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Diurnal hawk moth pollination of *Melampyrum koreanum* (Orobanchaceae) and the origin of this endemic Korean species

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Abstract

Melampyrum koreanum (Orobanchaceae) was described recently as an endemic species in Korea. This study examined the distribution range, relationship with the host plant, flower developmental pattern, pollinator, pollination mechanism, and seed development of *M. koreanum* (Orobanchaceae) on the island of Somaemul-do, Korea. *M. koreanum* is hemiparasitic and a strong candidate for its host plant is *Pinus thunbergii,* with which it is distributed sympatrically. The flower of *M. koreanum* represents a typical hawk moth pollination syndrome. *Macroglossum pyrrhostictum* Butler (Sphingidae, Lepidoptera), a diurnal hawk moth, is the only efficient pollinator. The proboscis length of *M. pyrrhostictum* and the floral tube length of *M. koreanum* are well coordinated, and the positions of the anther and stigma of *M. koreanum* are mechanically conformed to hawk moth pollination. The results suggest that adaptation to the pollinator is the main factor that has affected the evolution of the longer floral tube of *M. koreanum* compare to other species. Pollinator conservation in the native range of *M. koreanum* is an important issue for the conservation of endemic plant species, and it is necessary to establish a conservation plan for the host plant, *Pinus thunbergii,* as well as *M. koreanum.*

Key words: hawk moth pollination syndrome, hemiparasite, coevolution, conservation of endemic species

Introduction

Melampyrum koreanum Kim and Yun (2012: 48) is a species recorded on Somaemul-do, Hansan-myeon, Tongyeong-si, Gyeongsangnam-do, which is a small island in the South Sea of Korea (Kim & Yun 2012). This species has the longest floral tube and pistil (about 30 mm in length) in the genus *Melampyrum* Linnaeus (1753: 605) (Orobanchaceae). In addition, the species also has taller and more branched stems, fewer spines on the bract, and larger fruit, which can easily be distinguished from the closely related species, *Melampyrum roseum* Maximowicz (1859: 210) complex. In particular, the length and the shape of the corolla and the length of the pistil easily distinguish *M. koreanum* from other *Melampyrum* species. Most *Melampyrum* species, including three previously recognized Korean species, have floral lips with wide entries and short floral tube lengths (<15 mm), which allow effective pollination by wasps or bees, whereas it has been reported a hawk moth may be the pollinator of *M. koreanum* because its corolla is thin and long (Kim & Yun 2012).

Hawk moths are typically nocturnal and flowers pollinated by hawk moths normally bloom at night where the flowers are white or light pink. These flowers have a long and thin corolla, which secretes nectar and releases a scent (Grant 1983). Well-known hawk moth pollination systems include *Manduca quinquemaculata* (Sphingidae) on *Mirabilis longiflora* Linnaeus (1755: 176) (Nyctaginaceae) flowers, which has a long floral tube, in the southeast area of the US (Grant & Grant 1983), and *Sphinx* and *Eumorpha* (Sphingidae) pollination of the long-spurred *Aquilegia chrysantha* Gray (1873: 1335) (Ranunculaceae) in the southeast area of the US (Miller 1985). Species belonging to Solanaceae and Martyniaceae have been reported as feeding plants for hawk moth caterpillars in these areas (Mechaber & Hildebrand 2000). *Aerangis* Reichenbach (1865: 190), an African long spurred orchid (Orchidaceae), is pollinated by a hawk moth (Maritns & Johnson 2007) and several species of *Zaluzianskya* Schmidt (1793: 11) (Scrophulariaceae, *s.l.*) have also been reported to be pollinated by hawk moths (Johnson *et al.* 2002). These previous reports were focused on nocturnal hawk moth pollination.

There are 52 species of hawk moths (Sphingidae) belonging to 34 genera in Korea (Park 2012, Shin 2007). Among these, the five species of *Macroglossum* (Sphingidae) are diurnal. The flowers of *M. koreanum* open in the early morning, so the pollinating hawk moths should be diurnal rather than nocturnal. Among the Scrophulariaceae

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M. roseum, closely related species to *M. koreanum* have wider floral tubes and shorter floral lengths. Their flowers are usually pollinated by wasps and bees, so the long and thin corolla tube of *M. koreanum* is assumed to be an adaptation to hawk moth pollination. Therefore, it is assumed that coadaptation between the plant and pollinator had an important role in the origin of *M. koreanum*. The hawk moth pollinator is distributed widely in the southern islands, so *M. koreanum* may be present more widely on the islands and inland areas of the South Sea, Korea, although our investigations around Geoje-si, Tongyeong-si did not confirm this theory. Our study also confirmed that the most likely host plant for hemiparasitic *M. koreanum* is *Pinus thunbergii,* or less likely *Ligustrum japonicum* and *Camellia japonica*.

