Studies on a Korean Unrecorded Pamphilid-sawfly (Hymenoptera, Symphyta) Feeding on Korean Pine (Ⅱ)

The Life-history

LEE, Duck Sang
(Forest Experiment Station, Seoul, Korea)

잣나무를 食害하는 韓國未記錄種
넓적잎벌(膜翅目, 廣腰亞目)에 關한 硏究 (Ⅱ)

生 活 史

李 德 象
(農林部 林業試驗場)

(Received June 10, 1962)

摘 要

本論文은 京畿道光陵試驗場에서 잣나무를 食害하는 잣나무넓적잎벌의 生活史를 1958~1961年에 調査硏究한 것을 報告하는 것이다.

本虫의 生活史에 對한 硏究는 東洋에서 아직 報告된바 없다.

1) 光陵에서는 6月中旬부터 7月下旬에 걸쳐서 成虫이 出現한다. 生活期間은 成虫이 5(雄)~6(雌)日, 卵이 約 6日, 幼虫이 約 23日, 前蛹이 約 10.5個月, 蛹이 約 8日이다.

2) 産卵은 新生針葉의 內側에 行하고, 1雌虫의 産卵數는 38粒가량 되고, 1卵을 産付하는데 所要되는 時間은 約 3分間이다.

3) 幼虫은 5令을 經過한다. 幼虫은 吐絲에 依하여 針葉을 엮어서 집을 만든다. 1巢內에 普通 1마리의 幼虫이 棲息한다.

4) 幼虫의 食草는 韓國에 있어서는 잣나무 뿐이다.

INTRODUCTION

The present paper deals with the result of studies on the life history of the Pamphilid-sawfly(*Acantholyda posticalis posticalis* MATS.) feeding on Korean pine (*Pinus koraiensis* SIEB. et ZUCC.) in Kwang-nung Experimentl Forest during 1958-1961.

Besides Kwang-nung Forest, it is known that also the Korean pine forests in 3 areas of Yang-Zu-gun and 6 areas of Ka-pyung-gun, Kyungi-do and 2 areas of Chung-song-gun, Kang-won-do were infested by this from 1957 to 1960. The Korean pine distributes all over Korea except Junla-nam-do. There has been a brief biology on the European race of this insect in France(Berland, 1947), but no record on the life history of the Asian race of this pest we found. The author has published two preliminary reports on this suject (Lee and Cho, 1959 and Lee, 1961).

The Kwang-nung Forest is situated at the distance of about 30 Km in the north-east from Seoul. The soil is composed of gneiss sand and humus. The lowest air-temperature in Kwang-nung is lower than that of Seoul, although the highest temperature and temperature at 10 a.m. are the same with those of Seoul;

the temperature of day shows almost same degree in both places, but the difference in temperatures between day and night in Kwang-nung is greater than that in Seoul.

The soil is fertile and the humus is deep holding a proper amount of water. Water content in soil was 22% in mean as of May 24, 1959. The surface of the soil is covered by fallen needles of Korean pine about 10 cm in thickness. Acidity of the soil shows pH 6.8-7.0.

The forest consists of practically a simple, same-aged woods. The height of pine trees was 10.3 m in mean (range, 9-11 m) and the diameter of trunk on the level of man's breast was 19.7 cm (range, 13-24 cm) as of Oct. 15, 1959. The twigs of the trees are growing on the top only where they build up a crown. In the woods the sun-light is weak and there are many down-plants growing. About 45 families, 62 genera, 83 species and subspecies were found in July, 1961. About 80% of them were grasses(31 spp.), shrubes (19 spp.), vines (8 spp.), and small trees (7 spp.). Among them, Genus *Rubus* were dominant.

MATERIAL AND METHOD

The observation on all stadia of *Acantholyda posticalis posticalis* MATSUMURA feeding on *Pinus koraiensis* SIEB. et ZUCC. was made mainly in the forest and partly in the laboratory. In forest 300 prepupae were digged out and divided into three groups equally. All of them were buried again in the cleansed soil in proportion of one group per 1 m floor square. Each prepupa was taken in an artificial soil chamber which was put in a small stalk-having network. One group per day was pulled up for observation and then buried again. Details of method will be given in each section of the following course.

