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A Wild Bee Survey in Kibi (Wakayama Pref.), Southern Japan

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(*With 3 Text-figures and 4 Tables*)

The present paper deals with the result of a wild bee survey made in Kibi, Wakayama Prefecture, Southern Japan, during the bee season in 1969, in order to obtain some basic information upon the faunal makeup, phenology and flower visits. Through similar surveys being continued by two of us (S.F.S. and H.F.) in Hokkaido, Northern Japan, it has been recognized that the faunal makeup of wild bees can vary considerably even between two localities situated not much remote for each other, and the relative abundance of various groups measured by periodical sampling on flowers is affected by habitat conditions, especially by local floristic composition. Thus the result given below cannot be regarded as representing the real picture of the local bee fauna. But it could be useful as a preliminary bridge-head for further studies, in the virtual lack of wild bee surveys in Southern Japan.

Before going further, we would like to express our sincere thanks to Prof. Yoshihiro Hirashima, Kyushu University, Fukuoka, for the identification of some megachilid bees collected in the survey.

Methods

1. *Area surveyed*: Kibi is a small town along the River Arita, situated ca. 20 km south of Wakayama City, about 50～100 m above the sea level. The average climatic conditions are: Mean air temperature 15.5°C, the hottest month August (mean 27.2°C, mean maximum 31.6°C) and the coldest month January (mean 4.5°C, mean minimum 0.4°C), mean annual rainfall 1,733.8 mm, being most abundant in June (264.0) and July (231.3). Until recently the area had been covered with secondary mixed forests mainly consisting of pines, deciduous oaks, cherries, etc., with some remnants of the primary lucidophylous forest, *Shiia*, *Camelia*, etc. In recent years the forests are rapidly diminishing, replaced by rural or suburb areas. The collecting area is divided into three subareas. A. Citrus

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plantation, including reforestation of pines mixed with *Pseudacacia*. The soil is eroded, being rich in pebbles and gravels. Except for the bloom of citrus trees in mid May, poor in flowers as well as wild bees. B. Secondary forests mentioned above. Most trees are more than 10 m high. The undergrowth is dominated by ferns. Both bees and entomophilous plants are poor, though some shrubs and herbs, *Lonicera, Deutzia, Rubus, Adenophora,* etc. are sparsely found along forest roads. C. Rural zone. Flowers are richer than in A and B, especially in spring, by the bloom of some cultivated plants such as *Astragalus* and Cruciferae, with some weeds, *Cardamine, Ranunculus,* etc. After July, however, most weeds are artificially removed except for some ones on banks, *Ampelopsis, Indigofera,* etc. Bees are not abundant though relatively richer than in A and B.

Generally speaking, the area is poor both in bees and entomophilous plants and their phenologies show a distinct concentration on spring. Except for some observations on the visits to citrus flowers (Matsuura and Hatta 1973) and plums (Matsuura 1973), no intensive survey on bee-flower relations has bee carried out in the area.

2. *Sampling procedure*: Sampling was made three times per month, each time usually 3∼4 hrs, throughout the local bee season as follows:

Codes	Sampling dates (hrs)	Codes	Sampling dates (hrs)
III	March 29 (4)	VIII_1	August 9 (4)
IV_1	April 6 (4)	VIII_2	〃 20 (4)
IV_2	〃 12 (4)	VIII_3	〃 31 (4)
IV_3	〃 20 (4)	IX_1	Sept. 4 (4)
V_1	May 3 (4)	IX_2	〃 11 (4)
V_2	〃 18 (3)	IX_3	〃 29 (4)
V_3	〃 26 (4)	X_1	Oct. 3 (4)
VI_1	June 1 (3)	X_2	〃 12 (4)
VI_2	〃 15 (3)	X_3	〃 31 (4)
VI_3	〃 22 (3)	XI_1	Nov. 8∼9(4)
VII_1	July 6 (4)	XI_2	〃 18∼19(4)
VII_2	〃 13 (4)	XI_3	〃 30 (1)
VII_3	〃 24 (4)		

The sampling was executed mostly from 10:00 to 14:00, occasionally from 8:30 and to 16:00, taking a course A→B→C→A. At each sampling time any wild bees discovered on any kinds of flowers were captured without particular choice. The captured individuals were separately preserved according to the flower species visited. Further details on the procedure and possible sources of sampling biases were described and discussed in Sakagami, Laroca and Moure (1967) and Sakagami and Fukuda (1973).

Results and discussions

1. *Faunal makeup*: A list of the species collected is given below, together with the number of individuals sampled, total as well as each period separately. Abbreviations of generic names are mostly those used in Sakagami and Fukuda (1973). The species not accurately determined are shown with Arabic numerals, which correspond to those in the paper cited above (Sakagami and Fukuda 1973), except for, *Nomada* sp. A and *Coelioxys* sp. A. The asterisked species are those not reaching northward Sapporo, Northern Japan.

During the survey the queens of bumblebees and all individuals of *Xylocopa* were liberated after captured and registered, in order to avoid the decline of their populations in the area, though this may add a source of bias to the results. The honeybees were not sampled. The Japanese honeybee, *Apis cerana cerana* Fabricius occurs in and near the area but seldom observed during the survey. The European honeybee, *A. mellifera* Linné outnumbered the wild bees in April to May, visiting *Astragalus*, *Taraxacum*, *Brassica rapa*, *B. pekinensis*, *Pyrus* and *Citrus hassaku*. Thereafter it practically disappeared because most hives were managed by migratory apiculture predominantly adopted in Southern Japan.

COLLETIDAE

1. *Colletes* sp. 1. 1♀. IX_2.
2. *Hylaeus* sp. 7. 1♀. V_3.

