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Scientific Note

Visitation of African pineapple lily flowers (*Eucomis autumnalis* (Mill.) Chitt. and *Eucomis comosa* Houtt. ex. Wehrh.) by Japanese cockroaches

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Abstract. Pineapple lilies *Eucomis autumnalis* (Mill.) Chitt. and *Eucomis comosa* Houtt. ex. Wehrh. are endemic herbaceous plants in southern Africa but are planted as ornamental bulbous plants globally. The flowers are known to be primarily pollinated by pompilid wasps in their native range. In a Japanese botanical garden, *Blattella nipponica* Asahina, 1963 cockroaches visited the inflorescences of the two *Eucomis* species, fed on the floral nectar, and used the comae (i.e., leaf-like tufts on the top of inflorescences) as physical shelters and transported the pollen, thereby resulting in a fruit set. Ants, flies, and beetles were also observed to visit the flowers but did not touch the anthers or stigmas. These observations suggest that ground-dwelling cockroaches can act as pollinators of *Eucomis* flowers in an ex-situ setting.

Keywords: *Blattella nipponica, Eucomis autumnalis, Eucomis comosa,* pollination.

Cockroaches are widely distributed in various terrestrial habitats in the world and are considered to play a key role as omnivorous decomposers (Bell et al. 2007). Blattodea originated in the Permian Period and diversified into current families during the Cretaceous Period approximately concurrently with the tremendous diversification of angiosperms (Evangelista et al. 2019). In contrast to other important pollinating insect orders such as Hymenoptera and Diptera, Blattodea minimally contributes to pollen transfer for angiosperm flowers (Ashworth et al. 2015). However, a small number of extant plant species are reported to be predominantly reliant on cockroaches for pollination, with more plant species expected to bear cockroach-pollinated flowers (Xiong et al. 2020 and references therein). Most cockroaches are nocturnal and cryptic (Bell et al. 2007) and thus tend to be neglected as pollinators. This study reports that cockroaches visited the African pineapple lily flowers in a Japanese botanical garden for three consecutive summers. Their behavior and potential as pollinators are additionally described.

Pineapple lilies *Eucomis* spp. (Asparagaceae) are endemic to southern Africa, but are cultivated as ornamental plants globally. They are characterized by their erect inflorescences (racemes) and comae (leaf-like tufts) at the tops, which are reminiscent of pineapples (Zonneveld & Duncan 2010). *Eucomis* has evolved to adopt diverse specialist agents as pollinators from mammals to flies (Shuttleworth & Johnson 2009; 2010; Wester et al. 2019). Among them, *Eucomis autumnalis* (Mill.) Chittenden and *Eucomis comosa* Houtt. ex. Wehrh. bear hermaphroditic outcrossing flowers and are primarily pollinated by pompilid wasps in their native regions (Shuttleworth & Johnson 2009). These two *Eucomis* species are commonly planted in Japanese parks and gardens and can be discriminated from each other based on the floral color and morphology, leaf shape, and flowering phenology (Salachna 2016; Yamazaki personal observations; Fig. 1).

During a walk in the Nagai Botanical Garden (34º36'N, 135º31'E, 8 m above sea level) in Osaka Prefecture, central Japan, on July 20, 2019, I found that the pineapple lily *E. autumnalis* was in bloom in a flower bed (ca. 5 m × 3 m) along a grove consisting of American sweetgum, *Liquidambar styraciflua* L. trees. A closer look revealed that six adult cockroaches were located individually in the inflorescences of *E. autumnalis*. One was located on the flower and five between the comae (Fig. 2A). The cockroaches were identified as *Blattella nipponica* Asahina, 1963 (Blattodea: Ectobiidae). I, therefore, commenced the survey of floral visitors and their behavior on *Eucomis* inflorescences in the flower bed. Insects that were found on the inflorescences were recorded for 30 min between 16:00 and 17:00, during seven sunny or slightly cloudy days from 2019 to 2021 (Tab. 1). On July 21, 2019, two *B. nipponica* adults were observed drinking nectar from the flowers of *E. autumnalis* (Fig. 2B). In addition, an adult of *B. nipponica* was observed to be dusted with pollen grains on its pronotum and tegmen while moving between flowers (Fig. 2C). *Blattella nipponica* cockroaches also visited the inflorescences of *E. autumnalis* in the summer of 2020 (Tab. 1). Moreover, *B. nipponica* visited the inflorescences of *E. comosa* and pollen was observed to be attached to their backs on July 10, 2021 (Fig. 2D). Insects other than cockroaches also visited the inflorescences of *Eucomis*—four ant species, three flies, and a scarabaeid beetle (Tab. 1). However, during my observation, these insects did not touch the anthers and visible pollen grains were not attached to them to the naked eye. While the inflorescences were cut off before the fruit was set by the garden administrator in 2019, the fruits ripened and numerous black seeds were set in 2020 and 2021.

