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ON THE HOURLY CHANGE OF THE POLLINATOR ASSOCIATION FOUND IN THE JAPANESE PEAR, VAR. *NIJISSEIKI* ORCHARD IN DAY-TIME ※

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廿世紀ナシ園における訪花昆虫群集の日変化について

(山陰地方における圃場の昆虫群集に関する研究 7)

三 浦 正

INTRODUCTION

It is generally recognized that the Japanese pear, *Pyrus serotina* Rehder var. *Nijisseiki* has a nature of seed-setting by cross-pollination. Therefore, in the fruit grower of *Nijisseiki* an artificial pollination is generally applied to improve the yield of fruit. Using this method, however, an increase of production cost should be inevitable, and some technical problems are still remained in practice.

It can easily concerned that making use of a pollinator instead of a hand pollination might decrease the production cost of the Japanese pear, var. *Nijisseiki* fruit. For this purpose, it is necessary to investigate a species and/or number of pollinator living in the flowering *Nijisseiki* orchard.

According to Kobayashi,[1] the pollinator of the Japanese pear are as follows ; Hymenoptera : Apidae, Andrenidae, Halictidae, Megachilidae, Anthophridae and Vespidae, and Diptera : Syrphidae, Muscidae and Calliphoridae.

There are little investigation of the pollinator in the Japanese pear orchard at San-In District. In the present experiment, the hourly change of pollinator association in daytime was investigated in the Japanese pear, var. *Nijisseiki* orchard for five days during the flowering period.

EXPERIMENTAL

The experiment was performed in the Experimental Farm of Shimane University at Matsue-shi, using an orchard covered an area of 2.2 square kilometers and planted seventy 13-year-old of the Japanese pear, *Pyrus serotina* Rehder var. *Nijisseiki* trees. The orchard used had an easy slope, and was encircled with a mixed forest of coniferous and decidurous broad leaf trees at the east, west and south sides, and with a paddy field and an irrigation pond at the north side of lowland. The investigation was carried out on 15th to 18th days (full bloom time) and 27th day (last time of flowering) in April, 1975. In each experimental

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Table 1. Weather condition during the period of investigation

A) Weather condition

Factor	April-15	-16	-17	-18	-27
weather	Cloudy	Cloudy	Cloudy	Cloudy	Cloudy
Amount of precipitation (mm)	—	15.5	0.2	—	0.5
Wind direction	SE	SE	E	SE	NW
Wind force (m/s)	1.3	4.0	1.1	5.2	1.6
Daylight hours	6.0	0.3	0.2	9.9	0.5
Amount of evapotranspiration (mm)	3.5	0.5	1.4	5.6	2.6
Maximum wind speed (m/s)	7.9	7.2	10.9	10.8	5.3
Wind speed of twenty-four hours	2.5	1.8	2.7	2.8	0.7
Maximum temperature (°C)	17.2	16.4	16.5	15.1	21.6
Minimum temperature (°C)	10.4	10.7	12.6	10.7	15.3

B) Air temperature and humidity

	April-15		-16		-17		-18		-27	
Hour	Temp. (°C)	Humid. (%)	Temp. (°C)	Humid. (%)	Temp. (°C)	Humid. (%)	Temp. (°C)	Humid. (%)	Temp. (°C)	Humid. (%)
09 : 00	13.9	95.0	12.8	92.5	15.2	94.0	13.4	65.0	18.5	77.0
10 : 00	14.8	89.8	14.3	88.2	15.8	90.0	14.4	59.0	19.9	74.5
11 : 00	16.1	80.2	14.6	87.0	15.8	90.0	14.4	59.0	20.7	72.5
12 : 00	16.2	78.0	14.5	84.8	15.8	90.0	14.0	50.0	21.5	74.7
13 : 00	17.2	79.0	15.6	85.3	16.4	93.5	15.0	50.0	21.2	81.9
14 : 00	16.8	77.0	16.2	82.0	16.2	88.5	14.0	50.0	20.8	82.5
15 : 00	17.2	80.0	16.2	79.3	15.5	99.0	13.4	45.2	21.0	81.5
16 : 00	16.0	74.5	16.2	81.5	15.6	87.0	14.2	48.0	21.6	82.1
17 : 00	14.8	80.0	16.2	86.0	15.0	92.2	12.6	50.9	20.5	85.0
18 : 00	13.9	82.9	16.5	87.1	14.5	93.0	12.0	59.0	20.2	90.0

day, the collection of insects was undertaken hourly from 09.00 to 18.00 hrs. (daytime) during the initial 15 minutes of each hour by two collectors using the method of sweeping with insect net (42 cm in diameter and 90 cm in depth) and with sucking.

