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NOTE

Ten newly recorded species of insect on Dokdo Island, South Korea

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A survey of insect fauna on Dokdo Island was conducted by Yeungnam University from 2009 to 2016. The survey locations were the two islands of Dokdo Island (i.e., East and West Islands), located in the East Sea of South Korea. As a result of the survey, we identified five orders, 20 families and 27 species including 10 species newly recorded on Dokdo Island, of which *Eupelmus australiensis* (Girault) is recorded for the first time in South Korea. In combination with the results of previous surveys made from 1981 to 2016, the insect fauna of Dokdo Island is now known to consist of 10 orders, 77 families and 164 species (and 29 additional undetermined species). In this paper, we list the insect fauna on Dokdo Island and present photographs of 10 species with brief taxonomic notes of a eupelmid species.

Keywords: diversity, *Eupelmus australiensis*, list, new record

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INTRODUCTION

Dokdo Island, which is located in Gyeongsangbuk-do, Ulleung-gun, Ulleung-eup, Dokdo-ri, San 1-37, consists of two main islands (East and West Islands) and 89 annexed islands. As a protected natural area, this island was assigned as Natural Monument no. 336 in 1982 by the South Korean Government. The first reports of the insect fauna on Dokdo Island were by Jolivet (1974) and Yoon (1978), and these reports were followed by subsequent researchers (36 species by Lee and Kwon, 1981; 16 species by Kwon *et al*., 1996; 49 species by An, 2000; 69 species by Lee and Jeong, 2001; 58 species by Kim, 2004; six species by Park and Suh, 2005; eight species by Kim and Yeom, 2006; 10 species by Lee *et al*., 2006; 2009; 21 species by An, 2008; seven species by Park *et al*., 2010; 2011; 2012; 2013; two species by Oh *et al*., 2012; five species by Kang *et al*., 2013; three species by Yoo *et al*., 2013; eight species by Choi *et al*., 2015; three species by Park and Jang, 2016). As of 2015, 11 orders, 70 families and 154 species (and 28 undetermined species) had been recorded on Dokdo Island. Based on the list of insects on Dokdo Island (1981-2016) in the "Report of the ecosystem survey of Dokdo Island in 2015" published by the Ministry of Environment in 2016 (Park and Jang, 2016), we listed the total insect species on Dokdo Island with added species in this study, of which the order Collembola and 28 undetermined species are excluded.

In this study, we identified five orders, 20 families and 27 species (and one undetermined species) and added 10 species belonging to three orders: [Hemiptera] *Psammotettix striatus* (Cicadellidae); [Hymenoptera] *Brachymeria minuta* (Chalcididae), *Halticoptera circulus* (Pteromalidae), *Eupelmus australiensis* (Eupelmidae); [Diptera] *Calliphora nigribarbis* (Calliphoridae), *Campiglossa sada* (Tephritidae), *Coelopa frigida* (Coleopidae), *Lucilia illustris* (Calliphoridae), *Pegomya cuniculari* (Anthomyiidae), and *Scathophaga stercoraria* (Scathophagidae). The purpose of this study is to report unrecorded species on Dokdo Island including a eupelmid species newly recorded in South Korea.

MATERIALS AND METHODS

Survey sites and period

The present survey was performed along the roads, which included flat and steep areas, on the two main islands of Dokdo Island (Fig. 2). Using Google earth 7.1.7.2606, a satellite photograph of Dokdo Island was obtained (Fig. 1). The survey was conducted from 2009 to 2016.

Survey methods and contents

The insects were collected by sweeping and brandishing an insect net walking along a path. The researchers



Fig. 1. Map of Dokdo Island, East (right) and West (left) Islands.

also performed observation and soil collection. The collected specimens were preserved in 80% ethanol and taken to the Animal Systematic Laboratory at Yeungnam University, where they were exsiccated for classification and identification. The list of insect fauna on Dokdo Island was organized according to the order found in the Checklist of Korean Insects, 2010.

