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A Wild Bee Survey in Kiritappu Highmoor, Eastern Hokkaido[1,2,3]

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Abstract Results of a wild bee survey made in Kiritappu highmoor, Kushiro Province, are reported. The total sample, periodically collected from May to October spending 115 hrs, consists of 24 species and 848 individuals. Compared with previous surveys in other localities of Hokkaido, the faunal makeup is unusually poor and simple both in terms of species and individuals and remarkably skewed by the predominance of bumblebees, which occupy 71.5% of total individuals. This poor and skewed assemblage structure is probably conditioned both geographically and ecologically, particularly by unfavorable weather conditions during bee seasons and edaphic conditions unsuitable for nesting of bees. Some bionomic notes on bumblebees are briefly added to.

Introduction

The southeastern part of Hokkaido, comprising Kushiro and Nemuro Provinces, is climatically one of the severest areas through the lowlands of Japan by its rigorous winter and foggy spring and summer. Apparently this should affect the distribution and abundance of various insect groups seriously. Many casual records suggest the faunal impoverishment in these areas, but few systematic comparisons have been hitherto attempted. As the 11th report of our serial work "Wild bee biofaunistics and biocoenotics in Hokkaido", the present paper deals with some results of a wild bee survey made at Kiritappu highmoor (43°15′N, 145°07′E) during the bee seasons in 1972 to fulfil the lack of information on the bee fauna of eastern Hokkaido.

The area was also chosen by two other reasons. The highmoor is one of the most unfavorable habitats for bees. The faunal makeup should be quite different there from other types of lowland vegetations Further, Kiritappu highmoor is one of few places in the lowlands of Hokkaido, where

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the primary vegetation still persists without infestation by exotic weeds. This may elucidate some primary bee-flower relations not disturbed by human impacts.

Among the results obtained, this paper concerns the faunal makeup alone, with some bionomic notes on bumblebees, the predominant bee group inhabiting the area.

Area Surveyed and Methods

Two stations, S_1 and S_2 each 1 km sq., were chosen for sampling. S_1: Low and even highmoor mainly covered with grasses and *Sphagnum*. Other predominant plants are *Empetrum nigrum* L. var. *japonicum* K. Koch, *Maianthemum dilatatum* (Wood) Nels. et Macbr., *Sanguisorba tenuifolia* Fisch. var. *parviflora* Maxim. f. *alba* (Trautv. et Mey.) Kitam., *Adenophora triphylla* (Thunb.) A. DC. ssp. *aperticampanulata* Kitam., *Iris setosa* Pall., *Lobelia sessilifolia* Lamb., *Hosta rectifolia* Nakai, *Solidago japonica* Kitam. *Ligularia hodgsoni* Hook., f., *Gentiana trifolia* Pall. S_2: Small tableland peninsula 40 m above sea-level, with soil less humid than in S_2. Vegetation does not essentially differ from S_1, but *Sasa arthitricha* Koidz. is abundant. Other abundant plants not seen in S_1 are *Ligusticum scoticum* L., *Vicia cracca* L. and *Aruncus diocicus* (Walter) Fernald var. *tenifolius* Hara.

The meteorological conditions of Kiritappu are not obtainable. Some meteorological features in Kushiro, 60 km W of Kiritappu, are given in Table 3, and daytime air temperature at the survey (mean of figures obtained at 9 : 30, 12 : 00, 14 : 30) in Fig. 2.

The survey was carried out from May to October, 1972, once in May and October, thrice in August and six times in June, July, September, each time five hours mostly from 9 : 30 to 14 : 30. The method essentially follows that adopted by our serial work (5, 6, 8), i. e., any wild bees discovered on any kinds of flowers were captured without choice. The captured bees were separately sorted according to the flower species visited. Further details on the procedures are consulted in the papers cited.

