Kiger (large-flowered rockpink), currently known only from Monroe County in southwestern Illinois, is state endangered (Illinois Endangered Species Protection Board 2020; Mohlenbrock 2014).

Large-flowered rockpink ranges west from Illinois into Colorado and New Mexico and south from Nebraska to Texas and Louisiana (Kiger 2003). This herbaceous perennial, up to 40 cm tall, characteristically has rhizomatous, semi-woody roots; fleshy ascending stems that become decumbent and branched with age and size; sessile, fleshy, subterete, linear leaves up to 7 cm long; cymose inflorescences on a scape-like peduncle up to 25 cm tall that greatly overtops the leaves; 2 persistent ovate to suborbicular sepals, 4-6 mm long; five (rarely four) pink to red-purple obovate petals,10-15 mm long (Figure 1); 25-45 stamens; stigma 1, 3-lobed, subcapitate; capsules broadly ovoid, 6-7 mm long; and 1 mm long, black seeds that lack ridges (Kiger 2003).

This rockpink is an indicator species of the Central Section of the Illinois Ozark Natural Division of southwestern Illinois (Schwegman et. al. 1973). Dr. R. H. Mohlenbrock first discovered this plant in 1954 on sandstone ledges in Randolph County at a site known as Castle Rock (Jones and Fuller 1955; Mohlenbrock 2014). This population, at that time, consisted of

hundreds of plants, but competition from woody and herbaceous species along with the lack of management caused its recent disappearance (Newman et al. 2019).

Rockpinks are well known for the very brief blooming of individual flowers of just a few hours. The blooming times for *Phemeranthus* vary by species and populations, and observations indicate that flowering may also be influenced by local weather, such as cloud cover and the amount of direct sunlight (Price 2012; and this study). Large-flowered rockpink blossoms in Monroe County have been observed to open from 12:30 to 1:30 in the early afternoon and permanently close from 4:00 to 5:00 P.M. throughout a nearly three-month flowering period. The lower flower buds on the peduncle develop first, and fertilized blossoms produce capsules that mature quickly and begin releasing tiny, black seeds while blooming continues on the upper peduncle. Many of these seeds fall into moss and lichen colonies, present in shallow depressions, which appear to serve as germination beds based on the numerous seedlings observed among these plants each year of the study.

Little data are available concerning the insect visitors of the plant genus *Phemeranthus*. The bee *Calliopsis andrenoformis* Smith is known to visit flowers of the wrinkle-seeded rockpink, *P. rugospermus* (Price 2012). Bees of the genera *Apis*, *Auglochlora*, *Bombus*, and *Lasioglossum* have been documented to visit flowers of the rockpinks *P. mengesii* (W. Wolf) Kiger and *P. teretifolius* (Pursh) Rafinesque in the piedmont of Georgia. Sweat bees (Halictidae) were the primary pollinators of P. *mengesii* and *P. teretifolius*, and they are the only insects currently known to visit flowers of *P. calycinus* (Price 2012). No insects are known to be entirely dependent on any rockpink species.

No data are available for insect visitors to the three rockpink species native to Illinois. Such data would be useful in determining management for the rock outcrop community that supports this plant in Monroe County. The purpose of this study was to document insect visitors of large-flowered rockpink in Illinois, to describe the interactions of these visitors with this rare plant, to discuss the ecology of this outcrop community, and to propose future maintenance of this site and other rock outcrop communities.

METHODS

Study site

The Monroe County rockpinks are present on a nearly level outcrop of Au Vase sandstone, 35 m x 85 m, situated on the north bank of a tributary to Horse Creek (Grimley and Shofner 2008; McClain 2009). This expanse of sandstone is characterized by numerous shallow basins, ranging in depth from one to two cm, which vary in width from a few centimeters to nearly one meter. These basins hold water temporarily following rain, and many contain thin layers of soil sufficient to support colonies of mosses and lichens. Rockpinks, ranging from seedlings to mature plants, are concentrated in these colonies.

Site visits

We made collecting trips on 31 June, 11 August 2014; 20 July, 17 August 2015; 19 July and 1 August 2016; and 28 June, 13 August 2017. Collecting trips were scheduled from 10:30 A.M. to approximately 5:00 P.M to span the blooming time of rockpinks. The weather for each collecting day was sunny and warm with scattered clouds and mild winds. Short droughts during July and August sometimes reduced the number of rockpink flowers.