The morphological terminology follows Gibson and Fusu (2016). The adult morphology was observed with a Stemi 2000 stereomicroscope (Carl Zeiss). The images were captured with an AxioCam HRc camera through a SteREO Discovery V20 stereomicroscope (Carl Zeiss) and were produced with AxioVision64SE software (Carl Zeiss). Final plates were prepared in Adobe Photoshop CS6 (Adobe Systems Incorporated, San Jose, United States of America).

The following abbreviations are used: MCSN, Museo Civico di Storia Naturale "Giacomo Doria", Genoa, Italy; MNHN, Muséum National d'Histoire Naturelle, Paris, France; NMPC, Narodni Muzeum v Praze, Prague, Czech Republic; QMBA, Queensland Museum, Brisbane, Australia; USNM, United States National Entomological Collection, U.S. National Museum of Natural History, Washington DC, USA; ZINR, Zoological Institute of Russian Academy of Sciences, St. Petersburg, Russia; TD: Type Depository; TL: Type Locality. All insect specimens were housed at the Animal Systematic Laboratory in Yeungnam University (YNU, Gyeongsan, South Korea).

Results

Through the present survey, five orders, 20 families and 27 species (and one undetermined species of family Eulophidae) were identified (Table 1). Our results, combined with the six families and 10 examined species from 1981 to 2015, indicate that a total of 10 orders, 77 families and 164 species (and 29 undetermined species) have now been identified on Dokdo Island (Table 3 and Figs. 4, 5). Of the species added by this study, *Eupelmus australiensis* (Girault) is a newly recorded species in South Korea and we describe this species below.

Order Hymenoptera Linnaeus, 1758
Family Eupelmidae Walker, 1833
Genus *Eupelmus* Dalman, 1820

***Eupelmus australiensis* (Girault, 1913) (Fig. 4)**

Idoleupelmus australiensis Girault, 1913: 94-95. Lectotype: ♀; TL: Australia; TD: QMBA.

Eupelmus listeri Girault, 1915: 13. Syntype: ♀; TL: Australia; TD: QMBA.

Eupelmus australicus Girault, 1915: 8. Lectotype: ♀; TL: Australia; TD: QMBA.

Eupelmus popa Girault, 1917: 4. Syntype: ♀; TL: Dutch



Fig. 2. View of the survey areas of Dokdo Island, South Korea. A-C, East Island; D-F, West Island.

Table 1. Categorization of insects surveyed on Dokdo Island.

No.	Order	Family	Species	Individuals
1	Odonata	1	1	1
2	Hemiptera	5	6	52
3	Coleoptera	3	3	30
4	Hymenoptera	5	6	60
5	Diptera	6	11	21
Total	5	20	27	164

Table 2. Comparison of appearance of insects on the two main islands of Dokdo Island.

Site	Order	Family	Species	Individuals
East Island	5	10	1	68
West Island	4	15	15	96

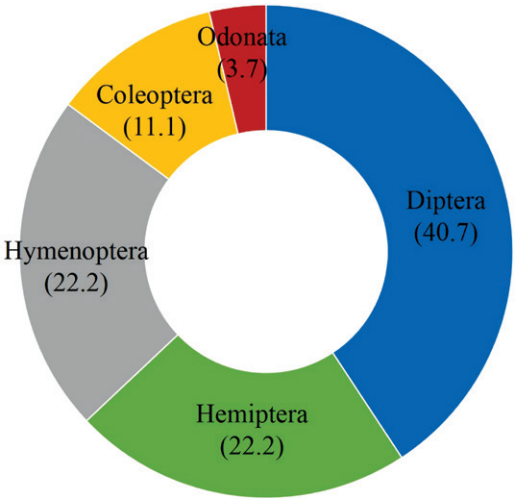


Fig. 3. The component ratio (%) of insect orders in the number of species in the present survey.

Antilles; TD: USNM.