Regardless of their unique inflorescences, the flowers of *E. autumnalis* and *E. comosa* have unspecialized floral structures and produce large amounts of nectar, suggesting a generalist pollination system. However, they emit aromatic and monoterpene compounds that primarily attract pompilid wasps for pollination (Shuttleworth & Johnson 2009). In my observations, however, wasps and bees did not visit the *Eucomis* flowers. This may be due to limited observation time and areas or diel period (i.e., late afternoon), although megachilids and vespids were observed on other flowers including Asteraceae and Lamiaceae during the survey.

In the Japanese flower bed, the *B. nipponica* cockroaches may have played a role in pollen transfer for the two *Eucomis* species considering they were frequent floral visitors and had pollen attached to their back, resulting in successful fruit setting. Other arthropods, however, might also be involved in the pollination. *Blattella nipponica* is distributed in Japan and Korea and inhabits forest floors (Asahi et al. 2016; Tomioka et al. 2016). This cockroach is omnivorous, sometimes invades indoor spaces, thereby becoming a pest (Tsuji 1985; Harunari et al. 2007),

and consumes fruits of a mycoheterotrophic herb, *Monotropastrum humile,* resulting in seed dispersal (Uehara & Sugiura 2017). Specialized cockroach pollination is limited to a small number of plant species in the world (Xiong et al. 2020). Shrubby plants with a short stature, pale floral color, nocturnal flowering, and distinct floral scent may be characteristic of these species (Nagamitsu & Inoue 1997; Vlasáková et al. 2008; 2019; Suetsugu 2019). Although the two *Eucomis* species are wasp-pollinated in southern Africa (Shuttleworth & Johnson 2009), their relatively short height (less than 130 cm above the ground), unspecialized floral structures, ample nectar, and unique comae as hiding sites may attract epigaeic Japanese cockroaches, thereby leading to an unexpected pollination interaction in an ex-situ setting. This finding suggests that cockroaches may function as facultative pollinators for more plant species.

Table 1. Insect visitors of *Eucomis* inflorescences in a Japanese botanical garden. Numbers with and without parentheses represent insects visiting *E. comosa* and *E. autumnalis*, respectively. A and N indicate adults and nymphs of *Blattella nipponica*, respectively. * Numbers with and without parentheses are those of *E. comosa* and *E. autumnalis* inflorescences during anthesis, respectively. ** Accurate counting was not carried out, but more than 10 individuals were present on the inflorescences.

Year	2019		2020			2021	
Month/Date	July 20	July 21	July 11	July 18	July 23	July 10	July 17
No. inflorescences*	11 (0)	11 (1)	10 (0)	12 (0)	10 (3)	3 (4)	5 (5)
Blattodea/Ectobiidae							
Blattella nipponica Asahina	6A	4A1N	2A	5A		(4A)	
Coleoptera/Scarabaeidae							
Anomala albopilosa (Hope)					(1)		
Diptera							
Drosophila sp.			1				
Sarcophagidae *Gen.* sp.					1		
Tachinidae *Gen.* sp.							(1)
Hymenoptera/Formicidae							
Formica japonica Motschoulsky	10					(>10)**	
Lasius japonicus Santschi					3		
Tetramorium tsushimae Emery					1		
Pristomyrmex punctatus Smith						(>10)**	