HALICTIDAE

*3. *Halictus* (*Seladonia*) *aerarius* (Smith). 190♀ 10♂. VI_1 8♀, VI_3 15♀, VII_1 39♀, VII_2 29♀ 3♂, VII_3 8♀ 4♂, VIII_1 36♀, VIII_2 11♀ 2♂, VIII_3 21♀, IX_1 8♀, IX_2 15♀ 1♂.
4. *Lasioglossum* (*Lasioglossum*) *occidens* (Smith). 1♀ 1♂. VI_2 1♀, IX_2 1♂.
5. *Lg.* (*Lg.*) *mutilum* (Vachal). 7♀. V_1 1, V_2 1, VI_2 2, VII_3 3.
6. *Lg.* (*Lg.*) *scitulum* (Smith). 7♀ 2♂. V_1 1♀, VII_1 5♀ 2♂, IX_2 1♀.
7. *Lg.* (*Lg.*) sp. 1. 1♀. IV_3.
8. *Lg.* (*Evylaeus*, carinate=*Et.*) *trispine* (Vachal). 5♀. IV_1 1, VII_3 4.
9. *Lg.* (*Et.*) *apristum* (Vachal). 20♀. III 1, IV_1 13, IV_2 5, VI_1 1.
10. *Lg.* (*Et.*) sp. 1. 2♀. IV_1 1, V_2 1.
11. *Lg.* (*Et.*) sp. 2. 102♀. III 14, IV_1 57, IV_2 18, IV_3 11, V_2 2.
12. *Lg.* (*Evylaeus*, carinaless=*El.*) sp. 8. 5♀. VII_1 2, VIII_3 3.
13. *Lg.* (*El.*) sp. 10. 6♀. V_1 2, V_2 1, V_3 2, X_1 1.
14. *Lg.* (*El.*) sp. 18. 4♀. IV_2 1, V_3 2, VII_3 1.
15. *Sphecodes scabricollis* Wesmael ssp. 1♂. X_3.

ANDRENIDAE

*16. *Panurginus crawfordi* Cockerell. 149♀ 83♂. IV_2 54♀ 62♂, IV_3 90♀ 18♂, V_1 5♀ 3♂.
*17. *Andrena* (*Andrena*) *longitibialis* Hirashima. 2♀. V_1 1, V_2 1.
*18. *Ad.* (*Calomelissa*) *prostomias* Pérez. 3♀ 2♂. IV_1.
*19. *Ad.* (*C.*) *tsukubana* Hirashima. 43♀ 6♂. V_3 13♀ 3♂, VI_1 30♀ 3♂.
20. *Ad.* (*Chrysandrena*) *knuthi* Alfken. 1♀ 4♂. IV_2 1♂, IV_3 1♀ 2♂, V_1 1♂.
*21. *Ad.* (*Gymnandrena*) *parathoracica* Hirashima. 1♀. V_3.
22. *Ad.* (*G.*) *watasei* Cockerell. 5♂. V_2.
23. *Ad.* (*Hoplandrena*) *dentata* Smith. 1♂. IV_3.
24. *Ad.* (*Simandrena*) *opacifovea* Hirashima. 5♀ 42♂. IV_1 1♂, IV_2 2♀ 25♂, IV_3 16♂, V_3 3♀.
25. *Ad.* (*Micrandrena*) *kaguya* Hirashima. 7♀ 1♂. IV_2 3♀, IV_3 1♀, V_1 1♀, V_2 2♀ 1♂.

MEGACHILIDAE

*26. *Chalicodoma* (*Chelostomoda*) *spissula* (Cockerell). 1♀ 5♂. VII_3 5♂, IX_2 1♀.

27. *Megachile nipponica* Cockerell. 7♀ 3♂. IV_3 1♂, VI_2 1♀, VII_1 1♂, VII_2 1♂, IX_1 1♀, IX_2 1♀, IX_3 2♀, X_1 1♀, X_3 1♀.
28. *Mg. tsurugensis* Cockerell. 1♀ 4♂. VI_2 1♂, IX_1 2♂, IX_3 1♀ 1♂.
29. *Mg. japonica* Alfken. 3♂. V_1.
30. *Mg. humilis* Smith. 9♂. IX_1 5, IX_2 4.
31. *Mg. remota sakagamii* Hirashima et Maeta. 4♀ 1♂. VII_3 1♀, IX_1 1♂, IX_3 3♀.
*32. *Mg. kobensis* Cockerell. 1♀. IX_2.
*33. *Mg. kyotensis* Cockerell. 2♀ 1♂. IX_1 1♀, IX_2 1♀, IX_3 1♂.
*34. *Osmia* (*Chalcosmia*) *orientalis* Benoist. 1♀. VI_2.
*35. *Coelioxys fenestrata* Smith. 1♂. IX_2.
*36. *Cx.* sp. A. 1♀. IX_2.
*37. *Euaspis basalis* (Ritsema). 1♀. IX_2.

ANTHOPHORIDAE

*38. *Amegilla quadrifasciata* (Villers). 1♀. VIII_3.
*39. *Anthophora acervorum villosula* Smith. 1♀. V_1.
*40. *Eucera spurcatipes* Pérez. 3♀ 8♂. IV_3 1♀ 8♂, V_1 1♀, V_2 1♀.
*41. *Tetralonia nipponensis* Pérez. 7♀ 2♂. IV_3 1♂, V_1 3♀, V_2 4♀ 1♂.
*42. *Tt. mitsukurii* Cockerell. 12♀ 4♂. IX_3 9♀ 3♂, X_1 3♀ 1♂.
*43. *Thyreus decorus* (Smith). 1♀. VIII_3.
44. *Nomada japonica* Smith. 3♀. V_1 2, V_2 1.
*45. *Nm.* sp. A. 1♀. IV_3.
*46. *Xylocopa* (*Alloxylocopa*) *appendiculata circumvolans* Smith. 120♀ 77♂. IV_1 3♀, IV_2 16♀ 10♂, IV_3 28♀ 18♂, V_1 50♀ 45♂, V_2 15♀ 4♂, V_3 1♀, VI_1 4♀, VI_2 2♀, VIII_2 1♀.