Eupelmus Zangherii Masi, 1946: 27-28. Syntype: ♀; TL: Italy; TD: MCSN.

Eupelmus alboannelatus Belanovsky & Dyadechko, 1951: 293. Syntypes: ♀, ♂; TL: unknown; TD: NMPC, ♀ and ZINR, ♂.

Brasema leersiae garouae Risbec, 1955: 224. Syntype: ♀; TL: Cameroon; TD: MNHN.

Diagnosis of female. Length about 2.37 mm, including ovipositor sheath (Fig. 4A). Head entirely golden-green except vertex with coppery luster between anterior and posterior ocelli, anterior margin of lower face metallic blue, and scrobal depression slightly bluish-green with bluish luster (Fig. 4B); in dorsal view with interocular distance about 0.30-0.50× as long as head width; vertex meshlike reticulate posteriorly; frons to parascrobal region very finely meshlike coriaceous-reticulate except scrobal depression finely, transversely wrinkled above interantennal region; lower face slightly and longitudinally meshlike coriaceous-reticulate; OOL : POL : LOL : MPOD = 1.5 : 2.9 : 1.7 : 1.0. Antenna dark brown except anellus and apical two-third region of pedicel yellow, and scape with metallic bluish-green luster (Fig. 4B). Mesoscutum variably golden-green to greenish-blue with coppery luster; mostly meshlike coriaceous-reticulate except inner side of lateral lobe slightly meshlike sculpture medially. Scutellar-axillar complex similar to mesoscutum in color; with axillae obliquely coriaceous and scutellum meshlike coriaceous to somewhat mesally sculpture on posterior margin. Acropleuron more variable than mesonotum with coppery and slightly purple lusters; meshlike coriaceous-reticulate anteriorly to distinctly meshlike reticulate posteriorly except slightly fine meshlike sculpture medially (Fig. 4C). Legs entirely whitish-yellow except mesotibia with dark spot on subbasal region, mesotarsal pegs reddish-brown and tarsomeres dark apically (Figs. 4D-E). Gaster entirely smooth to slightly coriaceous. Ovipositor sheaths similar to length of gaster and about twice as long as mv.

Material examined. South Korea: 1♀, Gyeongsangbuk-do, Ulleung-gun, Ulleung-eup, Dokdo-ri, Western Island, N37°14′28.9″, E131°51′53.2″, 5.IX.2016, Park DY (YNU).

Biology. [Primary hosts] Cecidomyiidae (Diptera): *Contarinia caudata*, *C. sorghicola*, *C.* sp., *Stenodiplosis panici*, *S. sorghicola*; Noctuidae (Lepidoptera): *Celama sorghiella*; [Parasitoid hosts] Eulophidae (Hymenoptera): *Aprostocetus diplosidis*, *Tetrastichus* sp.; [Plant associates] Poaceae: *Oryza sativa*, *Panicum* sp., *Sacchrum officinarum*, *Sorghum halepense*, *S.* sp.; Polygonaceae: *Polygonum* sp. (Gibson, 2011).

Distribution. South Korea (new record), Antilles, Argentina, Australia, Brazil, Bulgaria, Burkina Faso, Cameroon, Caribbean, China, Cuba, Czech Republic, El Salvador, Ghana, Hawaii, Hungary, India, Italy, Mexico, Micronesia, Moldova, Netherlands Antilles, Nigeria, Papua New Guinea, Peru, Senegal, Serbia, Slovakia, Ukraine, USA, Uruguay, Venezuela.

Remarks. *E. australiensis* is a common species in the genus *Eupelmus* and is widely distributed in the world. Although both sexes of this species are known, we collected only female specimen from Dokdo Island. Therefore, we describe diagnostic characteristics based on female.

When identified insects were classified according to the survey area, a total of five orders, 10 families, and 16 species of insects were observed in East Island and a total of four orders, 15 families, and 15 species were

Table 3. Total list of recorded species on Dokdo Island (1981-2016) (Species of order Collembola are excluded from the list).