Large-flowered rockpink

This rockpink population was discovered in 2001 when nearly 700 plants were counted on the sandstone exposure. This number compares to 1,800 in June of 2002, 2,430 in June of 2006, 2,743 individuals in July of 2009, and 1,500 in June of 2017. The increase in the number of individuals is likely due to management which made the site more suitable for rockpinks, and also more visible and easier to count.

Collecting

Two individuals participated in the collecting trips with one capturing insects with assistance from the other. We collected insects present on flowers opportunistically using a sweep net carefully placed over individual plants. No sweeping actions with the net were used to prevent damage to plants, including loss of flowers and seed. We selected a location within the outcrop, having a high density of rockpinks, as the primary collecting site during each trip (Droege 2016). This action was necessary because bee visits to flowers lasted not more than a few seconds. It was not practical to attempt to collect specimens from several meters away because of the short visiting time of bees, and the necessity of stepping slowly and carefully about the outcrop to avoid trampling of rockpinks.

Specimens

We had initial concern that some insect visitors could be rare, or even dependent upon large-flowered rockpink. These thoughts caused us to use caution and limit the number of specimens collected to reduce potential detrimental impacts on the rockpink/insect visitor community. The determination of the abundance of the various insect visitors was not an objective of the study. All insects collected were euthanized, transferred to a vial, and frozen upon returning to the laboratory. The specimens were sorted, and all insects, excluding Hymenoptera (bees), were pinned and

identified. All bees were cleaned of pollen and debris so features critical to their identification could be easily examined. Cleaning was accomplished using warm, soapy water (dish detergent) with vigorous (shaking) agitation to remove all pollen and other debris (Droege 2016). The bees were rinsed, dried, fluffed using a hot air dryer, and pinned for identification (Droege 2016). Identifications were made using standard bee identification guides (Holm 2017). Nomenclature for plants follows Kiger (2003) and Mohlenbrock (2014), and the Integrated Taxonomic Information System (https://www.itis.gov/) for insects. All specimens were deposited in the entomology collection of Eastern Illinois University (EIU).

RESULTS

Large-flowered rockpinks initiated blooming in late May or early June at the Monroe County site, depending on local weather. Blooming continued into August with decreasing flower production. Blossoms opened between noon and 1:30 P.M., depending upon the amount of sunlight. Local weather was observed to influence the time of blooming in June of 2009 when flowers did not open until 3:30 P. M. due to cloud cover. Most flowers reached full anthesis within 30 minutes, and insects, mostly bees, were observed visiting blossoms before anthesis was complete. The rockpink population was estimated to have hundreds of highly visible pink to rose-colored flowers in bloom on the flat, open expanse of sandstone.

Flowers began to close between 4:00 to 5:00 PM as shading developed and direct sunlight decreased. Short droughts reduced flowering to a level estimated to be less than 50 blossoms per day throughout the entire site. Insect visits were much diminished during these times, and some collection trips failed to produce any specimens. Insect visitors were most abundant during June at the beginning of the rockpink blooming when large numbers of new flowers were available on a daily basis.

A total of 39 insects, representing the orders Hymenoptera (14 bee species), Diptera (two hoverfly species), and Lepidoptera (two butterfly species), were collected. The specimens included 13 native genera represented by 18 species common to the Midwest. All insect visitors were generalists, and no specimen was identified as a specific pollinator of *Phemeranthus* (Table 1). Bees (Hymenoptera) were the most represented taxa, including *Adrena* sp., *Augochlorella aurata* Smith, *Calliopsis adreniformis* Smith, *Ceratina calcarata* Robertson, *C. strenua* Smith, *Halictus ligatus* Say, *Lasioglossum hitchensi* Gibbs, *L. tegulare* Robertson, *L. trigeminum* Gibbs, *L. versatum* Robertson, *L. weemsi* Mitchell, M*egachile mendica* Cresson, *Melissodes bimaculatus* Lepeletier, and *Pseudopanurgus compositarum* Robertson (Table 1). All but two bee specimens were females that were collecting pollen as evidenced by the pollen attached to their abdomen or legs. Flower visits by bees were very brief, usually lasting just a few seconds before moving to another flower. Pollen was observed on all bees, and visits by large bees, such as *Melissodes bimaculatus* Lepeletier, caused the thin, wiry rockpink peduncles to collapse immediately to the sandstone only to quickly return to an upright position once the bee left.