APIDAE

*47. *Bombus* (*Bombus*) *ignitus* Smith. 1♀ 1♂. IV_1 1♀, IX_1 1♂.
*48. *Bo.* (*Diversobombus*) *diversus diversus* Smith. 1♀ 34☿. IV_3 1♀, VI_1 4☿, VI_2 7☿, VI_3 11☿, VII_1 7☿, VII_2 1☿, VIII_1 4☿.

The number of species and individuals sampled at supraspecific levels are given in Table 1, accompanied with some comparisons to the result obtained in Sapporo, Northern Japan, in percentage ratios. Some differences seen in the relative abundance of species and individuals in certain taxa would be, as repeated in previous papers (op. cit.), a composite outcome of geographical and ecological differences between two areas surveyed, as well as some differential sampling biases being still impossible to exclude. Separation of the relative prevalence of these components is at the present difficult. Moreover the difference of sample size, about six times larger in Sapporo, strongly affects the values of relative abundance. The following enumeration, some items of which were given as suggesting geographical differences, is therefore a mere tentative for further studies.

1. Southern tendency in Kibi is recognized by the presence of some genera not reaching Northern Japan: *Panurginus, Euaspis, Amegilla, Thyreus* and *Xylocopa,* further by a higher species number of *Megachile.*

2. A poor northern tendency in Kibi is reflected in a scarcity of *Hylaeus* and *Bombus,* both in species and individuals.

Table 1. Number of species and individuals collected given at supraspecific levels, with comparison of relative abundance to the result in Sapporo, N. Japan.

Taxon (abbrev.)	No. species	No. individuals			% in species		% in individuals (♀♂)	
		♀	♂	♀♂	Kibi	Sapporo	Kibi	Sapporo
COLLETIDAE	**2**	**2**	**0**	**2**	**4.2**	**11.8**	**0.2**	**2.5**
Colletes (*Co.*)	1	1	0	1	2.1	1.0	0.1	0.1
Hylaeus (*Hy.*)	1	1	0	1	2.1	10.8	0.1	2.4
HALICTIDAE	**13**	**350**	**14**	**364**	**27.1**	**42.2**	**34.9**	**56.1**
Halictus (*Ha.*)	-	-	-	-	-	1.0	-	2.1
Seladonia (*Sl.*)	1	190	10	200	2.1	1.0	19.2	4.6
Lasioglossum (*Lg.*)	4	16	3	19	8.3	8.8	1.8	11.6
Dialictus (*Dl.*)	-	-	-	-	-	2.0	-	9.3
Carinate *Evylaeus* (*Et*)	4	129	0	129	8.3	6.9	12.4	18.7
Carinaless *Evylaeus* (*El*)	3	15	0	15	6.3	16.6	1.4	8.7
Sphecodes (*Sph.*)	1	0	1	1	2.1	5.9	0.1	1.1
ANDRENIDAE	**10**	**211**	**144**	**355**	**20.8**	**17.6**	**34.0**	**14.9**
Panurginus (*Pa.*)	1	149	83	232	2.1	-	22.2	-
Andrena (*Ad.*)	9	62	61	123	18.9	17.6	11.8	14.9
MEGACHILIDAE	**12**	**19**	**27**	**46**	**25.0**	7.8	**4.4**	**4.9**
Chalicodoma (*Ch.*)	1	1	5	6	2.1	1.0	0.6	0.1
Megachile (*Mg.*)	7	15	21	36	14.5	2.8	3.4	3.7
Osmia (*Os.*)	1	1	0	1	2.1	2.0	0.2	0.8
Coelioxys (*Cx.*)	2	1	1	2	4.2	2.0	0.1	0.3
Euaspis (*Ea.*)	1	1	0	1	2.1	-	0.1	-
ANTHOPHORIDAE	**9**	**149**	**91**	**240**	**18.8**	**14.7**	**23.0**	**14.1**
Amegilla (*Am.*)	1	1	0	1	2.1	-	0.1	-
Anthophora (*At.*)	1	1	0	1	2.1	-	0.1	-
Eucera (*Eu.*)	1	3	8	11	2.1	1.0	1.1	1.0
Clisodon (*Cl.*)	-	-	-	-	-	1.0	-	0.8
Tetralonia (*Tt.*)	2	19	6	25	4.2	-	2.4	-
Thyreus (*Ty.*)	1	1	0	1	2.1	-	0.1	-
Nomada (*Nm.*)	2	4	0	4	4.2	10.7	0.4	1.0
Ceratina (*Ct.*)	-	-	-	-	-	2.0	-	11.3
Xylocopa (*Xy.*)	1	120	77	197	2.1	-	18.9	-
APIDAE (all *Bombus Bo.*)	**2**	**2q+34**	**1**	**37**	**4.2**	**5.9**	**3.5**	**7.5**
Total number	**48**	**767**	**277**	**1,044**	**48**	**102**	**1,044**	**6,843**

3. At familial level Halictidae occupies the top rank in Kibi both in species and individuals. But its relative prevalence is far inferior to that in Sapporo, compensated by increase in Megachilidae (in species) and Anthophoridae (in species and individuals). The former is more abundant in Sapporo at individual level but this seems circumstancial, because it has always been less abundant in other surveys made in Hokkaido than in the survey made in Sapporo at the Campus of Hokkaido University. The relation among these three families may reflect a trend general in the northern Old World, though further comparisons are required.