M. koreanum is readily observed on Somaemul-do. However, the rapidly increasing number of tourists on Somaemul-do has caused many environmental issues, including contamination of trail areas, garbage incineration, and power plant extension due to power shortage. Therefore, the challenges for *M. koreanum,* an endemic species in Korea, may include: 1) decreased numbers of hawk moths, the pollinator; 2) habitat loss around the mountain trails; 3) thoughtless collection by plant lovers; 4) the vulnerability of *Pinus thunbergii*, the host plant, to the pine tree parasitic *Bursaphelenchus xylophilus* (Nematoda). The present study did not identify the feeding plants during the caterpillar period for the hawk moth. Therefore, further studies must be conducted to better understand the biology of hawk moths in order to maintain sufficient numbers for pollination. To conserve the endemic *M. koreanum* on Somaemul-do, future studies must examine all aspects of conservation, including maintenance of the correct hawk moths as pollinators, the hawk moth feeding plants, *M. koreanum* populations, and healthy host plant communities. In addition, it will also be necessary to study the relationships between *M. koreanum* and the host plant with respect to seed germination and juvenile growth.

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References

Grant, V. & Grant, K.A. (1983) Hawkmoth pollination of *Mirabilis longiflora* (Nyctaginaceae). *Proceedings of the National Academy of Sciences of the United States of America* 80: 1298–1299.
http://dx.doi.org/10.1073/pnas.80.5.1298

Johnson, S.D., Edwards, T.J., Carbutt, C. & Potgieter, C. (2002) Specialization for hawkmoth and long-proboscid fly pollination in *Zaluzianskya* section *Nycterinia* (Scrophulariaceae). *Botanical Journal of the Linnean Society* 138: 17–27.
http://dx.doi.org/10.1046/j.1095-8339.2002.00005.x

Kim, K.-J. & Yun, S.M. (2012) A new species of *Melampyrum* (Orobanchaceae) from southern Korea. *Phytotaxa* 42: 48–50.

Kim, Y.S. (2002) *Illustrated Book of Korean Butterflies in Color*. Kyo-Hak Publishing Co. Ltd., Seoul, pp. 266.

Martins, D.J. & Johnson, S.D. (2007). Hawkmoth pollination of aerangoid orchids in Kenya, with special reference to nectar sugar concentration gradients in the floral spurs. *American Journal of Botany* 94: 650–659.
http://dx.doi.org/10.3732/ajb.94.4.650

Maximowicz, C.J. (1859) *Melampyrum roseum*. *Primitiae Florae Amurensis*, St. Petersburg, pp. 210–211. http://books.google.co.kr/books?id=5_pKAAAAYAAJ

Mechaber, W.L. & Hildebrand, J.G. (2000) Novel, non-solanaceous hostplant record for *Manduca sexta* (Lepidoptera: Sphingidae) in the southwestern United States. Annals of the *Entomological Society of America* 93: 447–451.
http://dx.doi.org/10.1603/0013-8746(2000)093[0447:nnshrf]2.0.co;2

Miller, R.B. (1985) Hawkmoth pollination of *Aquilegia chrysantha* (Ranunculaceae) in southern Arizona. *The Southwestern Naturalist* 30: 69–76.
http://dx.doi.org/10.2307/3670658

Miguel, F.A.W. (1864) *Melampyrum. Annales Musei Botanici Lugduno-Batavi* 2: 122–123, Amsterdam. http://www.biodiversitylibrary.org/item/2543#page/1/mode/1up

Park, K.T. (2012) *Insects of Korea*. Geobook, Seoul, pp. 430–437.

Shin, Y. H. (2007) *Colored Illustrations of the Moths of Korea*. Academy book Publishing Co. Ltd., Seoul, pp. 288–303.

Verne, C. (1983) The systematic and geographical distribution of hawkmoth flowers in the temperate North American flora. *Botanical Gazette* 144: 439–449.
http://dx.doi.org/10.1086/337395

Yamazaki, T. (1989) On *Melampyrum laxum* Miquel and a new species, *M. yezoense* Yamazaki. *Journal of Japanese Botany* 64: 22–31.