Order	Family	Scientific name	In this study	Undetermined species
Odonata	Coenagrionidae	*Ischnura asiatica*		
	Aeshnidae	*Anax parthenope*		
	Libellulidae	*Sympetrum darwinianum*		
		Pantala flavescens	●	
		Rhyothemis fuliginosa		
Dictyoptera	Blattellidae	*Blattella nipponica*		
Dermaptera	Anisolabididae	*Anisolabis maritima*		
		Euborellia annulipes		
	Forficulidae	*Forficula scudderi*		
Orthoptera	Gryllacrididae	*Nippancistroger* sp.		●
	Gryllidae	*Teleogryllus emma*		
		Velarifictorus aspersus		
	Mogoplistidae	*Ornebius kanetataki*		
Hemiptera	Nabidae	*Prostemma hilgendorffi*		
	Anthocoridae	*Orius sauteri*	●	
		Orius sp.		●
	Miridae	*Trigonotylus coelestialium*		
		Orthotylus flavosparsus		
		Campylomma lividicorne		
		Campylomus sp.		●
	Tingidae	*Cantacader lethierryi*		
	Piesmatidae	*Piesma capitatum*		
		Piesma maculatum		
	Lygaeidae	*Nysius plebejus*	●	
		Stigmatonotum rufipes		
		Paradieuches dissimilis		
	Cydnidae	*Geotomus pygmaeus*	●	
	Scutelleridae	*Cantao ocellatus*		
	Pentatomidae	*Nezara antennata*		
	Cicadellidae	*Balclutha pseudoviridis*		
		Balclutha rubrinervis		
		Hishimonus sellatus		
		Laburrus impictifrons		
		*Psammotettix striatus**	●	
		Recilia oryzae		
		Cicadellidae sp.		●
	Delphacidae	*Laodelphax striatellus*		
		Sogatella furcifera	●	
		Sogatella kolophon		
		Unkanodes sapporonus	●	
	Triozidae	*Heterotrioza obliqua*		
	Aphididae	*Aphis nerii*		
		Aphis rumicis		
Neuroptera	Hemerobiidae	*Hemerobius humulinus*		
	Chrysopidae	*Chrysopa pallens*		
Coleoptera	Carabidae	*Anisodactylus signatus*		
		Anisodactylus tricuspidatus		
		Dolichus halensis halensis		
		Harpalus jureceki		
		Harpalus sinicus		
		Stenolophus difficilis		
	Hydrophilidae	*Hydrophilus acuminatus*		
	Staphylinidae	*Aleochara* (*Emplenota*) *fucicola*		
		Atheta (*Badura*) *tokiokai*		
		Atheta sp.		●
		Cafius histrio		
		Neobisnius sp.		●

Table 3. Continued.