RESULT AND CONSIDERATION

1. The adult

Appearance: The sawfly has a generation a year. By digging up method it was known that the adult emerged from 9th of June to 24th of July in the soil of the Kwang-nung Forest. The most abundant period of the adult was the first decade of July, 1961 (Table I). The newly emerged adult passed 2 or 3 days in the soil before escaping from the soil. In the view of the above fact, it is considered that the adult may appear on the ground from the middle decade of June to the last decade of July.

TABLE 1. The emergence of adult in soil (1961)

DATE	June 9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
TEMP. AT 10 A.M. IN FOREST(°C)	18	16	21	20	10	21	23	17	29	22	22	18	23	25	21	24	24	23.5	25	26	26	25
FEMALE	0	1	0	1	1	0	3	0	0	3	0	0	2	1	0	0	0	0	0	1	1	5
MALE	2	1	0	1	2	1	0	0	0	1	0	0	4	0	0	4	1	0	0	1	2	2
TOTAL	5	2	0	2	3	1	3	0	0	4	0	0	6	1	0	4	1	0	0	2	3	7

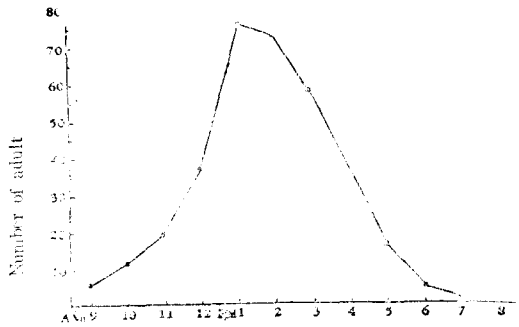
July 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOT.	SEX RATIO
26	26	25	27	28	24	25	24	25	27	26	26	25	24	25	27	28	28	29	30	26	26	26	27		
4	1	2	2	2	5	0	2	6	0	0	1	6	7	3	0	0	3	0	0	2	0	0	2	70	125
5	0	1	1	2	3	1	1	2	0	0	3	1	5	3	0	0	1	0	0	4	0	0	1	56	100
9	1	3	3	4	8	1	3	8	0	0	4	7	12	6	0	0	4	0	0	6	0	0	3	126	

Sex ratio of 126 adults emerged in soil from 9th of June to 24th of July, 1961 was 1:1.25, i.e., 56 males and 70 females (Table 1).

Longevity: The adults just after emerged in soil were collected and reared in net-cylindrical-chamber

(20 cm. in diameter and 30 cm. high), in which a cut twig of the Korean pine was preserved, its cut-end being kept in water. They were fed on honey solution, though their food in field still remains unknown. The longevity of the female seemed to be longer than that of the male; i.e., the male is able to live about 5 days and female about 6 days.

Habits: Flying-The adults are found crowling on the ground or flying under the down-plants for a while and then fly up to the host plant. By every-day collection of the flying adults at the center of the forest for one hour from noon to 1 a.m., it is known that the adults flied about from 26th of June to 26th of July, mostly during 13th to 24th of July, 1961(Table 2). In bright sunshine, they are extremely active and readily try to fly about, but not so active in dull and windy whenthers.



F.g. 1. Daily activity fluctuation in adults. (July 19~July 21, 1961)

The flying hours are from 8 a.m. to 7 p.m. and the most active hours are from noon to 3 p.m. They are more active in the afternoon than in the morning (Fig. 1). In worse wheather, they do not fly and remain still hiding themselves under the foliages. Copulation- Copulation of both sexes takes place on the twig or on the leaf.

TABLE 2. Collection of flying adults (1961).

