



Social Wasp Diversity and Wasp Nest Removal Trends on Ulleungdo Island, South Korea

Jaehee Kim¹, Il-Kwon Kim², Ohseok Kwon^{3,4*}, Moon Bo Choi^{4,5,6*}

¹Department of Applied Biology, College of Agriculture and Life Sciences, Kyungpook National University, Daegu, Korea

²Division of Forest Biodiversity, Korea National Arboretum, Pocheon, Korea

³Department of Plant Medicine, College of Agriculture and Life Sciences, Kyungpook National University, Daegu, Korea

⁴Graduate School of Plant Protection and Quarantine, Kyungpook National University, Daegu, Korea

⁵Institute of Plant Medicine, Kyungpook National University, Daegu, Korea



⁶Department of Research and Development, Wild Beei, Chilgok, Korea

ABSTRACT

This study aimed to conduct a comprehensive survey of social wasp diversity and its impacts on remote Ulleungdo Island, South Korea. A total of 12 wasp traps were placed across the island, and specimens were collected monthly from May to October. Additional collection was conducted by thoroughly inspecting the areas surrounding the traps. The traps yielded a total of 5,068 individuals, representing two genera and two species. A total of 3,961 *Vespa simillima simillima* Smith individuals (78.2%) were collected, and 1,107 individuals (21.8%) were identified as *Vespula flaviceps flaviceps* Smith. Additionally, five individuals of *Polistes snelleni* de Saussure were collected through sweeping, bringing the total to 5,132 individuals of three genera and three species. It is worth noting that our findings indicate potential misidentifications in the species list of Vespidae found in the literature. Emergency services call centers reported the removal of 60 social wasp nests on Ulleungdo Island between 2018 and 2022, with the highest number of reports occurring from July to September, accounting for 87% of all cases. Dodong-ri and Jeodong-ri, with the highest populations, reported the most incidents, although fortunately, there have been no recent injuries. Past incidents involving the destruction of dried squid products by *Vespula* species have resulted in significant economic losses, underscoring the need for preventative measures. Furthermore, ongoing surveillance of hornet invasions is essential to safeguard the Jangwon bees being reared on Ulleungdo Island.

Keywords: Checklist, Nest removal, Ulleungdo, *Vespa simillima simillima*, Vespidae, *Vespula flaviceps flaviceps*

Received September 1, 2023; Revised October 6, 2023;
Accepted October 9, 2023

*Co-Corresponding author: Ohseok Kwon
e-mail ecoento@knu.ac.kr
 <https://orcid.org/0000-0001-9075-3994>
Moon Bo Choi
e-mail kosinchoi@hanmail.net
 <https://orcid.org/0000-0001-7742-3704>

Introduction

Ulleungdo is a tholoid volcanic island located 130.3 km to the east of the Korean mainland (Kwon, 2012). It spans approximately 73 km² and is divided into three administrative divisions of 3 eup/myeon and 9 ri. Its unique characteristics sustain a native ecosystem through various indigenous and anagenesis-driven species (Choi *et al.*, 1998; Takayama *et al.*, 2013; Yang *et al.*, 2019). Regular investigations of the island's diverse biota have



This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0>), which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

been conducted since the 1950s (Byun *et al.*, 1996; Choi *et al.*, 2022; Kim & Kwon, 2013; Lee *et al.*, 2006; Lim *et al.*, 2013). Approximately seven comprehensive surveys conducted between 1955 to 2012 revealed a wide variety of insect fauna on Ulleungdo, with a total of 18 families, 179 genera, and 1,177 species. The Lepidoptera, Coleoptera, and Hemiptera orders exhibited high diversity (Lim *et al.*, 2013). A total of 124 species of Hymenoptera have been recorded, including 8 species of social wasps across 3 genera (Lim *et al.*, 2013).

Approximately 5,000 species of Vespidae have been recorded worldwide (Carpenter, 1982), with 98 species in 3 subfamilies found in Korea (KSAE & ESK, 2021). Of these, 30 social species (including 3 subspecies) of Vespinae and Polistinae are documented (Choi *et al.*, 2013; Kim, 2023). Social wasps, as apex predators, play a role in regulating the insect ecosystem balance (Sumner *et al.*, 2018). However, they are recognized as dangerous and troublesome insects to humans often using their poisonous stings to attack in groups when threatened (Choi 2021; Choi *et al.*, 2019). As urban gardens and green parks expand, the presence of social wasps in areas populated by humans has grown, posing an increased threat (Choi *et al.*, 2012; Kim *et al.* 2019; Komonen *et al.*, 2020). According to Choi *et al.* (2019), between 2010 and 2014 in Korea, the average annual number of wasp nest removals by 119 rescue teams was 96,647, the number of wasp sting injuries was 15,772, and the number of wasp sting-related fatalities was 9.8, constituting a significant public health concern.