4. Andrenidae shows a composite difference between two areas. At species level it is slightly more abundant in Kibi in relative terms, but taking the third

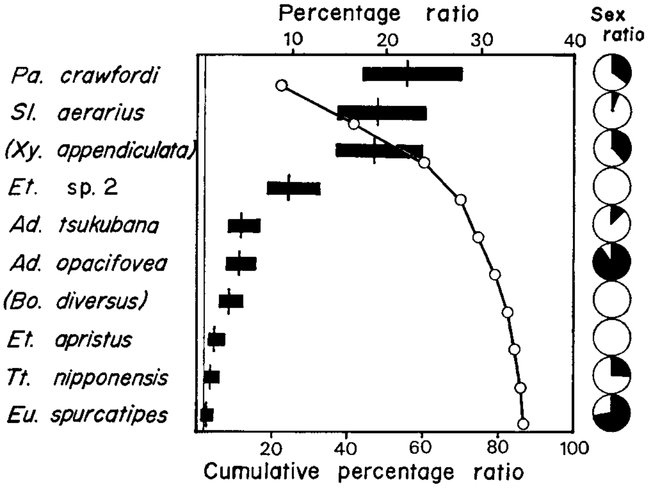

Fig. 1. Relative abundance of 10 predominant species shown by occurrence probability method. Percentage ratio (scale above) of each species is given by a short vertical line on each horizontal bar indicating fiducial limits. Vertical line at lefthand is the reciprocal of the number of species sampled multiplied by 100. Sex ratio in each species (pie graphs. White sector=♀, black=♂) and cumulative percentage curve (scale bottom) are accompanied. *Xy. appendiculata* and *Bo. diversus* are shown parenthetically because the individuals were liberated after recording.

rank against the second in Sapporo. At individual level, it occupies the second rank in both areas, but much more abundant in Kibi, nearly comparable to Halictidae. However, this mainly depends on the abundance of *Pa. crawfordi.* Excluding this species, all *Andrena* species combined are more abundant in Sapporo. Probably this family is in general more abundant in Northern Japan, gradually decreasing southward. But the decrease would be so mild that easily obscured by local abundance as well as floral conditions.

5. Table 1 shows that the relative abundance of Anthophoridae at individual level is largely determined by two xylocopine genera, *Xylocopa* and *Ceratina.* But this seems circumstancial, because *Xylocopa* is rather rare and sporadically distributed in the area surrounding Kibi, and, though not collected in the present survey, *Ceratina japonica* Cockerell, a predominant bee species in Sapporo, occurs in and near Kibi.

Among 48 species collected, 18 are common to Sapporo (Colletidae 2/2, Halictidae 12/13, Andrenidae 3/10, Megachilidae 1/12). As further seven species (*Andrena* 2, Hirashima 1966, *Megachile* 4, Hirashima and Maeta in press., *Nomada* 1) are known as reaching the vicinity of Sapporo, 23 out of 48 species, or ca. 47%, are tentatively regarded as the representatives of Central to Southern Japan, some ones further reaching more southern areas. It is remarkable that few halictine species belong to them.

On the other hand, the faunal resemblance between two areas decreases when the predominant species are considered. Fig. 1 shows the relative abundance of ten predominant species in percentage ratios with the upper and lower fiducial limits ($p=0.95$), arranged in the descending order of individuals sampled. In all except the last species, *Eu. spurcatipes*, the lower fiducial limit exceeds the reciprocal of species number sampled multiplied by 100. Only two of these species, *Lg.* (*Et.*) sp. 2 and *Lg.* (*Et.*) *apristum*, are common to Sapporo, both being not included within 20 predominant species there. *Bo. diversus* is common to Sapporo where it occupies the 9th rank, but there is a subspecific differentiation between two areas.

The percentage ratio occupied by these predominants combined is very high, ca. 87% of the total individuals sampled, and the sum of four top species alone ca. 70%, whereas in Sapporo the sum of ten top species not reaching 60%. This obviously relates to the small sample size but in part may reflect a relatively simple assemblage structure, partly caused by the history of faunal formation but probably also by the intensive human interference.

2. *Phenology*: Fig. 2 shows the seasonal change of species and individual numbers sampled, in the latter both sexes given separately. Further the change of individual number in four major groups are given separately, together with the phenology of five predominants and of a typical serotinal species, *Tt. mitsukurii*. At the top the change of maximum temperature during the survey as well as of the number of plant species in bloom and of those visited by bees are added to.

As explained previously flowers are relatively rich in early spring but drastically decrease after mid May (Fig. 2, B). Correspondingly the number of both bee species and individuals are the highest in late April to early May (Fig. 2, C, D).

The species curve shows a bimodal sequence with two maxima, one at early spring and the other at late autumn. The former is mainly caused by Andrenidae and Anthophoridae, while the latter by Megachilidae. Thus the sequence is quite different from that in Sapporo given synoptically, which forms, besides an obvious contraction at the start and end of the bee season, a mild plateau throughout the sampling period. The predominance of Andrenidae in spring is common to both areas but both Anthophoridae and Megachilidae do not affect much the curve in Sapporo with seasonal differentiation. Instead the curve in Sapporo is under the overwhelming predominance of Halictidae from spring to autumn. Thus the differentiation of an autumn bee assemblage, mainly consisting of Megachilidae, accompanied with some serotinal species such as *Tt. mitsukurii* (cf. Fig. 2, G) characterizes the phenology of species abundance in Kibi.

The phenologic curves of individual number, both females and males, keep, after a spring burst, a low level throughout the rest of bee season, which corresponds to the curve of the species number of flowering plants in bloom. The comparison with the curves obtained in Sapporo presented synoptically visualizes the displacement of the period of higher bee activities between two areas.