DATE	Jun. 26	27	28	29	30	Jul. 1	2	3	4	5	6	7	8	9	10
TEMP. AT 10 A.M. IN FOREST (°C)	23	25	26	26	25	26	26	25	27	28	24	25	24	25	27
FEMALE				1	1		2	1	4					3	5
MALE	1		2	1	2	1	1		3	1	3			3	2
TOTAL	1		2	2	3	1	3	1	7	1	3			6	7

11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	TOT.	SEX RATIO
26	26	25	24	25	27	28	28	29	30	26	26	26	27	27	24		
8	4	11	10	18	20	19	20	25	23	21	15	19	11	4	2	237	145
5	5	6	7	13	13	12	14	19	18	15	14	6	5	3	1	164	199
13	9	17	17	31	33	31	34	44	41	36	29	15	16	7	3	401	

Sometimes during copulation the couple fall down on the ground and continue their behavior. After copulation, the male falls down and then craws weakly on the ground for a while and finally dies. The female, however, rests under the foliage for a few days after copulation and then flies about to lay her eggs. Oviposition- Usually oviposition takes place afternoon. Even at the first time of oviposition the female visits only the newly grown leaf. As soon as she alights on the young leaf she begins to seek for the most suitable portion for oviposition. Usually the female selects the young leaves (about 94.7mm. in length) of new shoots on the over-wintered twigs for oviposition, and it has never been observed that they oviposited on the old leaves(about 112mm. in length). When the female has finished the first egg-laying, she goes on to the next leaf of other twig in same or other tree and repeats the above-mentioned action. Generally the course of one-egg-laying lasts only about 3 minutes (Table 3).

Table 3. The time for ovipositting an egg (July 19, 1960)

Time (Minutes)	2	2.5	3	4		
No. of eggs observed	1	1	7	1	Total 10	mean 2.95Minutes

Table 4. Number of eggs per needle(July 12, 1959)

No. of eggs	1	2	3	4	Total
No. of needles	29	16	3	2	50

Usually the eggs are laid on the inside of the upper half part of needles. Mostly the female lays one egg per needle in a group of leaves (Table 4).

Sometimes 2 to 4 eggs are laid per needle as shown in table 4. But it is considered that 2 to 4 females lay down their eggs one by one on a same needle. For the purpose of observation of egg-laying capacity, the females were dissected before and after oviposition. The results are shown in Table 5. From the table it will be seen that before oviposition the total number of eggs in ovaries of a female is about 42, but after oviposition only 4 eggs are remained in ovaries. Therefore, over 90% of the ovarian eggs are deposited.

Table 5. The number of eggs in ovary before and after oviposition (July 17, 1960)

	No. of eggs before oviposition	No. of eggs after oviposition	No. of deposited eggs by guess
No. 1	43	5	38
2	41	6	35
3	40	2	38
4	39	6	36
5	38	5	33
6	40	4	36
7	42	2	40
8	44	6	38
9	43	3	40
10	46	4	42
Total	416	40	376
Mean	41.6	4.0	37.6

It is considered that at least 6 days after emergence the female will begin oviposition, since one example of reared females deposited 9 unfertilized eggs at 6th day after emergence.

The eggs on leaves were found from 1st of July to 1st of August and the most abundant period was 21st to 27th of July, 1961.

About one day after finished oviposition the females die on the leaves or twigs and some of them fly down on the ground and die.

2. The egg

The egg is light yellowish green in color just after oviposition, but becomes purple-yellowish green 3 days after that. The shape of the egg is boat-like and the both ends of it process. Their sizes are shown in Table 6.

Table 6. Measurement of eggs(mm). July 12, 1959

	Min.	Max.	Mean	S. D.
Length	3.04	3.96	3.17	0.073
Width	0.70	1.09	0.87	0.114
Height	0.84	1.22	1.01	0.146

Table 7. Incubation period of the egg. (1960)

Incubation period (day)	5	6	7	Total	Mean
Number of eggs	3	9	12	24	6.38 days

In the laboratory the eggs on the leaves, just after deposited, were kept in open dishes 9cm. in diameter

and 1.5cm. in depth) moistened with wet cotton. 200 eggs were kept in this condition and only 48.5% of them hatched in 1960. The incubation period was 6.4 days in mean, details being seen in Table 7.