Results and Discussion

Faunal makeup

The species collected by the survey are listed below, together with the number of individuals captured (given as total = females + males, or, in bumblebees, t = queens + workers + males). The species, the scientific names of which are not settled yet, are shown with Arabic numerals for each genus, or, each subgenus in the halictine bees.

COLLETIDAE

1. *Hylaeus* sp. 7. 2 = 0 + 2.

HALICTIDAE

2. *Halictus* (*Seladonia*) *tumulorum higashi* Sakagami et Ebmer 5=5+0.
3. *Lasioglossum* (*Lasioglossum*) *scitulum* (Smith). 4=2+2.
4. *Lg.* ("*Dialictus*") *problematicum* (Blüthgen). 51=48+3.
5. *Lg.* (carinate *Evylaeus*) *albipes* (Fabricius). 113=110+3.
6. *Lg.* (ct. *E.*) *calceatum* (Scopoli). 6=6+0.
7. *Lg.* (ct. *E.*) *baleicum* (Cockerell). 2=2+0.
8. *Lg.* (ct. *E.*) sp. 2. 6=6+0.
9. *Lg.* (carinaless *Evylaeus*) *kiautschouense* (Strand). 17=17+0.
10. *Lg.* (cl. *E.*) sp. 4. 8=8+0.
11. *Lg.* (cl. *E.*) sp. 16. 3=3+0.
12. *Lg.* (cl. *E.*) sp. 17. 1=1+0.

ANDRENIDAE

13. *Andrena* (*Micrandrena*) *komachi* Hirashima. 11=9+2.
14. *Ad.* (*Taeniandrena*) *ezoensis* Hirashima. 7=1+6.
15. *Ad.* (*Oreomelissa*) *coitana pilosodorsata* Alfken. 5=5+0.

MEGACHILIDAE

16. *Megachile ligniseca* Kirby. 1=1+0.

ANTHOPHORIDAE

17. *Clisodon* sp. 1. 1=0+1.

APIDAE

18. *Bombus* (*Bombus*) *hypocrita sapporensis* Pérez. 91=1+67+23.
19. *Bo.* (*Pyrobombus*) *beaticola moshkarareppus* Sakagami et Ishikawa. 60=5+16+39.
20. *Bo.* (*Thoracobombus*) *schrencki albidopleuralis* Skorikov. 8=3+1+4.
21. *Bo.* (*Th.*) *pseudobaicalensis* Vogt. 324=11+112+201.
22. *Bo.* (*Th.*) *deuteronymus deuteronymus* Schulz. 60=0+15+35.
23s *Bo.* (*Diversobombus*) *diversus tersatus* Smith. 3=0+3+0.
24. *Bo.* (*Megabombus*) *yezoensis* Matsumura. 59=11+28+20.

The results are compared with those taken from some other localities, Sapporo-Hokkaido University Campus (=UC, 5), Sapporo, Mt. Moiwa (6), Obihiro (10), Hama Koshimizu (1) with respect to the number of species collected (Table 1), the relative abundance of genera and families in terms of the number of individuals collected (Fig. 1) and the composition of ten predominant species (Table 2).

Despite the time spent for collection is highest, the number of collected species and that per effort (=hr) are the poorest in Kiritappu among the localities compared. This poverity is seen in most genera, except bumblebees (*Bombus*). The abundance order among various families (abbreviations in Fig. 1) in five localities are:

