**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 2016). 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 (34°36′N, 135°31′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 (Tsuij 1985; Harunari et al. 2007),

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and consumes fruits of a mycoheterotrophic herb, *Monotropastrum humile*, resulting in seed dispersal (Jehara & 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 epigaean 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 | Month/Date | 2019 | 2020 | 2021 |
|------|------------|------|------|------|
|      | No. inflorescences* | July 20 | July 21 | July 11 | July 18 | July 23 | July 10 | July 17 |
|      |            | 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 |            |       |       |       |       |       |       |       |
| *Sarcophagidae* Gen. sp. | 1 |       |       |       |       |       |       |       |
| *Tachinidae* Gen. sp. |       |       |       |       |       |       |       |       |
| Hymenoptera/Formicidae |            |       |       |       |       |       |       |       |
| *Formica japonica* Motshoulsky | 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.

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Conflict of Interest Statement

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

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