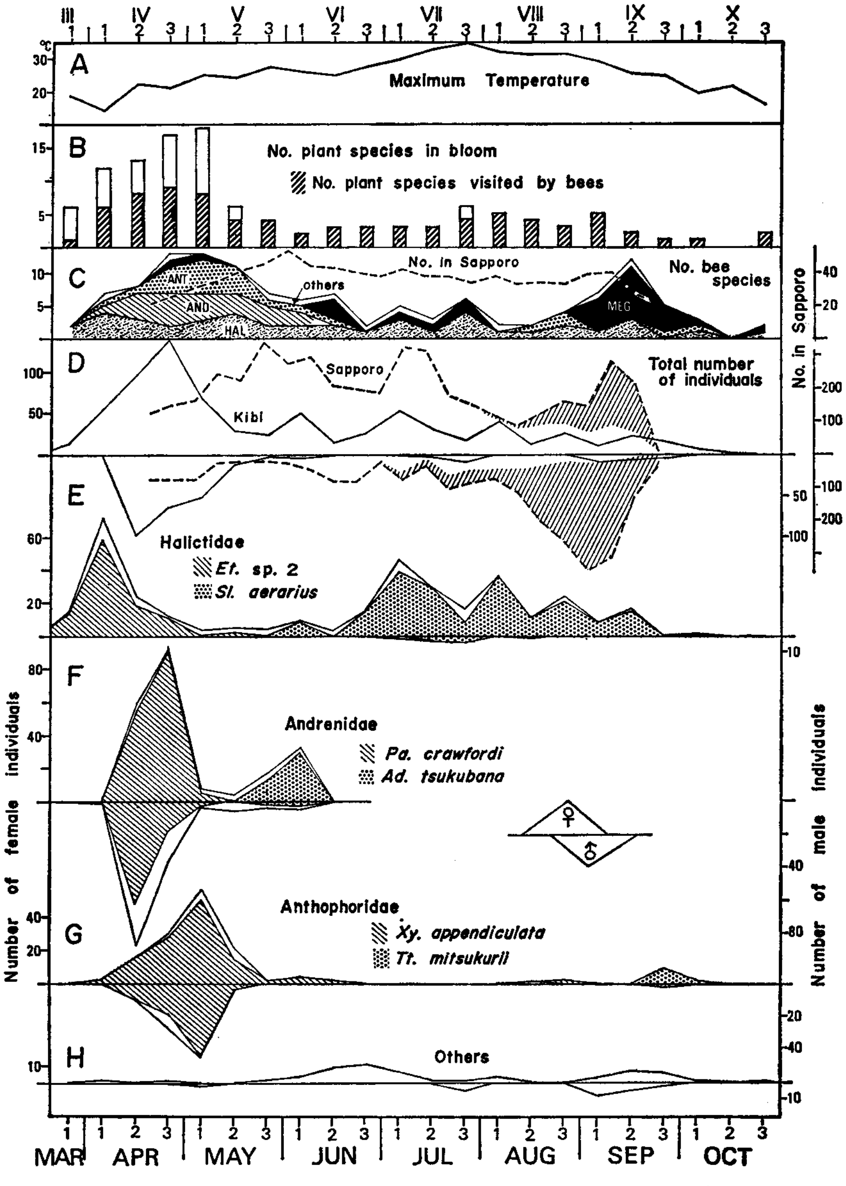

Fig. 2. Bee phenology in Kibi. In C, family names are shown with first three letters. In D, hatched parts show the number of newly emerged adults in Sapporo (♀=Halictidae and *Ceratina*. ♂=Halictidae and *Bombus hypocrita*).

Another important difference is the absence of autumn burst in Kibi, in both sexes but particularly in males. Here exists an unsolved problem which may interfere the unbiased comparison of the data sampled. As shown with differential hatching, the burst in Sapporo is mostly caused by particular groups, in females, newly emerged adults of *Ceratina*, *Halictus*, *Seladonia* and *Lasioglossum*, and in males, *Ceratina*, *Halictus*, *Seladonia*, *Lasioglossum*, carinate *Evylaeus* and *Bo. hypocrita*, i.e. all being new adults of the groups not belonging to typical solitary bees (cf. Sakagami and Fukuda 1973). Excluding *Ceratina* and *Bo. hypocrita* not collected in Kibi, the discrepancy between two areas as to newly emerged autumn adults, especially males, of halictine bees is remarkable. But this does not always imply a geographical difference, because in subsequent surveys made by S.F.S. and H.F. near Sapporo the ratio occupied by halictine new adults was often inferior to the result obtained at the campus of Hokkaido University shown in Fig. 2. The discrepancy may be interpreted by one or both of the following possibilities: 1) The amount of new adults produced varies from place to place according to habitat conditions. 2) Flower visits of new adults are affected by habitat conditions, especially by the qualitative and quantitative distributions of flowers in bloom. The first possibility is likely and the local variability of specific productivity is in itself a fascinating problem. But the difference given in Fig. 2 is too large to be explained by this possibility alone. Probably the spatiotemporal distribution of these new adults, which do not participate in brood rearing activities, is affected by local floral conditions, leading to a considerable difference between sampling results.

At the present we cannot remove this source of bias. Moreover, this factor also affects the relative abundance of various groups mentioned in the previous section. For instance, the percentage ratios occupied by some major groups change as follows when calculated based upon the females alone:

	Kibi	Sapporo
Halictidae	45.6	58.0
Andrenidae	27.5	12.7
Anthophoridae	19.4	15.7

The ratios do not change much in Sapporo (cf. Table 1) but the relative abundance of Halictidae increases in Kibi with corresponding decrease of Andrenidae and Anthophoridae. Some related discussions were given in Sakagami and Fukuda (1973) but further studies on flower visiting habits are required.

Phenologic curves of major groups in Fig. 2 show the abundance of Andrenidae and Anthophoridae in spring while the virtual monopolization by Halictidae of other periods. Further the separate presentation of five predominant species clearly demonstrates that the bee phenology in the area is mostly determined by them. Thus the bee season in the area is approximately divided into three periods:

I. Spring. April to early May. Rich in species and individuals. II. Late spring and summer. Poor both in species and individuals. III. Autumn. September to October. Poor in species and individuals but with a mild increase of species number. Further characterization of three periods are given in the next section.

It might be suspected that the low activity level of bees after spring burst is caused by the concentration of bees on scattered food sources ignored at sampling. Such possibility cannot be excluded. But that the spring burst followed by summer dearth forms the pattern basic to the local bee-flower relation is suggested by flower visiting activities of wasps, *Polistes, Eumenes, Sphex, Tachytes,* etc., which are much abundant than bees on flowers from July to August. Moreover, the experience by local bee keepers tells that the major honey flow is citrus plants in May. Thereafter, the non-migratory colonies seldom produce surplus honey, necessitating artificial feeding, nevertheless the flight radius of the European honeybee is much wider than in most wild bee species.