Table 1. Number of wild bee species collected in Kiritappu

Family	Genus	Sapporo, UC		Sapporo, Moiwa	
					No.
Colletidae		7	(9.1)	6	(8.3)
	Hylaeus	6	(7.8)	5	(6.9)
	Colletes	1	(1.3)	1	(1.4)
Halictidae		36	(46.7)	37	(51.4)
	Halictus	2	(2.6)	2	(2.8)
	Lasioglossum	29	(37.6)	28	(38.9)
	Sphecodes	5	(6.5)	7	(9.7)
Andrenidae	*Andrena*	12	(15.6)	11	(15.3)
Megachilidae		5	(6.5)	5	(6.9)
	Megachile	3	(3.9)	5	(6.9)
	Osmia	—	(—)	—	(—)
	Coelioxys	2	(2.6)	—	(—)
Melittidae		—	(—)	—	(—)
	Melitta	—	(—)	—	(—)
	Macropis	—	(—)	—	(—)
Anthophoridae		12	(15.6)	8	(11.2)
	Nomada	8	(10.4)	4	(5.6)
	Clisodon	1	(1.3)	—	(—)
	Eucera	1	(1.3)	1	(1.4)
	Ceratina	2	(2.6)	3	(4.2)
Apidae	*Bombus*	5	(6.5)	5	(6.9)
Total No. of species		77		72	
Total No of individuals		3,099		2,196	
Total time spent (hrs)		81		71	
No. species/hr		0.95		1.04	
No. individuals/hr		38.26		30.92	
Location		N 43°03′ E 141°20′			
Habitat		Secondary openland with some deciduous broad-leaved trees		Secondary openland along primary deciduous broad-leaved forest	

Sapporo-UC	HA≫AD=AT>CO>MG=AP>(ML)
Sapporo-Moiwa	HA≫AD>AT>CO>MG=AP>(ML)
Obihiro	HA≫AD>AT>MG>CO=AP>ML
Hama Koshimizu	HA≫AD>CO>AT>AP>MG>ML
Kiritappu	HA≫AP>AD>AT=CO=MG>(ML)

The basic assemblage structures such as the overwhelming dominance of Halictidae are more or less similar among five localities, but the deviation is largest in Kiritappu where Apidae replace Andrenidae, the second-ranked group in all other localities.

This predominance of Apidae (*Bombus*) is more conspicuous when the results are compared in terms of individual number. As seen in Fig. 1

and other four areas given at familial and generic levels

species (%)								
Obihiro			Hama Koshimizu			Kiritappu		
5		(5.7)	8		(14.5)	1		(4.2)
	4	(4.6)		6	(10.9)		1	(4.2)
	1	(1.1)		2	(3.6)		—	(—)
38		(43.1)	24		(43.7)	11		(45.7)
	3	(4.4)		1	(1.8)		1	(4.2)
	27	(30.6)		20	(37.4)		10	(41.5)
	8	(9.1)		3	(5.5)		—	(—)
16		(18.2)	10		(18.2)	3		(12.5)
10		(11.4)	3		(5.5)	1		(4.2)
	6	(6.8)		2	(3.6)		1	(4.2)
	—	(—)		—	(—)		—	(—)
	4	(4.6)		2	(1.8)		—	(—)
3		(3.4)	1		(1.8)	—		(—)
	2	(2.3)		—	(—)		—	(—)
	1	(1.1)		1	(1.8)		—	(—)
11		(12.5)	4		(7.3)	1		(4.2)
	7	(8.0)		1	(1.8)		1	(4.2)
	2	(2.3)		1	(1.8)		—	(—)
	1	(1.1)		1	(1.8)		—	(—)
	1	(1.1)		1	(1.8)		—	(—)
5		(5.7)	5		(9.1)	7		(29.2)
88			55			24		
2,230			1,045			848		
104			56.5			115		
0.85			0.97			0.21		
21.44			18.49			7.31		
N 42°55′ E 143°13′			N 43°51′ E 144°58′			N 43°15′ E 145°07′		
=Sapporo-UC			Primary coastal dune with admixture of secondary weeds			Primary highmoor		

the percentage ratio occupied by bumblebees attains 71.5% whereas only 5.8% in Sapporo-UC, 20.6% in Sapporo-Moiwa, 27.8% in Obihiro and 15.5% in Hama Koshimizu. In compensation all other groups are much scarcer except Halictidae which occupy 25.4%, against 58.7% in Sapporo-UC, 23.8% in Sapporo-Moiwa, 20.1% in Obihiro and 59.9% in Hama Koshimizu. The combined percentage ratio of the other groups is 35.5, 55.6, 52.1, 24.6%, in Sapporo-UC, Sapporo-Moiwa, Obihiro and Hama Koshimizu but only 3.1% in Kiritappu.