RESULTS AND DISCUSSION

1) *Weather condition during the period of investigation*

The weather condition of experimental days when the investigation was performed is shown in Table 1. We had 16.5 millimeters of rain on 16th (01.00 to 04.00) April.

2) *The composition of insect fauna*

The species and its numbers of insects collected per day are shown in Table 2. The insects known as pollinator were as follows ; Hymenoptera : eleven species of Andrenidae, two species of Halictidae, three species of Apidae, and Diptera : eight species of Syrphidae.

The species collected with a relatively large number of individuals were as follows ; Andrenidae : *Andrena* sp., *Andrena foveopunctata*, *Andrena benefica*, *Andrena kaguya*, and Syrphidae : *Eristalis cerealis*, *Helophilus virgatus*. Syrphidae, *Eristalis cerealis* is one of the pollinator used on apple orchard in northern Japan. Honeybee being a most ordinary pollinator was not active at the flowering period of the Japanese pear, var. *Nijisseiki* in San-In District. In the present experiment, only one of honeybee was

Table 2. Relative composition of pollinator fauna

Species	April-15		-16		-17		-18		-27		Total	
	N*	%**	N	%	N	%	N	%	N	%	N	%
Andrenidae												
Andrena sp.	27	20.93	70	23.18	3	1.50	1	0.81	6	10.34	107	13.17
Andrena foveopunctata AIFKEN	26	20.16	43	14.24	10	5.00	7	5.69	2	3.45	88	10.83
Andrena benefica HIRASHIMA	7	5.43	36	11.92	12	6.00	6	4.88	3	5.17	64	7.88
Andrena kaguya HIRASHIMA	1	0.77	20	6.62	15	7.50	4	3.25	12	20.69	52	6.40
Andrena sasaki COCKERELL	5	3.88	5	1.66			3	2.44	13	22.41	26	3.20
Andrena stellaria HIRASHIMA	3	2.33	6	1.99			2	1.63	4	6.90	15	1.84
Andrena watasei COCKERELL	1	0.77	4	1.32	2	1.00					7	0.86
Andrena brasicae HIRASHIMA			1	0.33					2	3.45	3	0.36
Andrena fukaii COCKERELL									1	1.72	1	0.12
Andrena sublevigatat HIRASHIMA	1	0.77									1	0.12
Andrena hebes PEREZ			1	0.33							1	0.12
Halictidae												
Lossioglossum sp. (1)	8	6.20	12	3.97	9	4.50	6	4.88			35	4.31
Lossioglossum sp. (2)									1	1.72	1	0.12
Apidae												
Tetralonia niponensis PEREZ									1	1.72	1	0.12
Apis mellifera LINNÉ									1	1.72	1	0.12
Xylocopa appendiculata circumvolans SMITH									1	1.72	1	0.12
Syrphidae												
Eristalis cerealis FABRICIUS	48	35.66	70	23.18	99	49.50	65	52.85	7	12.10	287	35.34
Helophilus virgatus COQUILLETT	3	2.33	21	6.95	23	11.50	18	14.63	3	5.17	68	8.37
Phytomyia zonata (FABRICIUS)							1	0.81			1	0.12
Syrphus torvus OSTEN-SACKEN			9	2.98	16	8.00	5	4.07			30	3.69
Chrysogaster okazaki SSHIRAKI	1	0.77	3	0.99	6	3.00	1	0.81			11	1.35
Dasysyrphus bilineatus (MATSUMURA)					3	1.50	3	2.44			6	0.73
Allograpta javana (WIEDEMANN)			1	0.33	2	1.00					3	0.36
Melanostoma scalare (FABRICIUS)							1	0.81	1	1.72	2	0.24
Total	124	100	302	100	200	100	123	100	58	100	812	100