Using this occasion, a presumable poor productivity of colonies of *Bo. d. diversus* in the area is briefly referred to, though here the influence of thermal condition is not excluded. Some colonies of this species founded in the area (mainly subarea B) seemingly dwindle without producing sexuals. Two cases are cited:

Case 1. Taken 24 VIII '70. With ca. 40 workers and the corpse of a queen died a few days ago. Three days after, one worker started oviposition and continued it to mid September. Emergence of only a few males in October.

Case 2. Taken 18 X '72. With the foundress queen (died 22 X) and ca. 20 small and medium workers. On 23 X with 24 workers and six worker cocoons. No sexuals produced.

Finally the number of generations per year in the collected solitary species is briefly referred to based upon the sampling data. The species apparently univoltine are: *Lg.* (*Et.*) sp. 1, *Pa. crawfordi, Ad. tsukubana, Ad. opacifovea, Ad. kaguya, Os. orientalis, At. acervorum, Tt. nipponensis, Tt. mitsukurii, Eu. spurcatipes* and *Xy. appendiculata.* Many other species may also be univoltine but the data are insufficient to be conclusive. On the other hand, some *Megachile* species may be bivoltine, especially *Mg. nipponica* and *Mg. tsurugensis.*

3. *Flower visits.*: Table 2 presents the number of bee individuals visiting various plant families, accompanied with the number of species visited in each plant family. Three families, Cruciferae, Leguminosae and Compositae occupy about 70% of total visits. The importance of these families is common to the result in Sapporo but the relative weight is different. In Sapporo, Compositae shows an overwhelming importance, occupying ca. 45% of visiting bees, whereas Cruciferae is the third-ranked (at the University Campus) or much inferior (at Botanical Garden), attracting less than 10% of visiting bees. Such difference is explained mainly by the difference of predominantly visited plants shown in Table 3 than the floristic difference between two areas.

According to their provenance, the plants in bloom during the bee season were classified into four types: A. Native plants. B. Native weeds. C. Cultivated, including those partly escaped. D. Escaped exotic. Their relative importance in flower visits of bees is summarized in Table 3. From the first two columns it is

Table 2. Number of bee individuals collected on various plant families

Plant family	No. plant species	Number of bee individuals									
		Total				Total in each bee family (shown by first three letters of family name)					
		♀	♂	♀♂	%	COL	HAL	AND	MEG	ANT	API
Cruciferae	5	246	120	366	35.1		106	253		7	
Leguminosae	6	116	79	195	18.7		25	1	30	138	1
Compositae	10	138	15	153	14.7		126	19	4	4	
Vitaceae	2	75	8	83	8.0	1	73		9		
Caprifoliaceae	2	50	10	60	5.7		1	7		23	29
Saxifragaceae	1	48	8	56	5.4		9	47			
Rutaceae	3	24	22	46	4.4		1	1		44	
Rosaceae	3	20	9	29	2.8	1	4	7		16	1
Ranunculaceae	2	17	3	20	1.9		8	9		3	
Anacardiaceae	1	11		11	1.1		1	10			
Campanulaceae	1	7	1	8	0.8		7				1
Rubiaceae	1	5		5	0.5					1	4
Labiatae	1	3	1	4	0.4		1		3		
Ericaceae	1	3	1	4	0.4					4	
Oleaceae	1	2		2	0.2		2				
Papaveraceae	1	1		1	0.1						1
Cariophyllaceae	1	1		1	0.1			1			
Total	42	767	277	1,044		2	364	355	46	240	37

Table 3. Grouping of plants visited by bees according to provenance

Provenance	Number of plant species		Number of bee individuals visiting			
	visited by bees	not visited	♀	♂	♀♂	%
A Natives	9	3	144	24	168	16.1
B Native weeds	16	14	198	43	241	23.2
C Cultivated	12	0	337	122	539	51.6
D Exotics	5	2	88	8	96	9.1
Total	42	19	767	277	1,044	100.0

recognized that about two thirds of plants in bloom during the sampling period were visited by bees. It is interesting that the number of plant species not visited by bees is quite high in native weeds, though being difficult to explain. The other part of the table shows that the local bee assemblage is strongly dependent on cultivated plants. The relative importance is compared with the results in Sapporo as follows (UC, BG respectively University Campus and Botanical Garden):

Kibi	Cultivated ⟩⟩⟩ Native weeds > Natives > Exotics
UC	Exotics ⟩⟩⟩ Cultivated > Natives > Native weeds
BG	Cultivated > Exotics ≥ Natives > Native weeds.

An interesting inversion of the role played by exotic and native weeds is recognized.

Table 4. Plants predominantly visited by bees (Family names abbreviated by first three letters. Cf. Table 2).

Plant name (Family)	Total visits				Visits by each bee family						Provenance	Blooming period
	♀	♂	♀♂	%	COL	HAL	AND	MEG	ANT	API		
Brassica nippo-oleifera var. *pekinensis* Makino (CRU)	159	103	262	25.1		29	230		3		C	$\mathrm{III}\sim\mathrm{IV}_2$
Vicia faba L. forma *anacarpa* Makino (LEG)	57	44	101	9.7					100	1	C	$\mathrm{IV}_1\sim\mathrm{IV}_3$
Brassica rapa L. (CRU)	77	15	92	8.8		72	20				C	$\mathrm{III}\sim\mathrm{IV}_1$
Erigeron annuus L. (COM)	85	7	92	8.8		90		2			D	$\mathrm{VI}_3\sim\mathrm{VII}_3$
Ampelopsis brevipedunculata Trautv. (VIT)	53	8	61	5.8	1	51		9			B	$\mathrm{VII}_3\sim\mathrm{IX}_2$
Deutzia sieboldiana Maxim. var. *dippeliana* C.K. Schn. (SAX)	48	8	56	5.4		9	47				A	$\mathrm{V}_3\sim\mathrm{VI}_1$
Poncirus trifoliata Rafin. (RUT)	19	22	41	3.9			1		40		C	$\mathrm{IV}_2\sim\mathrm{IV}_3$
Weigelia floribunda Nakai (CAP)	35		35	3.4					6	29	A	$\mathrm{VI}_1\sim\mathrm{VII}_1$
Lespedeza cyrtobotrya Miq. (LEG)	20	6	26	2.5		1			16	9	B	$\mathrm{IX}_3\sim\mathrm{X}_1$
Lonicera japonica Thunb. (CAP)	15	10	25	2.4		1	7		17		A	V_2
Taraxacum japonicum Koidz. (COM)	19	4	23	2.2		12	11				B	$\mathrm{III}\sim\mathrm{IV}_3$
Cayratia japonica Gagn. (VIT)	22		22	2.1		22					D	$\mathrm{VIII}_2\sim\mathrm{VIII}_3$
Indigofera pseudotinctoria Matsum. (LEG)	20	2	22	2.1		22					B	$\mathrm{VII}_2\sim\mathrm{VIII}_2$
Pueraria lobata Ohwi (LEG)	6	14	20	1.9		2		18			B	$\mathrm{IX}_2\sim\mathrm{IX}_3$
Ranunculus quaelpaertensis Nakai var. *glabra* Hara	16	3	19	1.8		7	9		3		B	$\mathrm{III}\sim\mathrm{IV}_3$
Other species (27)	116	31	147	14.1	1	46	30	17	65			