Order	Family	Scientific name	In this study	Undetermined species
Coleoptera	Staphylinidae	*Paederus fuscipes*		
	Helodidae	*Cyphon* sp.		●
	Elateridae	*Agrypnus miyamotoi*		
		Melanotus castanipes matsumurai		
		Melanotus cete	●	
	Dermestidae	*Dermestes tessellatocollis*		
	Nitidulidae	*Omosita colon*		
		Omosita japonica		
	Endomychidae	*Ancylopus melanocephalus*		
		Ancylopus pictus asiaticus		
	Coccinellidae	*Coccinella septempunctata*		
		Harmonia axyridis		
		Harmonia yedoensis		
		Propylea japonica		
		Scymnus (*Neopullus*) *babai*		
		Scymnus ferrugatus	●	
		Scymnus (*S.*) sp.		●
	Lathridiidae	*Cortinicara gibbosa*		
		Stephostethus chinensis		
	Mordellidae	*Mordella tokejii*		
		Mordella sp.		●
	Tenebrionidae	*Gonocephalum coenosum*		
		Gonocephalum coriaceum		
		Tenebrionidae sp.		●
	Chrysomelidae	*Cassida nebulosa*		
		Cassida piperata	●	
		Longitarsus succineus		
		Psylliodes punctifrons		
	Bruchidae	*Callosobruchus chinensis*		
	Curculionidae	*Baris borkhsenii*		
		Baris orientalis		
		Ceutorhynchus albosuturalis		
		Coeliodes sp.		●
		Rhinoncus cribricollis		
		Rhinoncus jakovlevi		
		Scepticus insularis		
		Scepticus uniformis		
		Sitona lineatus		
Hymenoptera	Chalcididae**	*Brachymeria minuta**	●	
	Pteromalidae**	*Halticoptera circulus**	●	
	Eupelmidae**	*Eupelmus australiensis****	●	
	Eulophidae**	*Aprostocetus* (*A.*) sp.		●
	Braconidae	*Apanteles* sp.		●
		Cotesia sp. 1		●
		Cotesia sp. 2		●
		Deuterixys sp.		●
		Lysiphlebus sp.		●
		Braconidae sp.		●
		Homiinae sp.		●
	Ichneumonidae	*Homotropus* sp.		●
	Bethylidae	*Acrepyris minutus*		
	Formicidae	*Lasius meridionalis*		
		Monomorium floricola		
		Monomorium intrudens	●	
		Myrmecina graminicola nipponica		
		Pachycondyla chinensis	●	
		Pheidole fervida		
		Ponera japonica		
		Ponera nippona		
		Pristomyrmex pungens		
		Solenopsis japonica	●	

Table 3. Continued.

Order	Family	Scientific name	In this study	Undetermined species
Hymenoptera	Formicidae	*Strumigenys lewisi*		
		Tetramorium caespitum		
Diptera	Tipulidae	*Tipula* sp.		●
	Psychodidae	*Psychoda alternata*		
		Tinearia alternata		
	Culicidae	*Culex orientalis*		
		Ochlerotatus togoi		
	Chironomidae	*Polypedium* sp.		●
	Syrphidae	*Allograpta javana*		
		Betasyrphus serarius		
		Episyrphus balteatus	●	
		Eristalis cerealis		
		Eristalis tenax		
		Melanostoma mellinum	●	
		Metasyrphus corollae	●	
		Metasyrphus nitens		
		Sphaerophoria cylindrica		
		Sphaerophoria menthastri		
		Xanthandrus comtus		
	Phoridae	*Megaselia spirawlaris*		
	Tephritidae	*Campiglossa sada**	●	
		Campiglossa sp.		●
		Ensina sonchi		
		Trupanea convergens		
	Sepsidae	Sepsidae sp.		●
	Agromyzidae	Agromyzidae sp.		●
	Chloropidae	*Thaumatomyia notata*		
	Coleopidae**	*Coelopa frigida**	●	
	Ephydridae	Ephydridae sp.		●
	Drosophilidae	*Drosophila* sp.		●
	Scathophagidae**	*Scathophaga stercoraria**	●	
	Sphaeroceridae	Sphaeroceridae sp.		●
	Anthomyiidae	*Delia platura*	●	
		Fucellia apicalis		
		Fucellia boninensis		
		*Pegomya cunicularis**	●	
	Calliphoridae	*Calliphora nigribarbis**	●	
		Hemipyrellia ligurriens		
		*Lucilia illustris**	●	
		Phaenicia sericata	●	
		Calliphoridae sp.		●
	Sarcophagidae	*Helicophagella melanura*		
	Muscidae	*Musca bezzii*		
		Musca hervei		
Lepidoptera	Tortricidae	*Adoxophyes orana*		
		Archips oporanus		
		Cochylidia contumescens		
		Cochylidia richteriana		
		Tortrix sinapina		
	Yponomeutidae	*Plutella xylostella*		
		Yponomeuta meguronis		
	Crambidae	*Cnaphalocrocis medinalis*		
		Diaphania indica		
		Spoladea recurvalis		
		Maruca vitrata		
		Palpita nigropunctalis		
	Pyralidae	*Oncocera semirubella*		
	Geometridae	*Odontopera arida*		
		Scopula ignobilis		
	Sphingidae	*Macroglossum stellaparum*		

Table 3. Continued.