In time the dorsal median line of the egg shell is splitted and a larva gets out from the shell.

3. The larva

Morphology: The brief description of the 5th instar larva has been done in the preliminary report on this subject (Lee, 1961).

1st instar larva with large head and slender trunk. The color of the head part black and trunk reddish yellow just after hatching, but soon changes into green. 2nd instar larva cylindrical in form and green in color. 3rd instar larva nearly similar to 2nd instar larva in form, but the color changes in bluish-green. 4th instar larva almost similar to 3rd instar larva in form and color. 5th instar larva reddish yellow in color.

Development: The development of the larva was observed during July 19–August 14, 1961 in forest where the temperatures at 11 a.m. were 30°C in max., 23°C in min. and 27°C in average.

The larva have usually 4 moults. In this paper "5th instar" is determined by the interval from the 4th moulting up to the time when the larva ceases eating. The 5th instar longest, the 2nd and 3rd instars subequal and shortest as shown in Table 8. The total larval period is 23.27 days on an average as recorded in Table 9.

The duration of the larval stage may be changed by the environmental condition.

Table 8. Durations of larval stadia (1961).

Duration (days)	Instar				
	1st	2nd	3rd	4th	5th
10	—	—	—	—	1
9	—	—	—	—	—
8	1	—	—	—	2
7	3	1	—	—	3
6	2	2	—	5	2
5	2	—	3	1	4
4	4	3	1	—	1
3	—	5	2	1	—
2	—	2	1	—	—
No. of examined specimens	12	13	7	7	13
Average of duration	5.58	3.85	3.86	5.43	6.38

Table 9. Length of larval period (1961)

Larval period(days)	21	23	24	Total	Average
No. of examined specimens	1	5	5	11	23.27 days

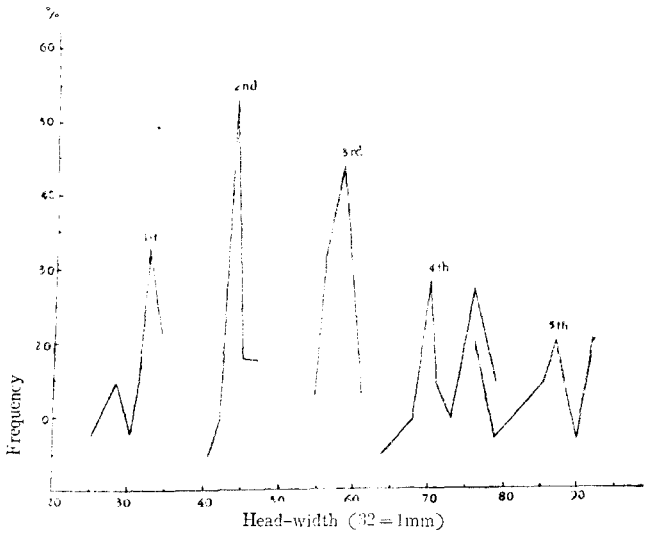


Fig. 2. Frequency distribution of the head-width of each instar. (Number of each instar larvae similar to Table 10)

The head width of the alcoholic specimens of each instar larva were measured with ocullar micrometer as shown in Table 10 and Fig. 2.

From this table it will be seen that the standard deviations of the older stages are larger than those of the younger. The growth ratios are largest in the 2nd instar and become smaller in order of the older stage. From Fig. 2 the differences between both sexes may be seen only at the 5th instar.

Habits: The hatching larva moves toward the base of the needle-fascicle swinging the head to and fro. When the larva reaches the top of the newly grown shoot she begins to lay a number of silks and

Table 10. Head-widths of each instar larvae (mm). 1961.