* Number of individuals ** Percentage in composition

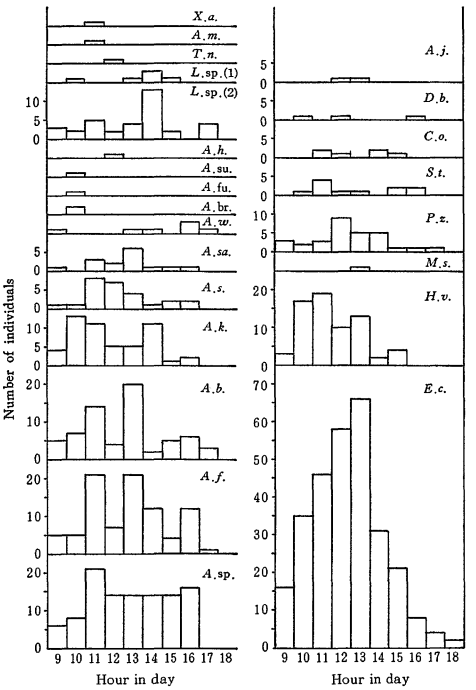

Fig. 1. The hourly sequence of the individual number of each species in daytime

X. a. : *Xylocopa appendiculata circumvolans*
A. m. : *Apis mellifera*
T. n. : *Tetralonia niponenis*
L. sp. (1) : *Lossioglossum* sp. (1)
L. sp. (2) : *Lossioglossum* sp. (2)
A. h. *Andrena hebes*
A. su. : *Andrena sublevigatat*
A. fu. : *Andrena fukai*
A. br. : *Andrena brasicae*
A. w. : *Andrena watasei*
A. sa. : *Andrena sasaki*
A. s. : *Andrena stellaria*
A. k. : *Andrena kaguya*
A. b. : *Andrena benefica*
A. f. : *Andrena foveopunctata*
A. sp. : *Andrena* sp.
A. j. : *Allograpta javana*
D. b. : *Dasysyrphus bilineatus*
C. o. : *Chrysogaster okazaki*
S. t. : *Syrphus torvus*
P. z. : *Phytomyia zonata*
M. s. : *Melanostoma scalare*
H. v. : *Helophilus virgatus*
E. c. : *Eristalis cerealis*

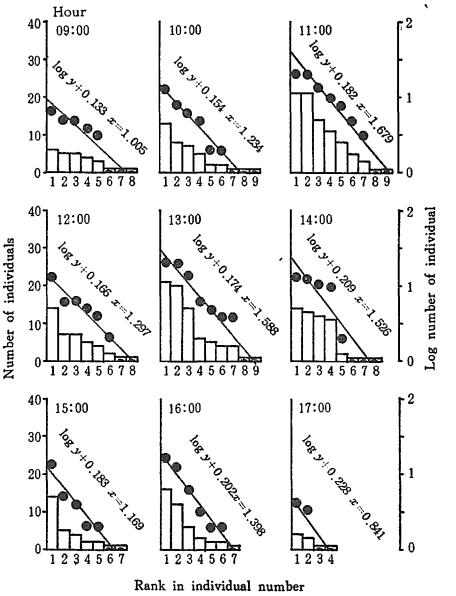

Fig. 2. Hourly change in the form of hymenopterous insects association shown by the geometrical progression method

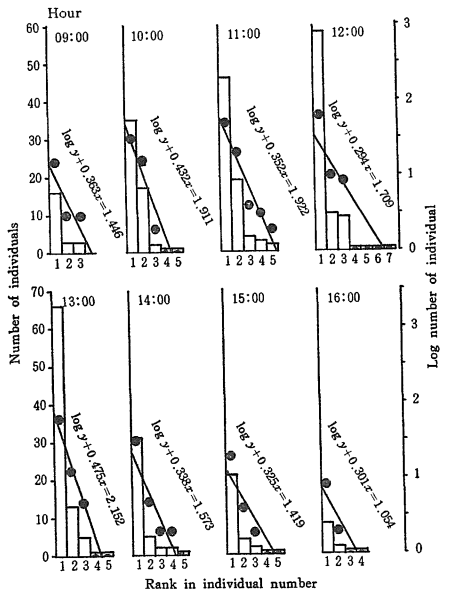

Fig. 3. Hourly change in the form of dipterous insects association shown by the geometrical progression method

collected on the last of flowering period.

The collected species and number of individuals in each species are shown in Figure 1.

3) *The structure of pollinator association*

The structure of pollinator association on each hour was examined by law of geometrical progression described by Motomura[2], i. e., the equation, $\log y+ax=b$. Where y is the number of individuals of one species per unit area, x is the rank in individual number of each species, the value of a is a constant indicating the complexity of the association and the value of b is a constant showing the population density of the association.

The structure of insect association summerized per hour in the present study is shown in Figures 2 and 3. The structure of hymenopterous insects association showed a very complicated pattern at 09.00 hr., and then the pattern gradually changed to a simple with the lapse of time. The population density was high at 13.00 and 14.00 hrs.

The structure of dipterous insects association showed a most complicated pattern at 12.00 hr, and the pattern turned into a simple and the population density was high at 13.00 hr.