Order	Family	Scientific name	In this study	Undetermined species
Lepidoptera	Noctuidae	*Agrotis ipsilon*		
		Arcte coerula		
		Callopistria argyrosticta		
		Catocala dula		
		Cosmia achatina		
		Daddala lucilla		
		Diarsia canescens		
		Macdunnoughia confusa		
		Mythimna separata		
		Thyas juno		
	Hesperiidae	*Parnara guttata*		
	Papilionidae	*Papilio xuthus*		
	Lycaenidae	*Arhopala bazalus*		
		Pseudozizeeria maha		
	Nymphalidae	*Cynthia cardui*		
	Total 10 orders, 77 families, 164 species		27	29

*unrecorded species from Dokdo Island; **unrecorded family from Dokdo Island; ***unrecorded species from South Korea

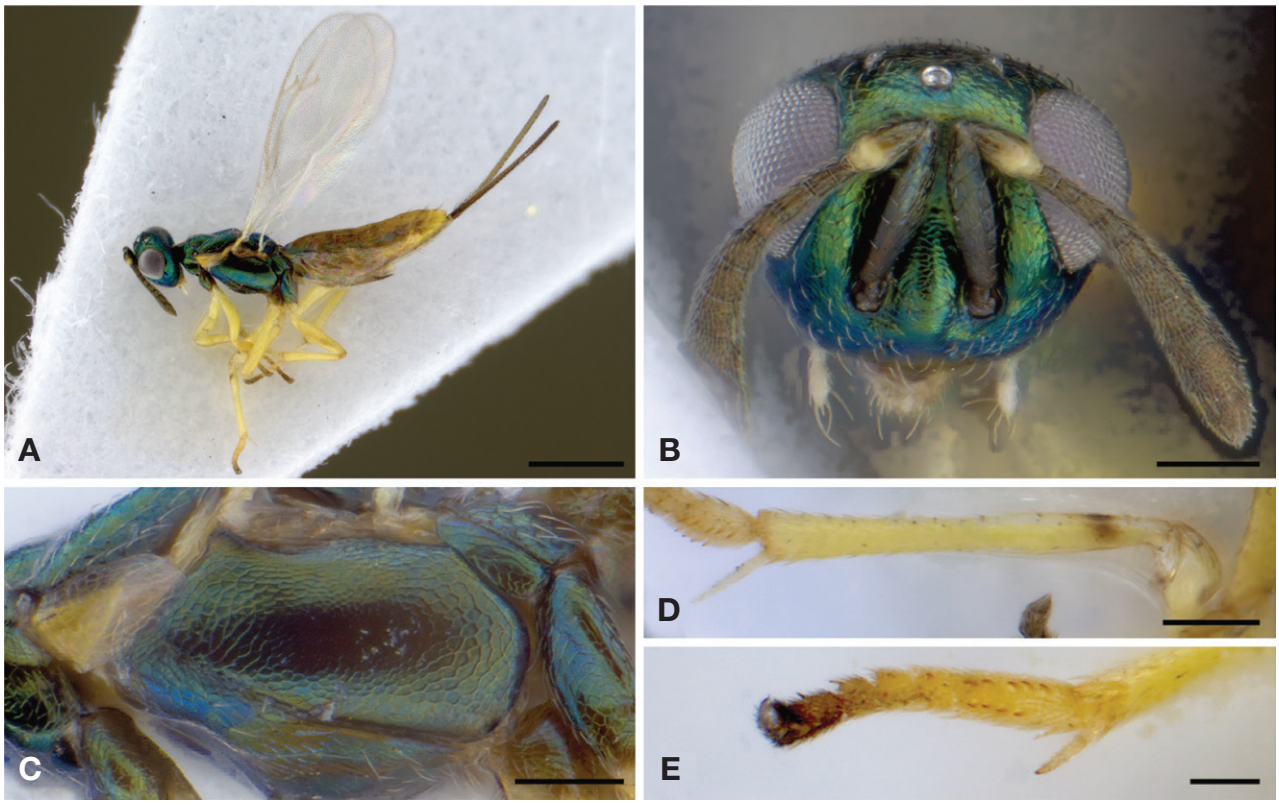


Fig. 4. *Eupelmus australiensis* (Girault), ♀. A, Habitus in lateral view; B, Head in frontal view; C, Acropleuron; D, Mesotibia; E, Mesotarsal pegs. Scale bars: A = 0.5 mm; B-D = 0.1 mm; E = 0.05 mm.

observed in West Island (Table 2). Among these, 10 species were newly recorded species from Dokdo Island. Specifically, five newly recorded species (*Psammotettix striatus*, *Eupelmus australiensis*, *Calliphora nigribarbis*, *Coelopa frigida*, and *Pegomya cunicularis*) were distributed on East Island, and eight newly recorded species (*Psammotettix striatus*, *Brachymeria minuta*, *Halticoptera circulus*, *Calliphora nigribarbis*, *Campiglossa sada*,