The composition of predominant species (Table 3) also reflects a simple and skewed assemblage structure. The simplicity is shown by the cumulative percentage ratio of five top species, which attains nearly 74%, whereas in

Table 2. Relative abundance of ten predominant species in Kiritappu and other four localities in terms of the individuals collected (percentage in parentheses)
Abbreviations of generic names: *Hy*=*Hylaeus*, *Co*=*Colletes*, *Ha*=*Halictus*, *Eu*=*Eucera*, *Ct*=*Ceratina*, others given in afore-mentioned list. Subspecific names in *Bombus* omitted

Sapporo-UC	Sapporo-Moiwa	Obihiro	Hama Koshimizu	Kiritappu
Lg. (ct. *Ev.*) *duplex* 446 (14.8)	*Ct. japonica* 625 (28.5)	*Ct. flavipes* 365 (16.4)	*Lg.* (ct. *Ev.*) *albipes* 154 (14.7)	*Bo. pseudobaicalensis* 324 (38.2)
Lg. (*Lg.*) *occidens* 295 (8.4)	*Bo. deuteronymus* 300 (13.7)	*Bo. deuteronymus* 299 (13.4)	*Lg.* (cl. *Ev.*) sp. 22 99 (9.4)	*Lg.* (ct. *Ev.*) *albipes* 113 (14.1)
Ha. tumulorum 239 (7.7)	*Ad. brassicae* 243 (11.1)	*Ad. ezoensis* 190 (8.5)	*Lg.* ("*D.*") *problematicum* 84 (8.0)	*Bo. hypocrita* 91 (10.7)
Ct. japonica 212 (6.8)	*Ct. flavipes* 109 (5.0)	*Eu. sociabilis* 126 (5.5)	*Lg.* (cl. *Ev.*) sp. 18 79 (7.5)	*Bo. deuteronymus* 60 (7.1)
Ad. ezoensis 173 (5.6)	*Bo. diversus* 100 (4.6)	*Bo. schrencki* 119 (5.3)	*Bo. hypocrita* 63 (6.0)	*Bo. beaticola* 60 (7.1)
Ad. valeriana 140 (4.5)	*Lg.* (ct. *Ev.*) sp. 2 90 (4.1)	*Ad. komachi* 87 (3.9)	*Bo. deuteronymus* 48 (4.5)	*Bo. yezoensis* 59 (7.0)
Ha. tsingtouensis 135 (4.4)	*Lg.* (*Lg.*) *exiliceps* 53 (2.4)	*Ad. valeriana* 85 (3.8)	*Bo. pseudobaicalensis* 48 (4.5)	*Lg.* ("*D.*") *problematicum* 51 (6.0)
Lg. ("*D.*") *problematicum* 105 (3.4)	*Hy. paulus* 52 (2.4)	*Ha. tumulorum* 43 (1.9)	*Lg.* (cl. *Ev.*) *ohei* 46 (4.4)	*Lg.* (cl. *Ev.*) *kiautshouense* 17 (2.0)
Bo. hypocrita 105 (3.4)	*Ad. stellaria* 51 (2.3)	*Lg.* (*Lg.*) *esonse* 43 (1.9)	*Lg.* (cl. *Ev.*) sp. 16 41 (3.9)	*Ad. komachi* 11 (1.3)
Ct. flavipes 81 (2.6)	*Bo. pseudobaicalensis* 46 (2.1)	*Lg.* (ct. *Ev.*) sp. 2 40 (1.8)	*Co.* sp. 2 36 (3.4)	*Bo. schrencki* 8 (0.9)
Cumulative %				
Five top species 43.3	62.9	49.1	45.6	73.4
Ten species 61.6	73.8	62,4	66.3	88.0
Total no. individuals 3,099	2,196	2,230	1,045	848