Moreover, as a representative predator of honey bees, the genus *Vespa* has sparked various social problems and inflicted severe economic damage on the beekeeping industry (Laurino *et al.*, 2020). Since the invasive hornet *Vespa velutina nigrithorax* du Buysson invaded Korea in 2003, its impact has increased dramatically (Choi *et al.*, 2012; Kim *et al.*, 2006). Despite the widespread impact of social wasps across South Korea, there has been no previous investigation into their diversity, impact, or the introduction of invasive alien wasps on the remote island of Ulleungdo.

Therefore this study collected wasps from all areas of Ulleungdo to assess species diversity and their effects in the Ulleungdo region. Additionally, the study analyzed the number of requests for wasp nest removal made to Ulleungdo emergency services call centers (ESCCs) and incidents of attacks on humans to understand the impact of social wasps.

Materials and Methods

Sample collection

A total of six wasp collection events were conducted on Ulleungdo. Wasp traps were installed at 12 locations from May 18 to 20, 2022, and collected monthly thereafter.

The traps were removed after the last collection between October 22 and 24, 2022.

Regarding survey points, one or two traps were installed for each ri to evenly survey the entire area, including Seonginbong Peak, Ulleungdo's iconic mountain. Initially, four traps (Trap No. 1-4) were installed around the trail from Dodong to Seonginbong, and the remaining traps (Trap No. 5-12) were allocated to each ri (Fig. 1).

Collection method

The wasp traps were installed by drilling a square hole (5×5 cm) in the upper half of a 2 L plastic barrel, into which a mixture of grape juice (500 mL) and yeast was added. Captured wasps were washed with water, immersed in 95% alcohol for preservation, and subsequently identified. Moreover, after collecting the wasp traps, any wasps not captured by the traps were collected through a 30-minute sweeping effort using an insect net in the grassy areas surrounding the traps. Furthermore, we scoured for wasp nests by visually inspecting the eaves of nearby houses, cracks in walls, grassy terrain, and cliffs.

Emergency call data

Information regarding calls for wasp nest removal in the Ulleungdo area was provided by the ESCCs under the National Fire Service. The data encompassed the past five years (2018–2022) and was categorized by year, month, and location. This data was subsequently analyzed and mapped. Additionally, the number of reports was analyzed in relation to unit area and population. Reports concerning other bees, such as bee swarms, were excluded from the dataset, focusing solely on reports pertaining to the removal of social wasp nest.

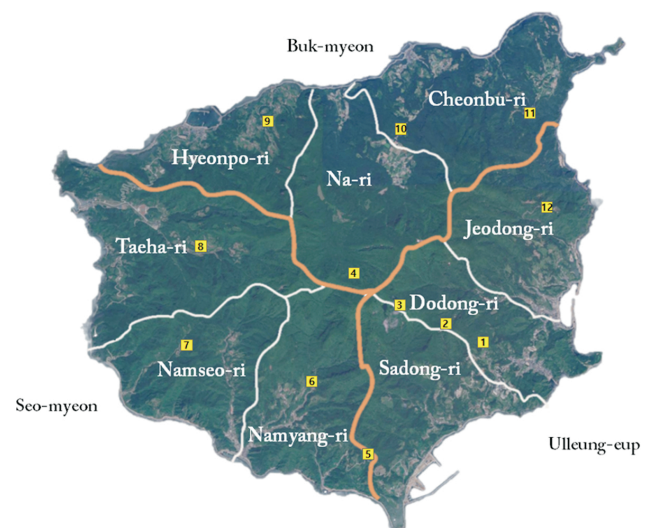


Fig. 1. Social wasp trapping sites on Ulleungdo.

Identification

Wasps collected via traps and insect nets were identified using identification keys from Archer (2012), Choi (2004), Kim (2001), Kim *et al.* (2006), and Matsuura and Yamane (1990). Additionally, as the information on the number of wasp nest removals was obtained from telephonic data, it was not used for species identification. However, some nests were reported via calls to 119 rescuers, and information on species at the genus level was secured through photo collation.