Instar	Min.	Max.	Average	Standard deviation	Growth ratio	No. of measured specimens
1st	0.780	1.073	0.782	0.071	1.000	14
2nd	1.268	1.433	1.383	0.029	1.498	23
3rd	1.707	1.902	1.811	0.018	1.309	15
4th	2.000	2.429	2.214	0.221	1.284	22
5th	2.311	2.829	2.634	0.297	1.174	15

spreads it on the leaves around herself.

In this way the larva spins a spindle-formed nest, the both ends of which are not closed, and around which a number of leaves are attached. Following the growth of larva, step by step, the nest becomes elongated distally by threads and more leaves are attached to the nest. The larva cut-eats the newly grown needles in the way of exposing the upper half part ef the body from the distal hole of the nest. A number of needle-peaces as remnants of food attaching to the nest (Fig. 3) or/and the excrements of the larva fall down on the ground. From the end of July to the beginning of August the falling sound of excrements becomes noisy. By this aspect it seems that the larva eats violently and grows quickly.

The average number of twigs per tree are 64 (range, 121-32) and the number of nests per twig are averaged to 82 (range, 327-22). The average number of larvae in a nest are 1,144 (Table 11). Therefore, it is calculated that about 6,000 (1,144×82×64) individuals are living on a tree.

Fig. 3. A sketch of nests
(A) 30×20mm
(B) 25×15mm

Table 11. Number of the larvae per nest. (Aug. 14, 1959)

No. of larvae per nest	1	2	3	Average no. of larvae per nest
No. of nests observed	220	24	6	1.144
Percentage	88.0	9.6	2.4	

Since 48.2 needle-fascicles in average are hung in a nest(Table 12) and all of them are damaged, it is calculated that the total number of infested needle-fascicles in a tree are approximately 250,009 (48.2×82×64).

Table 12. Number of needle-fascicles per nest. (Aug. 14, 1959)

Min.	Max.	Average	No. of observed nests
11	127	48.2	29

On the other hand, since a sound twig has about 4,688 needle fascicles in average, it is calculated that the total number of sound needle-fascicles in a tree are approximately 300,000 (4,688×64). Therefore, the proportion of damaged needle-fascicles is about 83% in a tree.

Food-plant: The larvae and eggs were found only on *Pinus koraiensis* SIEB. et ZUCC. in the field. The following 7 species of pine-trees were used for the purpose of experiments of ascertaining food-plant of the larvae: *Pinus koraiensis*, *P. densiflora*, *P. parviflora*, *P. rigidae*, *P. banksiana*, *P. strobus*. In each above-mentioned net-chamber, a twig with leaves of one species of the above pine-trees was preserved and a number of 3rd instar larvae were set free between leaves. The larvae did not eat any leaves but of *P. koraiensis*. From the above result it may be considered that the food-plant of this insect in Korea is *Pinus koraiensis* SIEB. et ZUCC.

At first the present insect eats up newly grown needles and then eats old one. In this way the larvae

eat almost all of needles on the twig. Therefore, the infested twig remains naked out in August.

In accordance to some records, the food-plant of the present insect in over-sea lands are: In Japan the host of this pest is recorded as *Pinus* (Takeuchi, 1949). On the other hand the habitat of this pest is Tokyo (Matsumura, 1912 and Takeuchi, 1930) and Kyoto (Takeuchi, 1930).

In Europe as the food-plants *P. silvestris* LINNE which is popular in north Europe and *P. pumilio* WILLK which is distributed in Mt. Pyrenees and most abundant near France are known (Berland, 1947). The above two species, however, are two-needle pines.

Falling: At the end of 5th instar the larva ceases eating and threading and then falls down on the ground. Some one falls down in prepupal form (=6th instar larva) after moulting once more on the tree. In accordance to the collection of the larvae which are fallen in one meter floor spuare, the rate of 5th and 6th instar larvae was 100:92 in 1961. The larva began to fall from July 29 (Temp. 27°C at 11 a.m. in the forest) to August 21 (Temp. 26°C at 11 a.m. in the forest), 1961. The diminition rates of the larvae on the tree were 2% at July 29, 22% at August 4, 48% at August 10, 70% at August 16, and 94% at August 21 in the same year. The fallen larva and prepupa after suspending animation about 10 minutes move around near-by on its ventral surface and then burrow the humus for about 5 minutes in suitable place diagonally on its dorsal surface.