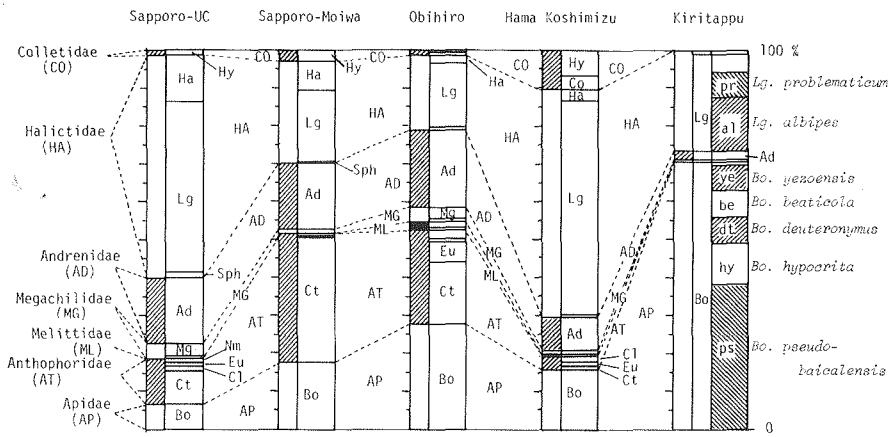

Fig. 1. The percentage abundance of bee families and genera in Kiritappu and other four localities in terms of the number of individuals collected. Predominant genera are mentioned with abbreviations given in the list of species and Table 2. Predominant species are also mentioned for Kiritappu.

Table 3. Some meteorological features in four localities concerned based upon the records compiled by Sapporo Regional Meteorological Observatory (1970)

Locality	Sapporo	Obihiro	Abashiri	Kushiro
1	N 43°03′ E 141°20′	N 42°55′ E 143°13′	N 44°01′ E 144°17′	N 42°59′ E 144°24′
2	21.7°C	20.0°C	19.0°C	17.9°C
3	26.7°C	25.2°C	22.8°C	21.6°C
4	67.8°C	59.0°C	53.7°C	46.9°C
5	66.4°C	67.0°C	61.1°C	55.4°C
6	14.0	41.7	23.0	80.8
7	490.1 mm	246.3 mm	278.2 mm	291.2 mm
8	17.8	28.7	32.5	41.3
9	−5.1°C	−9.0°C	−7.1°C	−6.6°C
10	−9.5°C	−16.2°C	−11.2°C	−13.0°C
11	−12.3°C	−24.4°C	−19.6°C	−23.6°C

1. Location; 2, 3. Mean monthly air temperatures of the hottest month (August, mean and mean maximum); 4. Warmth index. $\Sigma(t_i-5)$, t_i=mean monthly air temperature of month $i(t>5)$; 5. Cumulative soil temperature during bee season. $\Sigma(t_i-5)$. i=May~September; 6. Number of foggy days during May~September; 7. Winter precipitation during November~March; 8. Number of days with snow depth less than 10 cm during November~March; 9, 10. Mean monthly air temperatures of the coldest month (February in Abashiri, January in others; mean and mean minimum); 11. Coldness index, sum of mean monthly air temperatures below 0°C

all other localities remains more or less at 50%. The skewness is recognized by the fact that four out of five top ranks are occupied by bumblebees, a composition rarely expected elsewhere in the lowlands of Japan. It must also be mentioned that three non bumblebee dominants, *Lg. albipes, Lg. problematicum* and *Lg. kiautshouense* are all typical northern elements. Finally, the number of individuals collected per effort (=hr) is lowest in Kiritappu (Table 1). This index is affected by various factors other than actual population size. But the remarkably low value in Kiritappu must reflect a poor carrying capacity there.