Results

Diversity of social wasps collected from Ulleungdo

A total of 5,068 individuals belonging to two genera and two species were collected through five trappings at 12 locations on Ulleungdo Island. *Vespa simillima simillima* Smith exhibited the highest count, with 3,961 individuals (78.2%) collected (Fig. 2A), followed by *Vespula flaviceps flaviceps* (Fig. 2C) with 1,107 individuals (21.8%; Table 1).

By location, 942 and 936 individuals were collected from traps 1 and 3, respectively (the largest number of individuals collected), whereas only 42 and 39 individuals were collected from traps 8 and 9, indicating a significant variation. Furthermore, the majority of individuals collected by sweeping were either *V. simillima simillima* or *Vl. flaviceps flaviceps*, although five individuals of *Polistes snelleni* de Saussure (Fig. 2D) were collected at location 5. Although nests were searched for under house eaves, between wall gaps, and on cliffs, no nest traces were found except one *V. simillima simillima* nest found on a cliff (Fig. 2B). Consequently, this survey yielded a total of 5,132

wasps representing three genera and three species.

Emergency call data for social wasp nest removal in Ulleungdo

Over the past five years (2018–2022), a total of 60 emergency calls were made for wasp nest removal on Ulleungdo. By year, in 2018, 2019, and 2022, the number of cases appeared similar (17–20), but it notably decreased in 2020 and 2021 with only two and four cases, respectively (Fig. 3).

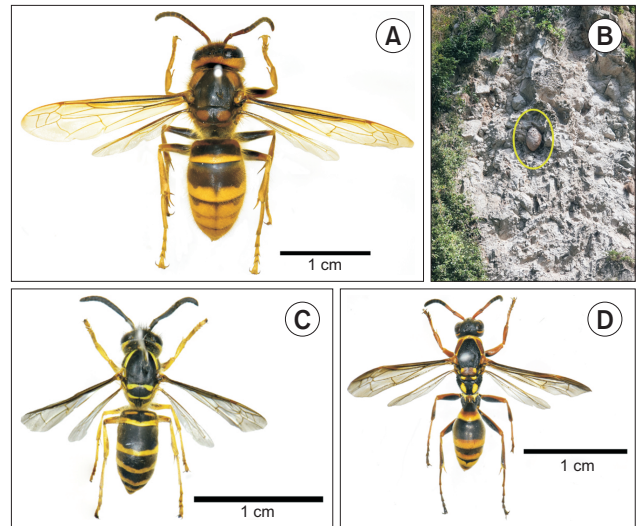


Fig. 2. Social wasps collected from traps and nest on Ulleungdo. (A) *Vespa simillima simillima*, (B) Nest of *Vespa simillima simillima*, (C) *Vespula koreensis koreensis*, (D) *Polistes snelleni*.

Table 1. List of social wasps collected from Ulleungdo in 2022

Scientific name	Trap no.												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
Subfamily Vespinae													
Genus <i>Vespa</i>													
<i>Vespa simillima simillima</i> Smith	875	95	518	27	34	503	803	42	22	223 (14)	631	188 (3)	3,961 (17)
Genus <i>Vespula</i>													
<i>Vespula flaviceps flaviceps</i> Smith	67	182	418 (36)	30	37	153 (3)	28	0	17	42 (3)	63	70	1,107 (42)
Subfamily Polistinae													
Genus <i>Polistes</i>													
<i>Polistes snelleni</i> de Saussure					(5)								(5)
Total	942	277	936 (36)	57	71 (5)	656 (3)	831	42	39	265 (17)	694	258 (3)	5,068 (64)

Numbers in parentheses are the number of individuals collected by sweeping.

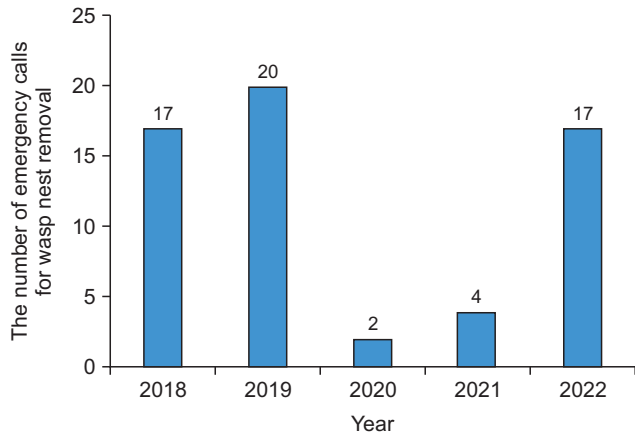


Fig. 3. Number of emergency calls to remove social wasp nests on Ulleungdo during 5 years (2018–2022).