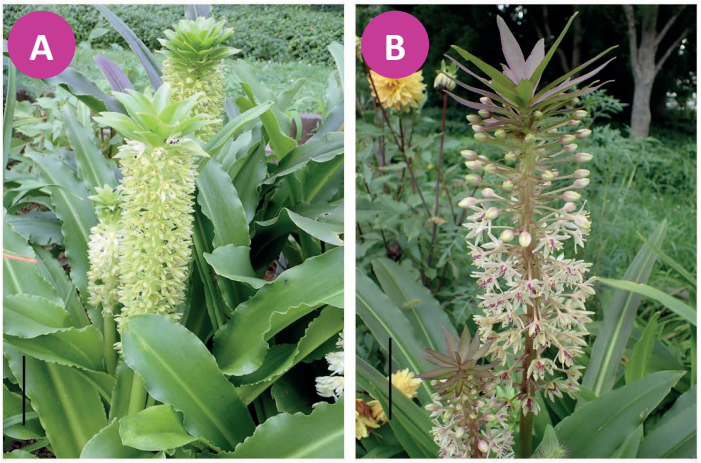

Figure 1. *Eucomis* inflorescences. (A) *E. autumnalis*, (B) *E. comosa*. Scale lines: 100mm.

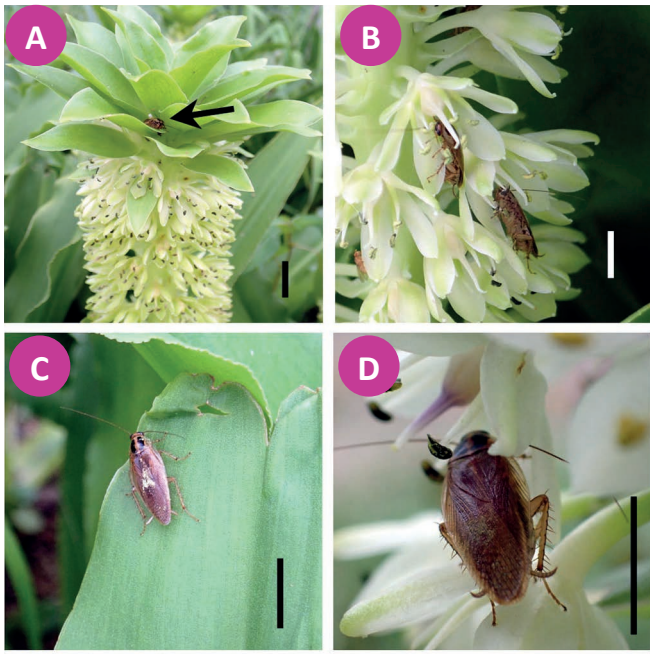

Figure 2. Visitations of *Eucomis* flowers by *Blattella nipponica* cockroaches in a Japanese botanical garden. (A) *B. nipponica* hiding between leaf-like tufts *of E. autumnalis* (arrow), (B) *B. nipponica* feeding on the floral nectar of *E. autumnalis*, (C) *B. nipponica* attaching pollen grains of *E. autumnalis* on its back, (D) *B. nipponica* visiting *E. comosa* flower with pollen on its tegmina. Scale lines: 10mm.

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Conflict of Interest Statement

The author declares that there is no conflict of interest for the publication of this manuscript.

References

Asahi, K.; Endo, T.; Komatsu, N. (2016) *Blattela nipponica* Asahina, 1964. In: Orthopterological Society of Japan (Ed.), *The standard of Polyneoptera in Japan*, p. 219, pl. 65. Gakken Plus. Tokyo.

Ashworth, L.; Aguilar, R.; Martén-Rodríguez, S.; Lopezaraiza-Mikel, M.; Avila-Sakar, G.; Rosas-Guerrero, V.; Quesada, M. (2015) Pollination syndromes: a global pattern of convergent evolution driven by the most effective pollinator. In: Pontarotti, P. (Ed.), *Evolutionary biology: biodiversification from genotype to phenotype*, pp. 203-224. Switzerland: Springer. doi: 10.1007/978-3-319-19932-0_11

Bell, W. J.; Roth, L. M.; Nalepa, C. A. (2007) *Cockroaches: ecology, behavior, and natural history*. Baltimore: Johns Hopkins University Press.