The poor and skewed assemblage structure in Kiritappu should be conditioned both geographically and ecologically. Some meteorological features in the four compared localities are given in Table 4 (The figures in Hama Koshimizu and Kiritappu respectively represented by those in Abashiri and Kushiro). A glance at the table we perceive the severe winter and cooler bee season in Eastern Hokkaido than in Sapporo. Among three eastern localities the winter severity is Obihiro>Abashiri>Kushiro (items 7~9), or O>K>A (10, 11), but the severity in Obihiro is compensated by more favorable summer conditions (items 2~5). On the other hand, the summer in Kushiro is very cool, particularly characterized by frequent foggy days (item 6). Evidently this should seriously affect the activities of wild bees, allowing the persistence of only the groups which are relatively cold resistant and capable of foraging under adverse weather. The bumblebees indubitably represent such group (2). Some predominant halictine bees of northern origin might also belong to this type. Another interesting case is the genus *Ceratina*, two species of which, *Ct. japonica* and *Ct. flavipes*, are very abun-

Table 4. Specific difference of flower visits in five bumblebee species given by the percentage individual number captured on flowers. *Bombus* species are arranged in the descending order of tongue length

Plant family	Compositae	Campanulaceae	Geraniaceae	Leguminosae	Labiatae	Gentianace	Minor families	Total No. individuals
Bombus species								
yezoensis	15.5	—	6.7	20.0	11.1	40.0	6.7	45
pseudobaicalensis	43.8	33.4	2.0	5.1	0.8	14.5	1.4	242
deuteronymus	61.7	12.8	8.5	2.1	2.1	8.5	4.3	47
beaticola	75.5	2.2	6.7	4.5	2.2	2.2	6.7	45
hypocrita	72.0	25.8	—	—	—	—	2.2	98
Total No. individuals	243	112	15	22	9	58	13	472
No. flower species	7[1]	2[2]	1[3]	5	5	2[4]	8	30

[1] 98 bees on *Ligularia hodgsoni* Hook f., 118 on *Solidago japonica* Kitam.
[2] 110 bees on *Adenophora triphylla* (Thunb.) A. DC. ssp. *aperticampanulata* Kitam.
[3] *Genranium erianthum* DC.
[4] 54 bees on *Gentiana trifolia* Pall.

dant in W. Hokkaido, and the latter species is the top-ranked species in Obihiro (Table 3). But the geuns is completely absent in Kiritappu and so far not collected in Kushiro Province (unpub.). These bees hibernate in hollow dead stems of plants (9) so that confront the severe cold rarely experienced by most bees which hibernate in soil. The fact that *C. flavipes* withstands the severe winter in Obihiro but does not found in Kushiro Province suggests the adverse influence of summer weather conditions.

However, the faunal poverity in Kiritappu should be affected also by local ecological conditions, particularly by humid edaphic nature of highmoor. At present, geographical and ecological influences cannot be separated clearly. But by the surveys carried out in and near Kushiro at non moor habitats, we have obtained more species than in Kiritappu (unpub.). This problem will be solved by performance of further surveys at different habitats in Kushiro Province.

Some bionomic notes on bumblebees

As given above the bumblebees occupied about 70% of the total bee individuals collected. Some biological notes on this group are briefly added to.

The seasonal abundance of five predominant species (Fig. 2) shows a gradual increase in late August, and attainment to the peak in September