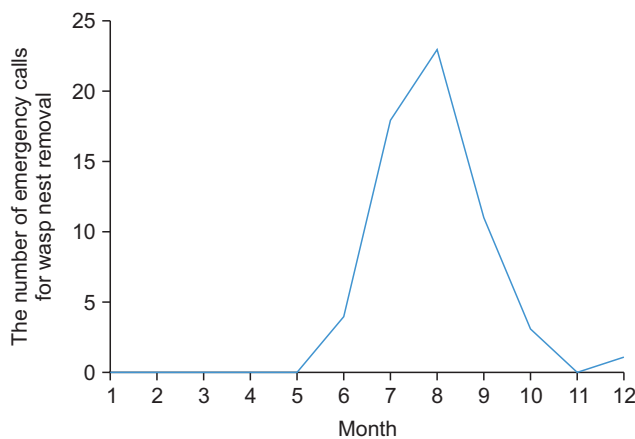


Fig. 4. Number of emergency calls per month for social wasp nests removal on Ulleungdo over 5 years.

Examining the monthly records, emergency calls initiated in June, peaked in August, and then decreased. In particular, the number of calls in July (18 cases), August (23 cases), and September (11 cases) accounted for 87% of the total reports (Fig. 4).

In terms of regions, the Dodong-ri area reported the most cases with 22, followed by Jeodong-ri with 10 cases. All other regions reported fewer than 10 cases, with Namseo-ri and Hyeonpo-ri recording the fewest cases, with two each (Fig. 5). When evaluating the number of reports per unit area, Dodong-ri had the highest ratio of 3.55, followed by Jeodong-ri with 1.35. However, in terms of the number of reports per population, Na-ri had the highest ratio of 3.00, followed by Namseo-ri with 1.00. Conversely, Dodong-ri and Jeodong-ri, which had the highest number of reports, exhibited very low numbers, with 0.51 and 0.53, respectively (Table 2).

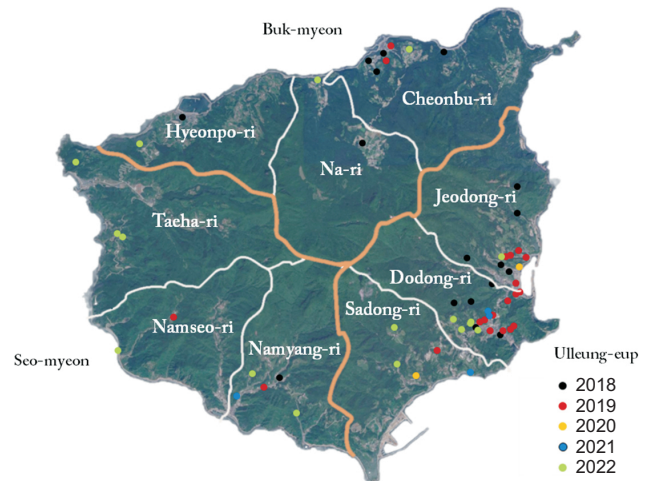


Fig. 5. Map of the number of emergency calls to remove social wasp nests in each administrative district of Ulleungdo for 5 years.

Discussion

Diversity of social wasps in Ulleungdo

Since Cho (1955), when Vespidae species were first recorded on Ulleungdo, a total of nine species of three genera in two subfamilies have been documented in the list of social wasps on Ulleungdo to date (Table 3; Cho, 1955; Choi, 2023; Lee & Kwon, 1981; Lee *et al.*, 2006; Lim *et al.*, 2013; Won *et al.*, 2023). However, as stated by Choi *et al.* (2013), the Vespidae species list in Korea has undergone significant revisions, with the inclusion of synonyms, new species, unrecorded species, and invasive species.

Consequently, when examining social wasp checklists in a specific area, entomologists and the general public (except some wasp taxonomists) often rely on outdated taxonomic information, potentially leading to errors in identification. This undermines the reliability of many of the recorded data for existing social wasps.