The importance of exotic weeds is overwhelming in UC, occupying 71.8%, and second-ranked in BG, 26.2% in spite of the presence of numerous cultivated plants as specimens, contrasting to the minor role played by native weeds. The difference may be explained by two ways. First the location of Kibi, being relatively distant from large cities would retard the dispersal of exotic weeds. But the difference in the influence of human interferences between two areas is also important. In Southern Japan, the original vegetations have been modified to the secondary ones through hundreds or thousands years which helped the dispersal and establishment of native weeds, many of which would be in reality the exotics arriving before

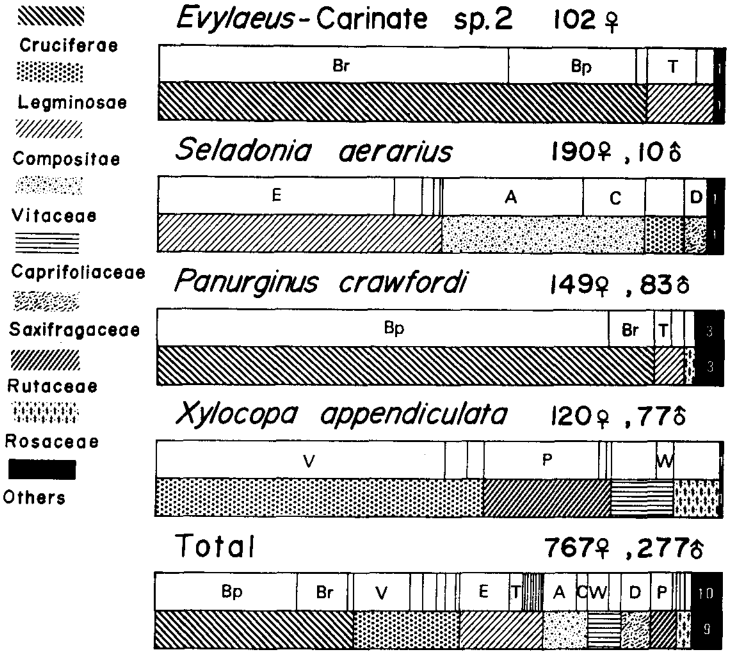

Fig. 3. Flower visit spectra of four predominant species and of total visits. In each bar, upper section shows the ratios occupied by plant species and lower section families. Some principal families are shown with differential hatchings. Only ten principal plant species are shown with symbols: Bp *Brassica pekinensis*, Br *Brassica rapa*, T *Taraxacum*, V *Vicia*, A *Ampelopsis*, P *Poncirus*, E *Erigeron*, C *Cayratia*, D *Deutzia*, W *Weigelia*. Black blocks at righthand indicate minor families with species and family numbers.

modern ages. On the contrary, the human interference to the original vegetation in Hokkaido has rather abruptly intensified about 100 years ago, partly by the adoption of the North American agricultural practice, which caused the establishment of numerous exotic weeds. In both areas, the role played by native plants representing the primary vegetation is small, suggesting a profound transformation of bee-flower relations in the lowlands of Japan.

Table 4 shows flower visits to 15 predominantly visited plants, occupying 90% of total visits. From the blooming period of each species given at the final column, further comments are added to the differentiation of bee season presented in the previous section:

I. Spring burst period: The period of highest bee activities, mainly determined by *Pa. crawfordi*, *Et.* sp. 2 and *Xy. appendiculata*, the first two species mainly foraging from Cruciferae and the carpenter bee from *Vicia* and some shrubs (Fig. 3). Although not collected, a concentration of *Xylocopa* on *Pseudacacia* (D) was observed in V_1. Besides these plants, *Taraxacum* and *Ranunculus* attract other bees of minor abundance. Further, *Cardamine flexuosa* With. (B), *Ixeris stolonifera* A. Gray (B) and *Veronica persica* Poir. (D) were relatively abundant but received little visits.

II. Summer dearth period: Both bees and flowers decrease. The predominant bee species is *Ad. tsukubana* in early summer, followed by the prolonged activity of an eusocial halictine bee, *Sl. aerarius* (cf. Sakagami and Fukushima 1961) (Fig. 2). The first species seems oligotrophic, collected mostly on *Deutzia* (34♀ 6♂, other 9♀ all on *Rhus silvestris* Sieb. et Zucc.). *Sl. aerarius* is polytrophic (Fig. 3). The plants predominantly visited in this period are, in the order of blooming, *Deutzia*, *Weigelia*, *Erigeron*, *Indigofera*, *Ampelopsis* and *Cayratia*.