4) *The similarity of structure among the associations*

The index of degree of overlap described by Kimoto[3] was used for examination of the similarity among the associations. The experimental equation of Kimoto[3] is as follows ;

$$C_{\Pi}=\frac{2\sum_{i=1}^{S} n_{1i}\cdot n_{2i}}{(\Sigma\Pi_1^2+\Sigma\Pi_2^2)N_1\cdot N_2} \qquad 0\leqq C_{\Pi}\leqq 1$$

$$\Sigma\Pi_1^2=\frac{\sum_{i=1}^{S} n_{1i}^2}{N_1^2},\quad \Sigma\Pi_2^2=\frac{\sum_{i=1}^{S} n_{2i}^2}{N_1^2}$$

Where N_1 and N_2 are the total number of individuals of each association, n_{1i} and n_{2i} are the number of individuals of species no. i in each association, and S is the number of species collected. When $N_1=N_2$, $n_1=n_2$, and two association are equal,

$$C_{\Pi}=\frac{2\sum_{i}(n_{1i})^2}{2(\Sigma(n_{1i})^2/N_1^2)N_1^2}=1$$

The indexes of degree of overlap among the associations of andrenid bees are shown in Figure 4. High similarity of each hour among andrenid bees association was observed as follows ; 09.00 hr vs. 11.00, 12.00, 13.00 and 14.00 hrs, 11.00 hr vs. 12.00 and 13.00 hrs, 12.00 hr vs. 16.00 hr, and 15.00 hr vs. 16.00 hr. As shown in Figure 5, similarity of syrphid flies association on each hour was high at 09.00 hr vs. 10.00 hr, and 10.00 hr vs. 16.00 and 17.00 hrs.

Hour in day	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00
09:00	1.000								
10:00	0.886	1.000							
11:00	0.974	0.826	1.000						
12:00	0.911	0.756	0.934	1.000					
13:00	0.934	0.720	0.940	0.792	1.000				
14:00	0.897	0.857	0.896	0.877	0.764	1.000			
15:00	0.824	0.644	0.837	0.899	0.751	0.790	1.000		
16:00	0.908	0.861	0.933	0.907	0.873	0.885	0.923	1.000	
17:00	0.572	0.347	0.498	0.291	0.699	0.257	0.364	0.451	1.000

Fig. 4. Similarity matrix of C_{Π} in degree of overlap of the andrenid bees association in each hour

Hour in day	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00
09:00	1.000								
10:00	0.876	1.000							
11:00	0.962	0.995	1.000						
12:00	0.999	0.954	0.966	1.000					
13:00	0.993	0.960	0.967	0.994	1.000				
14:00	0.999	0.914	0.931	0.977	0.985	1.000			
15:00	0.985	0.960	0.975	0.991	0.994	0.981	1.000		
16:00	0.943	0.874	0.904	0.954	0.941	0.954	0.959	1.000	
17:00	0.978	0.871	0.889	0.975	0.966	0.989	0.997	0.972	1.000

Fig. 5. Similarity matrix of C_{Π} in degree of overlap of the syrphid flies association in each hour

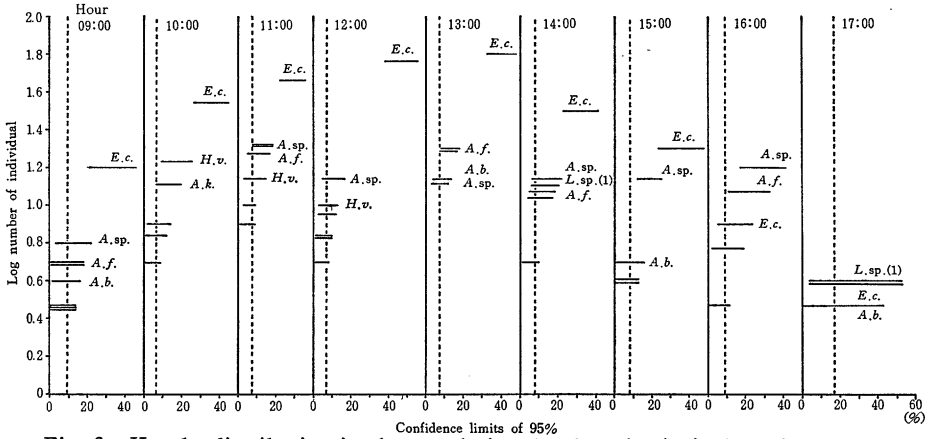

Fig. 6. Hourly distribution in the population density of principal species shown by the confidence limits of 95 per cent