For instance, when reviewing the species list in Table 3, *Vespula flaviceps lewisii* Smith was reidentified as *V. flaviceps flaviceps* by Choi *et al.* (2013). Moreover, *Vespula rufa schrenckii* Radoszkowski is the rarest species in Korea, primarily found in the highlands of Gangwon-do and northern Gyeongbuk. Therefore, the presence of this species on Ulleungdo is highly unlikely.

Additionally, *Polistes jadvigae jadvigae* Dalla Torre was once considered a synonym for *Polistes yokahamae* Radoszkowski by Kojima and Hagiwara (1998). However, in the past, it was often misidentified as *Polistes rothneyi koreanus* van der Vecht (Choi *et al.*, 2013). Therefore, most of the species categorized under the subgenus *Gyrostoma* are highly likely to be *P. rothneyi koreanus*.

Table 2. Comparison of the number of emergency calls for wasp nest removal in each administrative district and unit population and area (as of 2017)

Administrative district	Number of emergency calls	Population (100 units)	Area (km ²)	n/population	n/area
Dodong-ri	22	43	6.2	0.51	3.55
Jeodong-ri	10	19	7.4	0.53	1.35
Sadong-ri	6	8	7.9	0.75	0.76
Namyang-ri	5	8	8.7	0.63	0.57
Namseo-ri	2	2	7.6	1.00	0.26
Taeha-ri	3	7	10.9	0.43	0.28
Cheonbu-ri	7	8	9.1	0.88	0.77
Na-ri	3	1	9.2	3.00	0.33
Hyeonpo-ri	2	5	6	0.40	0.33
Total	60	101	73		

Table 3. List of social wasps recorded on Ulleungdo from 1955 to 2023

Scientific name	1955*	1981 [†]	2006 [‡]	2013 [§]	2023a	2023b [¶]	This study
Subfamily Vespinae							
Genus <i>Vespa</i>							
<i>Vespa simillima simillima</i> Smith				○	○	○	●
Genus <i>Vespula</i>							
<i>Vespula flaviceps flaviceps</i> Smith					○	○	●
<i>Vl. flaviceps lewisii</i> Smith			○				
<i>Vl. rufa schrenckii</i> Radoszkowski				○			?
Subfamily Polistinae							
Genus <i>Polistes</i>							
<i>Polistes jadwigae jadwigae</i> Dalla Torre		○	○				X
<i>P. rothneyi koreanus</i> van der Vecht							▲
<i>P. japonicus japonicus</i> Saussure		○	○				?
<i>P. mandarinus</i> Saussure	○	○	○				?
<i>P. olivaceus</i> Geer	○	○	○				X
<i>P. snelleni</i> Saussure		○	○	○			●

○, recorded in literature; ●, species confirmed on Ulleungdo; X, not distributed; ?, very strong doubts about the distribution; ▲, distribution is possible, but not confirmed.

*Cho (1955), [†]Lee and Kwon (1981), [‡]Lee et al. (2006), [§]Lim et al. (2013), [¶]Choi (2023), **Won et al. (2023).

Hence, despite considerable efforts made throughout Ulleungdo to confirm the distribution of *P. rothneyi koreanus*, neither individuals nor any signs of nests were discovered. Although some information on its existence was obtained through photo comparisons of nest removal by rescue teams at the Ulleungdo fire station, further verification is necessary.

Polistes olivaceus De Geer is a species not naturally found in Korea, but its continuous recording for approximately 50 years poses questions regarding the reliability

of species identification in the genus *Polistes*. Furthermore, as *Polistes japonicus japonicus* de Saussure and *Polistes mandarinus* de Saussure are representative species that are commonly misidentified by domestic entomologists, their records in Ulleungdo are also highly dubious.

In contrast, it appears quite unusual that *V. simillima simillima* and *Vl. flaviceps flaviceps*, which dominated the results of this survey, are absent from the collection records of Ulleungdo in the past. It remains uncertain whether this absence is due to past misidentifications

by entomologists or if these species have been recently introduced from the mainland and have since thrived. Additionally, there is currently no way to ascertain whether the *Polistes* species recorded in the past were indeed misidentified or have vanished for specific reasons.

Therefore, the findings of this survey indicate that there are currently three species of social wasps belonging to three genera in Ulleungdo. Furthermore, additional species will need to be confirmed through further investigations.