The larva or prepupa burrowed to considerable depth makes a pupal chamber, with the soil and its own saliva. The 5th instar larva moults one more in the pupal chamber and then enters the prepupal stage.

4. Prepupa

The pupal chamber, in which the prepupa hibernates, looks like a small bird nest as shown in Fig. 4. The thickness of the wall is about 4 mm. and the size of the cavity is about 10×8.7×19 mm. The prepupa almost always curves itself ventrad as a ring. Judging from the observation through the glass of petri-dish, the prepupa may be able to change the direction by itself in the pupal chamber. The prepupa can be segregated into male and female by the body length as shown in Table 13.

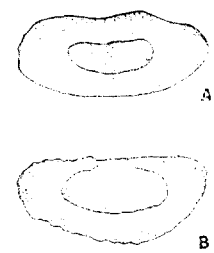


Fig. 4. Pupal chambers
A. Horizontal section
B. Sagital section

Table 13. The body lengths of the prepupae (mm). (June 29, 1961)

Body lengths	14	15	16	17	18	19	20	21	22	23	24	Total
No. of prepupae	5	12	5	2	—	1	3	13	—	6	3	50
Male	3	9	4	1	—	—	—	—	—	—	—	17
Female	—	—	—	—	—	—	3	9	—	4	2	18

Note: 15 among 50 prepupae were dead.

Namely the prepupa of 14—17 mm. in body length will become male and the same of 20—24 mm. female. The difference in length between the largest male and the smallest female is 2—3mm.

The location of them was in a depth of 1—30cm. in the ground and over 92% of them located in a depth of 1—15 cm. as shown in Table 14.

Table 14. Vertical distribution of the prepupae in the soil (Nov. 11, 1959).

Depth (cm.)	1—5	5—10	10—15	15—20	20—25	25—30
Distribution condition(%)	30.94	37.10	24.07	6.67	1.12	0.11

But it is considered that the location of the pupal chambers in the ground may vary with the soil conditions. 417 prepupae were made to burrow in a certain limited space (1cm²) of the forest soil on Sept. 10, 1959, whereas only 232 of them were found in prepupal form when dug out and made thorough examination on May 29, 1960. The reduction of the individual number may be due to the attacking of their natural enemies, the detail of which will be described the other day. The prepupal period is very long, about 10.5months from August to June of the following year.

5. The pupa

The pupation takes place in the pupal chamber from the beginning of June to the middle of July, most abundantly in the last of June. The pupal period is very short, 7.0 days in average before emergence as shown in Table 15.

Table 15. Pupal period (May 27-July 22, 1960, June 3-July 24, 1961)

Pupal period(days)			5	6	7	8	9	10	11	Total	Average
No. examined	1960	female	—	5	15	12	5	1	—	38	7.5 days
		male	—	1	10	7	1	3	—	22	7.8 days
	1961	female	1	13	7	11	12	—	1	44	7.5 days
		male	1	9	6	5	14	—	—	35	7.6 days

In laboratory the pupation took 48.3 minutes in average as shown in Table 16.

Table 16. The proceeding time for pupation (July 10—12, 1959)