Both hoverfly species were less active than bees, tending to remain on individual flowers for as much as several minutes. The sinuous hoverfly (*Hemipenthes sinuosa* Wiedemann) was a common flower visitor during June. Its numbers were observed to decrease as the blooming period progressed, and this insect was not seen during July and August, times when fewer flowers were present. The sweat bee (*Allograpta obliqua* Say) was present throughout the blooming period, and was sometimes difficult to distinguish from true bees due to its mimicry.

The two butterfly species, hackberry (*Asterocampa celtis* Boisduval and Leconte) and dainty sulfur (*Nathalis iole* Boisduval), were rare visitors to rockpink flowers. Their visits were very brief, and they usually did not move from flower to flower like bee visitors. They visited one flower, and

left the outcrop after a visit of just a few seconds. The number of butterflies present at the same time within the entire study area never exceeded two individuals. Less than ten butterfly individuals were observed visiting flowers throughout the study.

Multiple capsules were observed following flowering on virtually every peduncle within the rockpink population. Capsules developed quickly following flowering and successful pollination, and begin releasing seeds once mature. The seeds were small (1 mm), black, reniform, and without ridges. Thousands of seeds were likely produced each year. Many likely fall onto bare sandstone, and may be washed away by rainfall. Others appear to fall into moss/lichen beds where they germinated and formed seedlings.

DISCUSSION

Bees of the genera *Adrena, Augochlorella, Calliopsis, Ceratina, Halictus, Lasioglossum, Megachile*, *Melissodes*, and *Pseudopanurgus* are native, solitary bees that actively gather pollen to feed to developing young (Dyer and Shinn 1978; Ginsberg 1984; Portman et al. 2019). All but two bee specimens were females with pollen on their abdomens or back legs, suggesting they were collecting it as food (Figure 1, Table 1). All bee species collected in this study are polylectic, meaning they collect pollen from flowers of many unrelated plant species (Gibbs et. al. 2017; McCravy et. al. 2019). Bees of the genera *Megachile* and *Ceratina* are above-ground nesters, but the remaining taxa are all below-ground nesting species that lay eggs on pollen balls placed within a system of underground tunnels (Danforth et al. 2019; McCravy et. al. 2019).

Hoverflies were less common visitors of rockpink flowers at the Monroe County site. Adults feed on pollen, but do not collect it for use as food for young. They accomplish pollination inadvertently when they transfer pollen caught on their bodies from flower to flower (Klecka et. al.

2018). Hoverflies (*Hemipenthes sinuosa* Wiedemann and *Allograpta obliqua* Say) were actively foraging during June, but *Hemipenthes* was absent in subsequent months when flower numbers were reduced by short droughts.

Butterflies feed on nectar or other sugar sources as adults. Dainty sulfur (*Nathalis iole* Boisduval) is a generalist species known to feed on nectar from several plant species. Hackberry (*Asterocampa celtis* Boisduval and Leconte) is known to feed on sap, rotting fruit, and nectar. Individuals of these butterflies made brief, very infrequent visits to rockpink flowers. Rockpink flowers contain nectaries, but little is known about their nectar producing capabilities. These short duration visits suggest nectar may be in amounts insufficient for these butterflies.

Rockpinks have a floral biology distinct from most plant species. New flowers are produced daily, but they remain open just a few hours before senescing. The production of new flowers each day greatly enhances the potential for successful pollination because insects do not waste time visiting old flowers that are no longer fertile. The potential for successful pollination is also increased by the early afternoon blooming of rockpinks, 12:30 to 4:00 P.M., which coincides with the time of day when sunlight is most direct and temperatures are highest, the hours of peak insect activity. The simultaneous timing of rockpink blooming and high insect activity is critical for the survival of rockpinks and their visitors at this site (Solga et al. 2020).

The process of pollination is mutually beneficial to plants and insects. It is also greatly influenced by a number of variables, including flower visibility and favorable weather (Buchman and Nabhan 1996; Geroff et al. 2014). Both factors could limit or cause pollination failure which could reduce or cause the loss of plant species from a community, resulting in the subsequent loss of insect taxa (Rathcke and Jules 1993; Biesmeijer et al. 2006; Geroff et al. 2014). Pollination is

especially critical for plants restricted to small, unique, highly vulnerable habitats, such as rock outcrops (Hooper et al. 2012). Rock outcrop communities of the eastern United States are known for their rare, sometimes endemic, plant species (Baskin and Baskin 1988). The xeric nature of these communities limits competing plant growth, but rockpinks, with their succulent leaves and stems, thrive in these open, sparsely vegetated sites. The rockpink flowers are highly visible and accessible to foraging insects due to the absence of competing vegetation (Heinrich 1975; Newman et al. 2019). The current vegetative composition of the rock outcrop appears to be very favorable for rockpinks based on the observations of high numbers of developing capsules and subsequent seed production.