E. c. : *Eristalis cerealis*　　A. sp. : *Andrena* sp.
A. f. : *Andrena foveopunctata*　　*A. b.* : *Andrena benefica*
H. v. : *Helophilus virgatus*　　*A. k.* : *Andrena kaguya*
L. sp. (1) : *Lossioglossum* sp. (1)

5) *The main species of fauna*

The percentage of occurrence probability of the species in fauna was calculated by the method described by Katō et al.[4], and shown in Figure 6. The fauna was mainly composed with the species as follows ;

09.00　*Eristalis cerealis*>*Andrena* sp.
10.00　*Eristalis cerealis*>*Helophilus virgatus*>*Andrena kaguya*
11.00　*Eristalis cerealis*>*Andrena* sp.>*Andrena foveopnnctata*
12.00　*Eristalis cerealis*>*Andrena* sp.
13.00　*Eristalis cerealis*>*Andrena* sp.
14.00　*Eristalis cerealis*>*Andrena* sp.>*Lassioglossum* sp. (1)>*Andrena foveopunctata*
15.00　*Eristalis cerealis*>*Andrena* sp.
16.00　*Andrena* sp.>*Andrena foveopunctata*
17.00　*Lassioglosuum* sp. (1)>*Eristalis cerealis*

From these results, it is concluded that the main species of pollinator in the Japanese pear, var. *Nijisseiki* orchard are six species as follows ; Syrphidae : *Eristalis cerealis* and *Helophilus virgatus*, and Andrenidae : *Andrena* sp., *Andrena foveopunctata*, *Andrena benefica* and *Andrena kaguya*. In particular, *Eristalis cerealis* may be a principal species as a pollinator in the *Nijisseiki* orchard. In the future, it is necessary to investigate the practical use of this species as a pollinator of the Japanese pear, var. *Nijisseiki*.

SUMMARY

1) In the present experiment, the pollinator association in the Japane pear, *Purus serotina* Rehider var. *Nijisseiki* orchard on the flowering period was investigated at 15th to 27th April, 1975.
2) The collected insects as pollinator are as follows ; Andrenidae : eleven species, Halictidae : two species, Apidae : three species, and Syrphidae : eight species.
3) The structure of pollinator association in hymenopterous insects showed the most complexity at 09.00 hr, and that in dipterous insects showed the most complexity at 12.00hr.
4) The similarity of structure among the associations was examined by the method of index of overlap degree. The index of degree of overlap in andrenid bees association

was low 17.00 hr vs. the other times. In syrphid flies association, the index of overlap degree on each hour was low in 09.00 hr vs. 10.00 hr and in 10.00 hr vs. 16.00 and 17.00 hrs.

5) The main species in pollinator association collected at 09.00−15.00, 16.00 and 17.00 hrs was *Eristalis cerealis*, *Andrena* sp. and *Lassioglossum* sp. (1), respectively.

6) It can be concerned that the main species of pollinator in the Japanese pear, var. *Nijisseiki* orchard at San-In District are six species as follows ; Andrenidae : *Andrena* sp., *Andrena foveopunctata*, *Andrena benefica* and *Andrena kaguya*, and Syrphidae : *Eristalis cerealis* and *Helophilus virgatus*.

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摘　　要

この報告は，廿世紀ナシ園における訪花昆虫に関する調査結果である．

1） 採集された訪花性昆虫は，膜翅目ヒメハナバチ科11種，コハナバチ科２種，ミツバチ科３種と双翅目ハナアブ科８種であった．

2） 膜翅目昆虫群集は，午前９時に最も複雑な形態を示した．双翅目昆虫群集は，12時に複雑形態となった．

3） 時刻単位に調査された群集について，群集構成種の重複度指数を求めた．その結果，ヒメハナバチ科昆虫群集についてみると，17時に構成された群集と他の時刻に構成された群集における種の重複度は低かった．ハナアブ科の群集では，９時に構成された群集対10時の群集，10時の群集対16，17時の群集の間の重複度は低かった．

4） 時刻単位において群集をみると，９時から15時までの群集においては，*Eristalis cerealis*, *Andrena* sp. によって代表される．16時から17時の群集は，*Lassioglassum* sp. (1) によって代表された．

5） 廿世紀ナシの花粉媒介昆虫の主要種は，*Andrena* sp. (1), *Andrena foreopunctata*, *Andrena benefica*, *Andrena kaguya* と *Eristalis cerealis*, *Helophilus virgatus* の６種であった．