Removal of wasp nests on Ulleungdo

Over the past five years, there have been 60 reports for wasp nest removals on Ulleungdo, averaging 12 per year. This number does not significantly differ from the mainland (Choi *et al.*, 2012; 2019). The limited inflow and outflow of external wasp populations due to the geographical characteristics of islands likely contribute to the consistent number of wasp colonies that occur each year.

When we examine the yearly data, the numbers for 2018, 2019, and 2022 appear relatively high, while in 2020–2021, they dropped significantly. By region, it was observed that Dodong-ri and Jeodong-ri reported the highest numbers. As the number of wasp nest removals is not a measure of the number of natural occurrences of wasp nests, but the number of calls made, it is inevitably influenced by the activity of the individuals encountering the wasp nest. Consequently, given that the number of reports tends to be higher in areas with larger populations (Choi *et al.*, 2019), it is reasonable to see higher reports in Dodong-ri and Jeodong-ri, which have the highest populations on Ulleungdo. Additionally, the sharp decline in 2020–2021 may be attributed to a significant reduction in tourist numbers and a decrease in opportunities to encounter wasp nests, as locals limited their outdoor activities because of COVID-19.

According to the life cycle of social wasps, queens emerge from winter hibernation in April to form embryonic nests, with the first workers appearing in June. The number of workers increases rapidly in July as the nest size increases. By August and September, the nest reaches its maximum size. As these nests, initially inconspicuous, become visible to the naked eye, the number of reports surges, particularly from July onwards.

Despite no reported cases of wasp stings in Ulleungdo over the past five years, it is important to note that *V. simillima simillima* and *Vespula koreensis koreensis* being the most populous native wasps in Korea, can engage in group attacks. These attacks typically occur when humans inadvertently disturb their nests or act threateningly near the nest entrance.

Therefore, if a nest is discovered in spring or early summer, it is necessary to ensure its swift removal by reporting it to the 119 rescue team. While the number of human

casualties from wasp stings remains low in Ulleungdo, damage to marine products caused by yellowjackets is frequently reported. Ulleungdo is a significant hub for squid production in Korea, accounting for approximately 750 tons of squid as of 2018, which amounts to nearly 94% of Ulleungdo's seafood sales (Kim, 2019). Yellowjackets contribute to the supply of protein to their larvae by hunting Lepidoptera larvae in the forests. However, they also collect the remains of terrestrial animals such as mammals, amphibians, fish, and annelids, as are the flesh of aquatic products such as fish, squid, and clams left on land (Matsuura & Yamane, 1990). In Ulleungdo, captured squids are left outdoors to naturally air-dry, attracting numerous yellowjackets that consume the squids' flesh. This significantly diminishes the quality of squid products and leads to substantial economic losses (Cho, 2011). Given that these damages can persist as long as yellowjackets are present, preventive measures are imperative.

Furthermore, since 2017, only Jangwon honey bees, known as Korea's premier beekeeping breed, have been reared, replacing the existing honey bees on Ulleungdo (Hong, 2017; Kim *et al.*, 2015). *V. simillima simillima* has been documented as a major pest that preys on bees in apiaries (Choi & Kwon, 2015). However, the damage caused by this species is less severe than that inflicted by *Vespa mandarinia* Smith or *V. velutina nigrithorax*, which are typically found inland. Therefore to prevent negative impacts on beekeeping, it is necessary to continuously monitor the possible invasion of *V. mandarinia* or *V. velutina nigrithorax*, which have not been detected in Ulleungdo until now.

Conflict of Interest

The authors declare that they have no competing interests.

Acknowledgements

This work was supported by the Korea Institute of Planning and Evaluation for Technology (IPET) in Food, Agriculture, Forestry, and Fisheries through the Agriculture, Food and Rural Affairs Convergence Technologies Program for Educating Creative Global Leaders (or Project), funded by the Ministry of Agriculture, Food, and Rural Affairs (MAFRA) (grant no. 321001-03). Additionally, this study was supported by grants from the Korea National Arboretum's Scientific Research program (KNA1-1-25, 19-1). We would like to thank Mr. CH Ma for his invaluable assistance in collecting wasps on Ulleungdo. We also extend our gratitude to Ulleungdo Rescuer JW Kim for providing essential species information on wasp nest removals on Ulleungdo Island.