Increased growth of woody and herbaceous plants could disrupt rockpink flower visitor interactions by reducing flower visibility and accessibility to foraging insects. The large-flowered rockpink population at Castle Rock in Randolph County decreased from hundreds of plants in 1954 to none in 2019, a period when woody and herbaceous plants were observed to increase substantially in density and size, eventually creating continuous shade and increased competition for the rockpinks (Newman et al. 2019). Maintaining a sparse vegetative cover that allows for high visibility of and accessibility to rockpink flowers to visiting insects is essential for the long-term survival of this species at this site.

Changing weather patterns may affect rock outcrop communities in Illinois and other states in the future. The Monroe County rock outcrop was significantly affected by several high rainfall events during the study. These episodes of high precipitation washed soil onto the outcrop, promoting the rampant growth of lesser ragweed (*Ambrosia artemisifolia* L.), and providing soil for the expanded growth of Japanese honeysuckle (*Lonicera japonica* L.), necessitating their removal to prevent permanent damage to the rockpink outcrop vegetation. Vegetation control is thought to

be a management problem of many rock outcrop communities. Documentation of insect visitor/rare plant interactions at these sites is needed to develop strategies for their long-term preservation.

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LITERATURE CITED

Baskin, J.M. and C.C. Baskin. 1988. Endemism in rock outcrop plant communities in the eastern united states: an evaluation of the roles of edaphic, genetic and light factors *Journal of Biogeography* 15:829-840.

Biesmeijer, J.C., S.P.M. Roberts, M. Reemer, R. Ohlemueller, M. Edwards, T. Peeters, A.P. Schaffers, S.G. Potts, R. Kluekers, C.D. Thomas, J. Settle, and W.E. Kunin. 2006. Parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands. *Science* 313:351-354.

Buchman, S.L. and G.P. Nabhan. 1996. The Forgotten Pollinators. Island Press, Washington, D.C.

Danforth, B. N., R. L. Minckley, J. L. Neff, and F. Fawcett. 2019. The Solitary Bees, Biology, Evolution, Conservation. Princeton University Press, Princeton, New Jersey.

Droege, S., J.D. Engler, E. Sellers, and LE. Obrien. 2016. The very handy manual: how to catch and identify bees and manage a collection. USGS Native Bee Inventory and

Monitoring Lab, Beltsville, Maryland.

Dyer, J.G. and A.F. Shinn. 1978. Pollen collected by *Calliopsis andreniformis* Smith in North America (Hymenoptera: Andrenidae). *Journal of the Kansas Entomological Society* 51:787-795.

Geroff, R.K., J. Gibbs, and K.W. McCravy. 2014. Assessing bee (Hymenoptera: Apoidea) diversity of an Illinois restored tallgrass prairie: methodology and conservation considerations. *Journal of Insect Conservation* 18:951-964.

Gibbs, J., J.S Ascher, M.G. Rightmyer, and R Isaacs. 2017. The bees of Michigan (Hymenoptera: Apoidea: Anthophila), with notes on distribution, taxonomy, pollination, and natural history. *Zootaxa* 4352:1-160.

Ginsberg, H.S. 1984. Foraging behavior of the bees *Halictus litgatus* (Hymenoptera, Halictidae) and *Certina calcarata* (Hymenoptera, Anthophoridae): Foraging speed on early-summer Composite flowers. *Journal of the New York Entomological Society* 92:162-168.

Gleason, H.A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. Second Edition. The New York Botanical Garden, Bronx, New York.

Grimley, D.A. and G.A. Shofner. 2008. Surficial Geology of Ames Quadrangle, Monroe and Randolph counties, Illinois: Illinois State Geological Survey, Illinois Geologic

Quadrangle Map, IGQ Ames-SG, 2 sheets, 1:24,000.

Heinrich, B. 1975. Bee Flowers: A Hypothesis on Flower Variety and Blooming Times. *Evolution* 29 (2):325-334.

Holm, H.N. 2017. Bees: an Identification and Native Plant Forage Guide. Pollination Press, Minneapolis.