III. Autumn period: Bee activities are not high but the species number slightly increases partly by the appearance of some autumn species, such as an oligotrophic anthophorid, *Tt. mitsukurii*, all collected on *Lespedeza*. The important food sources are *Ampelopsis* continuing from late summer and some legumes, *Pueraria* and *Lespedeza*.

By the poverity of both bees and flowers, the bee-flower relation is mostly determined by the combination of some predominant species. For instance, *Br. pekinensis*, visists of 70.6% by *Pa. crawfordi*, *Br. rapa*, 68% by *Et.* sp. 2, *Vicia* 99.0% by *Xy. appendiculata*, *Erigeron* and *Ampelopsis* respectively 90.2 and 82.0% by *Sl. aerarius*. Flower visit spectra of four top ranked bee species are given in Fig. 3, accompanied with that of total visits (in all cases little difference between sexes). Flower visits of other relatively abundant bee species are given as follows (Plant names are fully shown only in those first cited):

Et. apristus (all females). *Brassica pekinensis* 5, *Br. rapa* 9, *Taraxacum* 3, *Cardamine* 1, *Ranunuculus sceleratus* L. 1, *Deutzia* 1.

Ad. opacifovea, ♀: *Br. pekinensis* 1, *Taraxacum* 1, *Rhus* 1, *Deutzia* 2. ♂: *Br. rapa* 1, *Br. pekinensis* 40, *Pyrus communis* L. var. *sativa* DC. 1.

Mg. nipponica, ♀: *Prunella vulgaris asiatica* Hara 1, *Pueraria* 1, *Ampelopsis* 1, *Cosmos bipinnatus* Cav. 2, *Deutzia* 3. ♂: *Ixeris debilis* A. Gray 1, *Erigeron* 2.

Eu. spurcatipes, ♀: *Br. pekinensis* 1, *Rhododendron macrosepalum* Maxim. 1, *Circium japonicum* DC. 1, *Rhaphanus sativus* L. var. *acanthiformis* Makino 1, ♂: *Br. pekinensis* 2, *Astragalus sinicus* L. 6.

Tt. nipponensis, ♀: *Rhododendron* 1, *Astragalus* 2, *Lonicera* 1, *Circium* 1, *Rhaphanus* 2, ♂: *Rhododendron* 1, *Raphanus* 1.

Bo. diversus, ♀: *Vicia* 1, ☿: *Weigelia* 34, *Macleaya cordata* R. Br. 1, *Paederia scandens* Merrill var. *maerei* Hara 4.

Except for visits of *Bo. diversus* to *Weigelia*, most species behave as polytrophic, interestingly even *Tetralonia* and *Eucera*, whose preference for tubular flowers is well known in other areas.

Summary

Wild bee fauna of Kibi (Wakayama Pref.), Southern Japan, was surveyed in 1969 by periodical sampling on flowers, three times per month and each time 3–4

hours, from late March to late November. The results are, in part compared with those obtained in Sapporo, Northern Japan, summarized as follows:

1) The total sample consisting of 48 species and 1,044 individuals shows the predominance of Halictidae (27.1%), followed by Megachilidae (25.0), Andrenidae (20.8) and Anthophoridae (18.8) in species number. But the relative abundance of Halictidae is inferior to that in Sapporo, compensated by Megachilidae and Anthophoridae.

2) In individual number Halictidae and Andrenidae are equally abundant, occupying in combination about 70%, followed by Anthophoridae (23.0). Halictidae is again less abundant and Anthophoridae more than in Sapporo. Andrenidae is far more abundant but about two thirds is occupied by *Panurginus crawfordi* Cockerell.

3) The assemblage structure is simple. Ten top species occupy about 87% of total individuals and four top ones, *Pa. crawfordi, Halictus* (*Seladonia*) *aerarius* Smith, *Xylocopa appendiculata circumvolans* Smith and *Lasioglossum* (carinate *Evylaeus*) sp. 2 in combination nearly 70%.

4) Phenologic curves show a conspicuous peak at spring both in species and individuals of bees as well as the abundance of flowers, followed by a distinct decline. The local bee season is thus divided into three periods. I. Spring burst, II. Summer dearth and III. Autumn. The absence of autumn burst of newly emerged adults in non typical solitary bees indicates the presence of an unsolved problem as to their flower visiting habits.

5) About 70% of total bees were collected on three plant families, Cruciferae, Leguminosae and Compositae. The analysis of the data shows a strong dependence of bees on cultivated plants (51.6%), especially Cruciferae in spring, followed by native weeds (21.0), natives (16.1) and exotic weeds (11.3). The minor importance of exotic weeds is contrasting to the result in Sapporo.

6) In conclusion the area is poor both in bees and flowering plants so that predominant bee-flower combinations such as *Pa. crawfordi* and *La.* (*Et.*) sp. 2 — Cruciferae and *Xy. appendiculata* — *Vicia* strongly affect the pattern of local bee-flower relations.

References

Hirashima, Y. 1966. Systematic and biological studies of the family Andrenidae of Japan (Hymenoptera, Apoidea). Part 2. Systematics, 7. J. Fac. Agr., Kyushu Univ. **14**: 89–131.

Matsuura, M. 1973. A survey on the insect pollinators of plums. Mimeographed from unpublished data. (In Japanese)

——— and S. Hatta 1973. Flower-visiting insects in citrus orchards, with special reference to scarring of fruit surface. Proc. Kansai Plant Prot. Soc. **15**: 55–62. (In Japanese with English summary)

Sakagami, Sh. F. and H. Fukuda 1973. Wild bee survey at the Campus of Hokkaido University. J. Fac. Sci. Hokkaido Univ. Ser. VI, Zool. **19**: 190–250.

——— and K. Fukushima 1961. Female dimorphism in a social halictine bee, *Halictus*

(Seladonia) aerarius Smith. Jap. J. Ecol. **11**: 118–124.

————, Laroca, S. and J. S. Moure 1967. Wild bee biocoenotics in São José dos Pinhais (PR), South Brazil. Preliminary report. J. Fac. Sci. Hokkaido Univ. Ser. VI, Zool. **16**: 253–291.