Evangelista, D. A.; Wipfler, B.; Béthoux, O.; Donath, A.; Fujita, M.; Kohli, M. K.; Legendre, F.; Liu, S.; Machida, R.; Misof, B., et al. (2019) An integrative phylogenomic approach illuminates the evolutionary history of cockroaches and termites (Blattodea). *Proceedings of the Royal Society of Biological Sciences*, 286(1895): 20182076. doi: 10.1098/rspb.2018.2076

Harunari, T.; Kutukake, M.; Tanikawa, T.; Tomioka, Y. (2007) An indoor invasion and seasonal changes of *Blattella nipponica* Asahina (Blattaria: Blattellidae) in a food factory. *House and Household Insect Pests*, 29: 55-59.

Nagamitsu, T.; Inoue, T. (1997) Cockroach pollination and breeding system of *Uvaria elmeri* (Annonaceae) in a lowland mixed-dipterocarp forest in Sarawak. *American Journal of Botany*, 84(2): 208. doi: 10.2307/2446082

Salachna, P. (2016) Comparison of growth, bulbs yield and nutrient content of *Eucomis autumnalis* (Mill.) Chitt., *E. bicolor* Baker and *E. comosa* (Houtt.) Wehrh. Grown in a greenhouse as pot plants. *Folia Pomeranae Universitatis Technologiae Stetinensis Agricultura, Alimentaria, Piscaria et Zootechnica*, 326(38): 97-102. doi: 10.21005/aapz2016.38.2.09

Shuttleworth, A.; Johnson, S. D. (2009) A key role for floral scent in a wasp-pollination system in *Eucomis* (Hyacinthaceae). *Annals of Botany*, 103(5): 715-725. doi: 10.1093/aob/mcn261

Shuttleworth, A.; Johnson, S. D. (2010) The missing stink: sulphur compounds can mediate a shift between fly and wasp pollination systems. *Proceedings of the Royal Society of Biological Sciences*, 277(1695): 2811-2819. doi: 10.1098/rspb.2010.0491

Suetsugu, K. (2019) Social wasps, crickets and cockroaches contribute to pollination of the holoparasitic plant *Mitrastemon yamamotoi* (Mitrastemonaceae) in southern Japan. *Plant Biology*, 21(1): 176-182. doi: 10.1111/plb.12889

Tomioka, Y.; Satake, H.; Tanikawa, T. (2016) The distribution of *Blattella nipponica* Asahina in the eastern part of Kanto and Tohoku districts, Japan: special references to the northern limit distribution. *Medical Entomology and Zoology*, 67(3): 177-181. doi: 10.7601/mez.67.177

Tsuji, H. (1985) The life cycle of *Blattella nipponica* Asahina in Kyoto. *Kontyû*, 53: 42-48

Uehara, Y.; Sugiura, N. (2017) Cockroach-mediated seed dispersal in *Monotropastrum humile* (Ericaceae): a new mutualistic mechanism. *Botanical Journal of the Linnean Society*, 185(1): 113-118. doi: 10.1093/botlinnean/box043

Vlasáková, B.; Kalinová, B.; Gustafsson, M. H. G.; Teichert, H. (2008) Cockroaches as pollinators of *Clusia* aff. *Sellowiana* (Clusiaceae) on Inselbergs in French Guiana. *Annals of Botany*, 102(3): 295-304. doi: 10.1093/aob/mcn092

Vlasáková, B.; Pinc, J.; Jůna, F.; Kotyková Varadínová, Z. K. (2019) Pollination efficiency of cockroaches and other floral visitors of *Clusia blattophila*. *Plant Biology*, 21(4): 753-761. doi: 10.1111/plb.12956

Wester, P.; Johnson, S. D.; Pauw, A. (2019) Scent chemistry is key in the evolutionary transition between insect and mammal pollination in African pineapple lilies. *New Phytologist*, 222(3): 1624-1637. doi: 10.1111/nph.15671

Xiong, W.; Ollerton, J.; Liede-Schumann, S.; Zhao, W.; Jiang, Q.; Sun, H.; Liao, W.; You, W. (2020) Specialized cockroach pollination in the rare and endangered plant *Vincetoxicum hainanense* in China. *American Journal of Botany*, 107(10): 1355-1365. doi: 10.1002/ajb2.1545

Zonneveld, B. J. M.; Duncan, G. D. (2010) Genome sizes of *Eucomis* L'Hér. (Hyacinthaceae) and a description of the new species *Eucomis grimshawii* G.D.Duncan & Zonneveld. *Plant Systematics and Evolution*, 284(1-2): 99-109. doi: 10.1007/s00606-009-0236-y