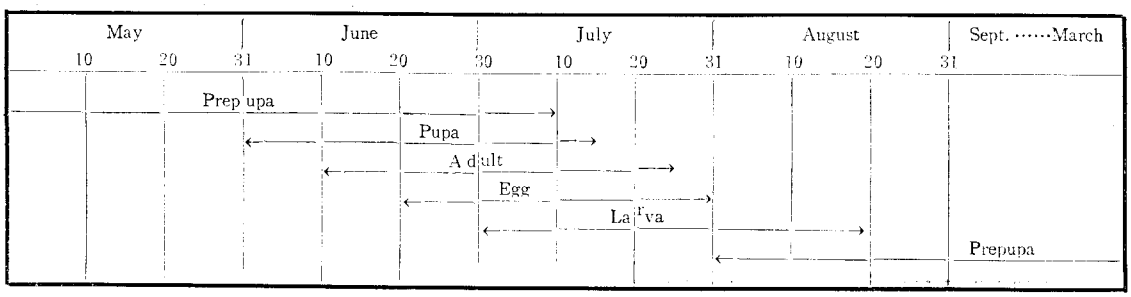
Time (minutes)	35	36	37	39	41	42	43	48	57	63	65	Total
No. observed	1	1	1	1	1	1	1	1	1	1	2	12
Mean	48.3 Minutes				Temperature						23°C at 10 a.m.	

The color of the pupa is yellow just after pupation and the eyes are black from the beginning. 4—5 days before emergence the ends of mandibles become to be colored, and 3 days before emergence the dorsal part of thorax and the wings become to be violetish and the color of body becomes heavy.

6. The life cycle

The life cycle of this sawfly is summarized in Table 17.

Table 17. Life cycle



SUMMARY

The present paper contains the observation made on the life-history and habits of *Acantholyda posticalis posticalis* MATS. (1912) in Kwang-nung Forest.

1). The saw-fly has one generation a year. The life on the earth is about one month from June to July

and that in earth is about 11 months in prepupal and pupal stages. The details are as follows: adult about 5 days in male and about 6 days in female; incubation period about 6 days; larval pericd about 23 days; prepupal stage in the ground about 10.5 months; pupal stage about 8 days.

2). The female lays eggs one by one on the inside of needles. The egg is about 3.17×0.87× 1.81 mm. in size. Usually one egg is deposited on each shoot.

3). The larvae have 5 instar, which conceal themselves in nests made by means of thread and live always solitary.

4). The food-plant is always *Pinus koraiensis* SIEB. et ZUCC. in Korea.

Acknowledgements

The author wishes to express his heartiest thanks to Dr. Robert B. Benson for his advice as to the food-plants in Europe, to professor Teiichi Okutani for his help as to the valuable literatures, to Dr. Duk-Bong Lee for his identification of the down-plants, to the director of the Forest Experiment Station in Seoul for the financial support, and to Mr. Beomsu Yun for his cooperation in field works.

REFERENCES

Matsumura, S., 1930; Hymenoptera, Ill. Thous. Ins. Jap. Vol. II, 95—96.

Takeuchi, K., 1930; A revisional list of Jap. Pamphilidae, with descrip. of nine new sp., Trans. Kansai Ent. Soc. No. 1, 4.

———, 1949; A list of food-plants of Jap. sawflies, 47.

Berland, L., 1947; Faune de France, 47, Hymenopteres Tenthredoides, P. 34-

Okutani; T., 1955; Studies on Symphyta (Ⅱ), Sci. Rep. Hyogo Univ. Agri.: Vol. Ⅱ, No. 1, Series: Agri., 80—88.

———, 1956; Outline of life-history of a sawfly, Sci. Rep. Hyogo Univ. Agri: Vol. Ⅱ, No. 2, Series: Agri. Bio., 3—10.

———, 1959; Sawflies as injurious forest ins., News of forest prevention of epidemics, Vol. Ⅷ, No. 10, 174—175.

———, and Mikata S., 1958; Studies on Symphyta X., Jap. Jour. Appl. Ent. Zool., Vol. Ⅱ, No. 2, 100—112.

Kato, Y., 1958; Sawflies feeding pines, News of forest prevention of epidemics, Vol. Ⅷ, No. 10, 174—175.

Lee and Cho, 1949; Studies on the destructive leaf-rolling-sawfly of the Korean pine(Preanouncement), Bull. of Forest Experiment Station, No. 8, 85—110.

Lee, 1960; Studies on a Korean unrecorded Pamphilid-sawfly (Hymenoptera, Symphyta) feeding on Korean pine (Ⅰ), Kor. Jour. Zool., Vol. Ⅳ, No. 1, 1—6.