References

- Archer, M.E. (2012). History of dichotomous keys and a revised key. In M.E. Archer (Ed.), *Vespine Wasps of the World* (pp. 199-310). Siri Scientific Press.
- Byun, B.K., Lee, B.Y., and Kim, S.S. (1996). Lepidoptera of the Is. Ullung, Korea. *Journal of Lepidoptera Society Korea*, 9, 26-33.
- Carpenter, J.M. (1982). The phylogenetic relationships and natural classification of the Vespoidea (Hymenoptera). *Systematic Entomology*, 7, 11-38. <https://doi.org/10.1111/j.1365-3113.1982.tb00124.x>
- Cho, B.S. (1955). The insect fauna of Ulleungdo. *Sungkyun Journal of East Asian Studies*, 2, 179-266.
- Cho, J.H. (2011). Yellowjacket attack on Ulleungdo "eats squid". Retrieved Aug 9, 2023 from <https://www.kyongbuk.co.kr/news/articleView.html?idxno=551846>.
- Choi, H.K., Kim, Y.D., Sun, B.Y., and Shin, H.C. (1998). Phylogeny of Dystaenia in subfamily Apioideae (Family Apiaceae) based on ITS sequences. *Korean Journal of Plant Taxonomy*, 28, 139-149. <https://doi.org/10.11110/kjpt.1998.28.2.139>
- Choi, J.W., Won, M.H., Lee, D.Y., Bang, W.J., Moon, M.K., Kim, Y.K., et al. (2022). Insect fauna of Seonginbong in Ulleungdo, Korea. *Journal of Asia-Pacific Biodiversity*, 15, 518-526. <https://doi.org/10.1016/j.japb.2022.08.001>
- Choi, K.S. (2023). 2020 Ulleungdo insect list. Retrieved Jun 27, 2023 from <https://www.gbif.org/dataset/b2ccb272-cd23-4c1e-8c07-660ff0099fff#contacts>.
- Choi, M.B. (2004). Ecological systematics by morphological and ecological characters of Vespine wasps (Vespidae: Hymenoptera) in Busan and its surrounding area. [master's thesis]. Kosin University, Busan.
- Choi, M.B. (2021). Defensive behavior of the invasive alien hornet *Vespa velutina nigrithorax* against potential human aggressors. *Entomological Research*, 51, 186-195. <https://doi.org/10.1111/1748-5967.12514>
- Choi, M.B., and Kwon, O. (2015). Occurrence of Hymenoptera (wasps and bees) and their foraging in the southwestern part of Jirisan National Park, South Korea. *Journal of Ecology and Environment*, 38, 367-374. <https://doi.org/10.5141/ecoenv.2015.038>
- Choi, M.B., Kim, J.K., and Lee, J.W. (2012). Increase trend of social hymenoptera (wasps and honeybees) in urban areas, inferred from moving-out case by 119 rescue services in Seoul of South Korea. *Entomological Research*, 42, 308-319. <https://doi.org/10.1111/j.1748-5967.2012.00472.x>
- Choi, M.B., Kim, J.K., and Lee, J.W. (2013). Checklist and distribution of Korean Vespidae revisited. *Korean Journal of Applied Entomology*, 52, 85-91. <https://doi.org/10.5656/KSAE.2013.02.1.072>
- Choi, M.B., Kim, T.G., and Kwon, O. (2019). Recent trends in wasp nest removal and Hymenoptera stings in South Korea. *Journal of Medical Entomology*, 56, 254-260. <https://doi.org/10.1093/jme/tjy144>
- Hong, S.P. (2017). Ordinary bees are prohibited from entering! Only Jangwon bee lives on Ulleungdo. Retrieved Aug 10, 2023 from <https://www.hankyung.com/economy/article/2017111696131>.
- Kim, J.E., Kim, S.G., Kang, S.J., Kim, C.S., and Choi, Y.S. (2015). Characterization of triple crossed honey bee (*Apis mellifera*, Jangwon) in Jeon-Nam province. *Journal of Apiculture*, 30, 239-244.
- Kim, J.K. (2001). A new species of genus *Polistes* Latreille (Polistinae, Vespidae, Hymenoptera) from Korea. *Korean Journal of Entomology*, 31, 59-62.
- Kim, J.K. (2023). Taxonomic review of *Polistes* (Polistella) (Hymenoptera: Vespidae: Polistinae) in Korea, with a description of a new species and a new status. *Oriental Insects*, 57, 908-934. <https://doi.org/10.1080/00305316.2022.2163516>