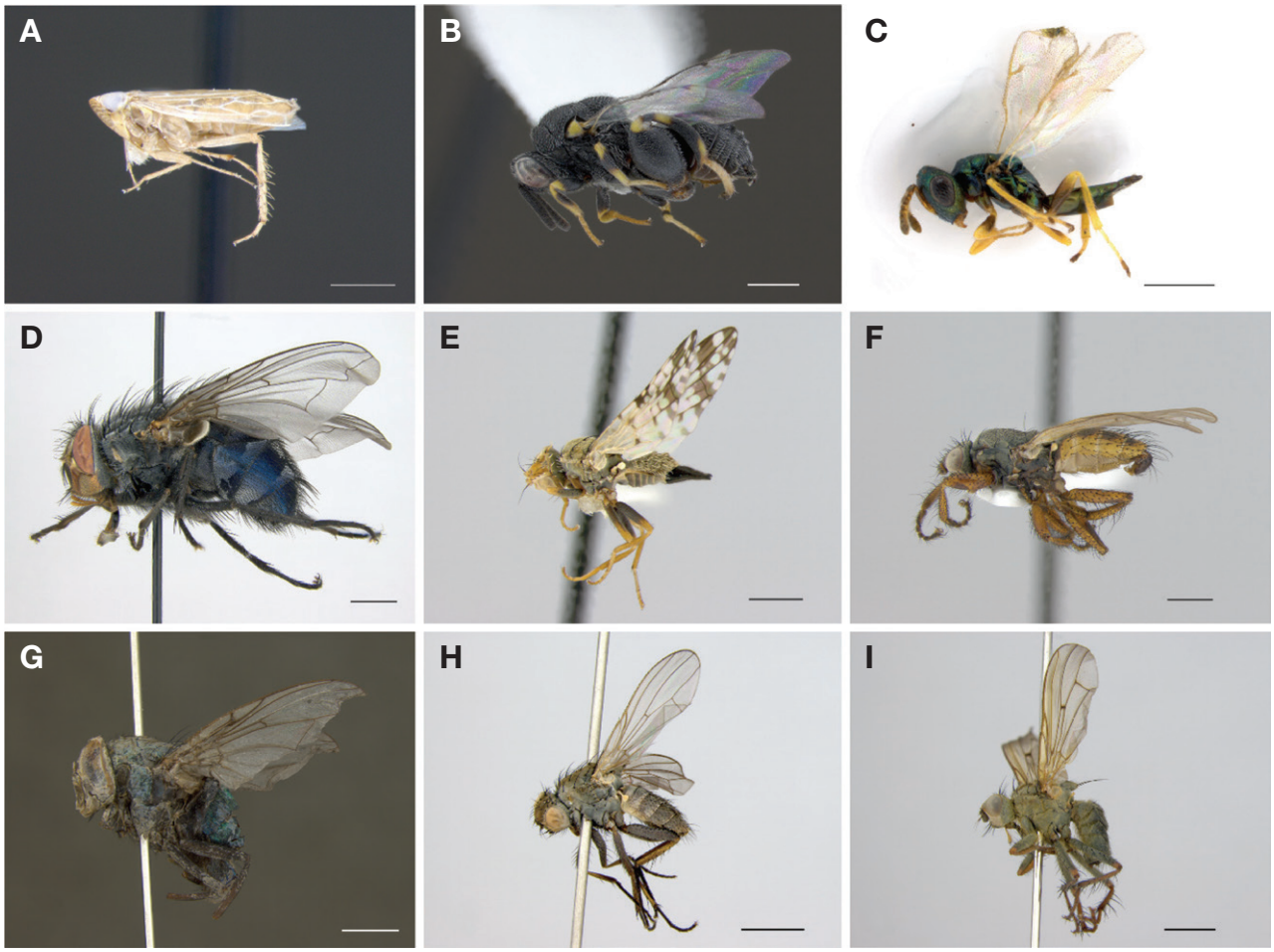


Fig. 5. Habitus of newly recorded species from Dokdo Island. A, *Psammotettix striatus* (Cicadellidae); B, *Brachymeria minuta* (Chalcididae); C, *Halticoptera circulus* (Pteromalidae); D, *Calliphora nigribarbis* (Calliphoridae); E, *Campiglossa sada* (Tephritidae); F, *Coelopa frigida* (Coleopidae); G, *Lucilia illustris* (Calliphoridae); H, *Pegomya cuniculari* (Anthomyiidae); I, *Scathophaga stercoraria* (Scathophagidae). Scale bars: D, G-I = 2.0 mm; A, B, E, F = 1.0 mm; C = 0.5 mm.

Coelopa frigida, *Lucilia illustris*, and *Scathophaga stercoraria*) were distributed on West Island.

In terms of the taxonomic groups, the species composition of each order, based on the results of monitoring in this survey, were as follows: 6 families and 11 species of Diptera (40.7%), 5 families and 6 species of Hymenoptera and Hemiptera (22.2%), respectively, 3 families and 3 species of Coleoptera (11.1%), 1 family and 1 species of Odonata (3.7%) were identified (Fig. 3).

Discussion

Prior to the this survey, 11 orders, 70 families and 154 species (and 28 undetermined species) of insects had been recorded on Dokdo Island, of which the order Collembola and 28 undetermined species are excluded from the list (Park and Jang, 2016). The reason for the decrease in the number of orders in this study, compared to the results of previous surveys, is that the order Homoptera was previously classified as the suborder Homoptera, a subtaxon of the order Hemiptera in accordance with the National List of Species of Korea, Insect (Hemiptera II) published by the National Institute of Biological Resources (NIBR). In addition, in the case of five species of the family Pyralidae (all except *Oncocera semirubella*), the classification system was redefined as the "family Crambidae" in this report in accordance with the National List of Species of Korea, Insect (Lepidoptera I) published in 2012.

Species have been continuously added to the fauna of Dokdo Island through annual surveys, and a small number of species are identified each year: eight species by Choi *et al.* (2015); three species by Park and Jang (2016); ten species by the present survey. Therefore, we suggest that more species can be recorded by conducting long-

term and continuous monitoring. However, 15% of the 193 species (including 29 undetermined species) of insects investigated to date are identified only to the family or genus levels and there are numerous unidentified specimens in our collection (YNU). Considering these problems, if accurate identification of species of relevant taxa can be conducted by specialists, it will be possible to analyze and record unidentified species and produce a more accurate list of species of insect fauna on Dokdo Island.

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