Hooper D.U., E.C. Adair, B.J. Cardinale, J.E.K. Byrnes, B.A. Hungate, K.L. Matulich, A. Gonzalez, J.E. Duffy, L. Gamfeldt, and M.I. O'Connor. 2012. A global synthesis reveals biodiversity loss as a major driver of ecosystem change. *Nature* 486:105–108.

Integrated Taxonomic Information System. 2021. https://www.itis.gov/. Accessed 29 August 2021.

Illinois Endangered Species Protection Board. 2020. Checklist of Illinois Endangered and Threatened Animals and Plants (https://www2.illinois.gov/dnr/ESPB/Pages/default.aspx).

Jones, G.N. and G.D. Fuller. 1955. Vascular plants of Illinois. The University of Illinois Press, Urbana, and the Illinois State Museum, Springfield (Museum Science Series, Vol. VI).

Kiger, R.W. 2003. *Phemeranthus*. *In*: Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico. 22+ vols. New York and Oxford. Vol. 4:488-495.

Klecka, J., J. Hadrava, P. Biella, and A. Akter. 2018. Flower visitation by hoverflies (Diptera:Syrphidae) in a temperate plant-pollinator network. *PeerJ* 6:e6025 (http://doi.org/10.7717/peerj.6025).

McClain, W.E. 2009. Status of *Phemeranthus calycinus* (Holz.) Kiger in Illinois. Unpublished report to the Division of Natural Heritage, Illinois Department of Natural Resources.

McCravy, K.W., R.K. Geroff, and J. Gibbs. 2019. Bee (Hymenoptera: Apoidea: *Anthophila*) functional traits in relation to sampling methodology in a restored tallgrass prairie. *Florida Entomologist* 102 (1):134-140.

Mohlenbrock, R.H. 2014. Vascular Flora of Illinois, 4th ed. Southern Illinois University Press, Carbondale, Illinois.

Newman, D.S., W.E. McClain, and J.E. Ebinger. 2019. Noteworthy Collection: Illinois. *Castanea* 84 (1):45- 46.

Portman, Z.M., M.C. Orr, and T. Griswold. 2019. A review and updated classification of pollen gathering behavior in bees. *Journal of Hymenoptera Research* 71:171-208.

Rathcke, B. and E.S.D.A. Jules. 1993. Habitat fragmentation and plant-pollinator interactions. *Current Science* 65: 273-277.

Schwegman, J.E., G.B. Fell, M. Hutchison, W.M. Shepherd, G. Paulson, and J. White. 1973. Comprehensive plan for the Illinois Nature Preserves System, Part 2. The natural

divisions of Illinois. Illinois Nature Preserves Commission, Rockford.

Solga, M.J., J.P. Harmon, A.C. Ganguli. 2020. Timing is everything: an overview of phenological changes to plants and their pollinators. *Natural Areas Journal* 34 (2):227-234.

Table 1. Insect visitors of large-flowered rockpink in Monroe County, Illinois. An "x" indicates the month of collection of specimens.

Species	Sex	Month of Collection		
		June	July	August
Adrena sp. (mining bee)	f	x		
Allograpta obliqua (oblique syrphid)	f	x		
Asterocampa celtis (hackberry)	-			x
Augochlorella aurata (sweat bee)	f	x	x	x
Calliopsis adreniformis (mining bee)	m	x		
Ceratina calcarata (carpenter bee)	f		x	
Ceratina strenua (nimble Ceratina)	f		x	
Halictus ligatus (ligated furrow bee)	f	x		
Hemipenthes sinuosa (sinuous hoverfly)	-	x		
Lasioglossum hitchensi (Hitchen's sweat bee)	f	x		x
Lasioglossum tegulare (Epaulate metallic sweat bee)	f	x		

Lasioglossum trigeminum (no common name)	f	x	x	x
Lasioglossum versatum (experienced sweat bee)	f	x		
Lasioglossum weemsi (Weem's sweat bee)	f	x		x
Megachile mendica (leafcutter bee)	f			x
Melissodes bimaculatus (two-spotted longhorn bee)	f		x	
Nathalis iole dainty sulfur)	-			x
Pseudopanurgus compositarum (mining bee)	f	x		

Figure 1. The bee *Augochlorella aurata* Smith visiting a *Phemeranthus calycinus* blossom. Note the wiry peduncle, five petals, and number of stamens (approximately 45).

Figure 2. Two *Phemeranthus calycinus* plants in center of photograph showing flowers, stems and fleshy, terete leaves. Note their presence in a moss colony.