- Kim, J.K., Choi, M.B., and Moon, T.Y. (2006). Occurrence of *Vespa velutina* Lepeletier from Korea, and a revised key for Korean *Vespa* species (Hymenoptera: Vespidae). *Entomological Research*, 36, 112-115. <https://doi.org/10.1111/j.1748-5967.2006.00018.x>
- Kim, S.S., and Kwon, T.S. (2013). Monitoring and revision of the butterfly fauna on Ulleungdo Island, South Korea. *Journal of Asia-Pacific Biodiversity*, 6, 255-259. <https://doi.org/10.7229/jkn.2013.6.2.255>
- Kim, W.M., Kim, S.Y., Song, W., and Choi, M.B. (2019). Ecological characteristics of hornets (genus *Vespa*) considering environmental spatial information in urban children's parks. *Korean Journal of Environment and Ecology*, 33, 506-514. <https://doi.org/10.13047/KJEE.2019.33.5.506>
- Kim, Y.B. (2019). Fluctuation of common squid catches and development plan of squid industry of Ulleungdo. *Journal of Fisheries and Marine Sciences Education*, 31, 1574-1591. <https://doi.org/10.13000/JFMSE.2019.12.31.6.1574>
- Kojima, J., and Hagiwara, Y. (1998). Lectotype designation of four species and one form of the paper wasp genus *Polistes* Latreille, 1802, described from Japan, with notes on the scientific names of Japanese *Polistes* (Insecta: Hymenoptera: Vespidae, Polistinae). *Natural History Bulletin of Ibaraki University*, 2, 247-262.
- Komonen, A., Nirhamo, A., and Tornaiainen, J. (2020). Social wasps (Vespinae) in urban gardens and woods. *Annales Zoologici Fennici*, 57, 41-46. <https://doi.org/10.5735/086.057.0105>
- Korean Society of Applied Entomology (KSAE), and The Entomological Society of Korea (ESK). (2021). Check list of insects from Korea. Paper and Pencil.
- Kwon, D.H. (2012). A geomorphology on the Ulleungdo. *Journal of The Korean Geomorphological Association*, 19, 39-57.
- Laurino, D., Lioy, S., Carisio, L., Manino, A., and Porporato, M. (2020). *Vespa velutina*: an alien driver of honey bee colony losses. *Diversity*, 12, 5. <https://doi.org/10.3390/d12010005>
- Lee, C.U., and Kwon, Y.J. (1981). About insect fauna of Ulleungdo and Dokdo Island. *Korean Association for Conservation of Nature*, 19, 139-182.
- Lee, J.W., Jung, J.C., Park, C.S., and Nam, S.H. (2006). The study on the insect fauna from Ulleung-do and Dokdo. *Nat Sci (Daejeon Univ)*, 16, 39-70.
- Lim, J.S., Park, S.Y., Lim, J.O., and Lee, B.W. (2013). A faunistic study of insects from Is. Ulleungdo and its nearby islands in South Korea. *Journal of Asia-Pacific Biodiversity*, 6, 93-121. <https://doi.org/10.7229/jkn.2013.6.1.093>
- Matsuura, M., and Yamane, S. (1990). Phylogeny and classification. In M. Matsuura, and S. Yamane (Eds.), *Biology of the Vespine Wasps* (pp. 219-238). Springer Verlag.

- Sumner, S., Law, G., and Cini, A. (2018). Why we love bees and hate wasps. *Ecological Entomology*, 43, 836-845. <https://doi.org/10.1111/een.12676>
- Takayama, K., Sun, B.Y., and Stuessy, T.F. (2013). Anagenetic speciation in Ullung Island, Korea: genetic diversity and structure in the island endemic species, *Acer takesimense* (Sapindaceae). *Journal of Plant Research*, 126, 323-333. <https://doi.org/10.1007/s10265-012-0529-z>
- Won, M.H., Choi, J.W., Bang, W., Lee, D., Moon, M.K., Kim, Y.K., et al. (2023). Insect fauna including unrecorded species in Ulleungdo, South Korea. *Biodiversity Data Journal*, 11, e100783. <https://doi.org/10.3897/BDJ.11.e100783>
- Yang, J., Pak, J.H., Maki, M., and Kim, S.C. (2019). Multiple origins and the population genetic structure of *Rubus takesimensis* (Rosaceae) on Ulleung Island: implications for the genetic consequences of anagenetic speciation. *PLoS One*, 14, e0222707. <https://doi.org/10.1371/journal.pone.0222707>