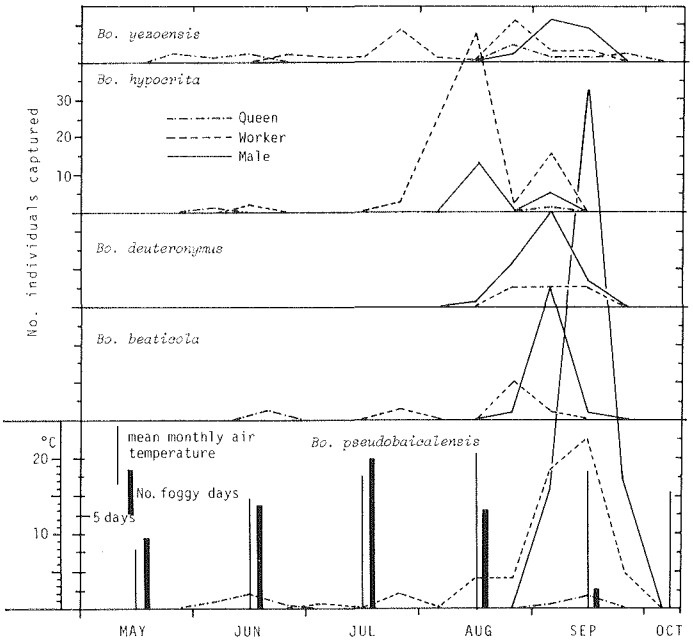

Fig. 2. Seasonal trend of extranidal activity of bumblebees in Kiritappu

Air temperature: Monthly mean of measurements at 9:30, 12:00, 14:30 made at survey

followed by a rapid decline. Comparing the result with those obtained in Sapporo (5) and Obihiro (10) shift of the peak to the end of the season is recognized in Kiritappu. Probably the colony development is more retarded than in other areas. This also reflects the climatic peculiarity of the area, as the population trend corresponds to the decrease of foggy days (recorded in Kushiro, compiled by Sapporo Meteorological Observatory, 1970) from the late summer to the fall. Among five species *Bo. yezoensis* is characterized by a relatively even trend of the seasonal shift. It is unknown whether this is typical to the species or not, as no comparative data are available for this species being relatively rare elsewhere. The peak of *Bo. hypocrita* is earlier than in other species. This tendency is traced also in Sapporo (5) and in Honshu (3, 7) in relation to *Bo. diversus*, the species being rare in Kiritappu. The appearance of *Bo. beaticola*, the typical mountainous or alpine species in other areas of Japan, is later than in other species, but it attains the climax at early September as in most other species, never exhibiting a short colony life characteristic to another consubgeneric species, *Bo. ardens* (7).

Table 5 depicts the flower choice of five predominant species at family level of flowering plants given by the percentage individual number for each species. (females and males combined). The species are arranged in the descending order of tongue length, i. e., *yezoensis*$\gg$*pseudobaicalensis*$\geq$*deuteronymus*$>$*beaticola*$>$*hypocrita*.

Evidently the composite flowers are the top-ranked food sources. But their importance decreases in parallel with the increase of tongue length, not frequently visited by *Bo. yezoensis*. Two extreme species, *Bo. yezoensis* and *Bo. hypocrita*, behave oppositely as for the flower choice, showing a segregation in resource utilization (2). It must also be mentioned that only 16 out of 427 individuals (=3.3%) were captured on the exotic weeds (6 on *Trifolium repens* L., 8 on *T. pratense* L., and 2 on *Solidago gigantea* Ait. var. *leiophylla* Fern). This low ratio is rarely expected in the most parts of lowlands in Hokkaido, suggesting a highly primary nature of vegetation in the area surveyed. The corresponding ratio is 13.2% in Sapporo-Moiwa (6), 32.0% in Hama Koshimizu (1), 36.7% in Obihiro (10), and attaining even 71.8% in Sapporo-UC (5).

During the survey five nests of *B. pseudobaicalensis* (all on the ground surface) and three of *B. yezoensis* (all underground) were discovered.

Leaving detailed accounts elsewhere, some evidence of intra- and interspecific drifting are recorded here: 1) In two *pseudobaicalensis* nests, each contained beside the living queen one corpse of dead queen=Successful or unsuccessful intraspecific ursurpation; 2) One *yezoensis* worker in a queenright *pseudobaicalensis* colony=Interspecific drifting; 3) One *yezoensis* colony headed by a *pseudobaicalensis* queen without the proper queen=Sucessful intersubgeneric usurpation, being rarer than consubgeneric cases (4).

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