ECOLOGY OF PLA TYGASTER MA TSUTAMA AND INOSTEMMA SEOULIS (HYMENOPTERA : PLATYGASTRIDAE), EGG-LARVAL PARASITES OF THE PINE NEEDLE GALL MIDGE, THECODIPLOSIS JAPONENSIS (DIPTERA, CECIDOMYIIDAE)

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ECOLOGY OF *PLATYGASTER MATSUTAMA* AND *INOSTEMMA SEOULIS* (HYMENOPTERA : PLATYGASTRIDAE), EGG-LARVAL PARASITES OF THE PINE NEEDLE GALL MIDGE, *THECODIPLOSIS JAPONENSIS* (DIPTERA, CECIDOMYIIDAE)[1)2)3)]

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Abstract

Platygaster matsutama and *Inostemma seoulis* and their host, *Thecodiplosis japonensis*, are univoltine. Adults of both parasites emerge from hibernating host puparia ; the emergence periods are mid-May through mid-June for *P. matsutama* and early June through mid-July for I. *seoulis*. The females of *P. matsutama* oviposit into host eggs, those of *I. seoulis* either into newly hatched larvae or into eggs just prior to hatching. The average numbers of ovarian eggs per female were 1,569 and 555 for *P. matsutama* and *I. seoulis*, respectively, and the female : male sex ratios for adults of both species collected in field emergence traps were 38 : 62 and 60 : 40, respectively. The parasites mate and oviposit during the day, and rest on the undersides of leaves of broadleaved plants at night. In both parasites, development is monembryonic. Whereas *P. matsutama* has only one larval instar, *I. seoulis* has two. In P. *matsutama*, the duration of the pupal stage averaged 31.6 days at a laboratory temperature of 20°C. In cases of symparasitism, adults of only *P. matsutama* emerge ; *I. seoulis* dies in the first stadium. In cases of superparasitism by *P. matsutama*, all individuals reach adulthood, but in *I. seoulis* only one adult can emerge from a single host puparium.

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[3)] Contribution from the Entomological Laboratory, Faculty of Agriculture, Kyushu University, Fukuoka (Ser. 3, No. 193).

Introduction

Four hymenopterous parasites are recorded in Korea as natural enemies of the pine needle gall midge, *Thecodiplosis japonensis* Uchida et Inouye. Among them, *Platygaster matsutama* Yoshida et Hirashima and *Inostemma seoulis* (Ko) are known to be most important. Although their ecologies have been studied by many researchers (Ko, 1963, 1965, 1966, 1971 ; Miura, 1962 ; etc.), little was known about the earlier stages of development and about the details of the life histories. This paper helps to fill that knowledge gap.

P. matsutama and *I. seoulis* occur in midge-infested pine stands. *I. seoulis* occurs in all part of Korea inhabited by the pine gall midge and is also known from Japan. *P.* matsutama, which was first discovered in Japan, has a Korean distribution that is restricted to the warmer coastal regions.

Study Site

Site A is located in Namgok-ri, Taech'bm-tip, Poryŏng-gun, where the midge population decreased to non-injurious levels following an outbreak that peaked several years ago.

Site B is located in Himang-ri, Hongch'ŏn-ŭp, Hongch'ŏn-gun, where the midge population is gradually increasing.

Materials and Methods

For both the field and laboratory rearing, all host material was field-collected. The ontogeny of the parasites was studied at Sites A and B throughout 1983 and 1984 by observing the various non-adult stages of *T. japonensis* and making dissections of them. Parasite eggs and larvae were measured with an ocular micrometer to determine changes in length during growth.

During the period May 13 through July 20 in both years of the study, adult emergence traps (60 at Site A, 40 at Site B) were placed beneath pine branches from which the midge larvae had emerged and entered the soil. The traps were examined daily, and the newly emerged adults of the parasites and the host were brought into the laboratory for examination. After being sexed, they were preserved in 70 % ethanol. The habits of the adult parasites were observed both in the field and the laboratory.

Results and Discussion

GENERALIZED LIFE CYCLES

The adult and immature stages of the pine needle gall midge or pine gall midge, *Thecodiplosis japonensis*, are illustrated in Fig. 1.

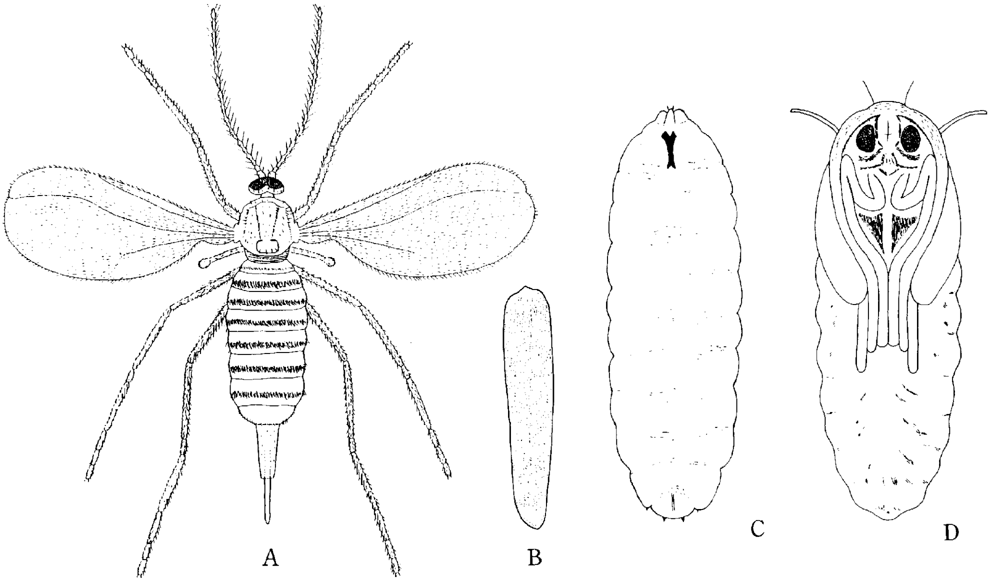

Fig. 1. The pine needle gall midge, *Thecodiplosis japonensis*. A : Adult. B : Egg. C : Full grown larva. D : Pupa.

The life cycles of the parasites are illustrated in Figs. 2 and 3. Both parasites are univoltine. *P. matsutama* adults emerged from May 14 through June 20, whereas those of I. *seoulis* emerged from June 13 through July 18. Mating occurs soon after emergence and is followed immediately by oviposition.

Eggs are inserted into the eggs or newly hatched larvae of the host. The eggs do not hatch until the host reaches larval maturity, and the parasites pass the winter as embryos (*P. matsutama*) or first instars (I. *seoulis*) within the host larva. In the spring of the following year, the parasite larvae develop rapidly, and when they mature, the host larvae die. Pupation occurs within the skins of the host puparia, and the parasite adults emerge about 5 weeks later.

PLATYGASTER MATSUTAMA LIFE STAGES AND DEVELOPMENT

The egg

The egg (Fig. 4, A) of *P.* ***matsutama*** is hyaline, highly refractive, and 0.018 mm long immediately after oviposition. The shape is subellipsoidal, rounded at the cephalic end, but slightly attenuated and usually turned a little to one side at the caudal end. There is an overall similarity to the shape of the egg of *P. herrickii* Packard (Hill and Emery, 1937), but the egg of the latter species differs from that of *P.* ***matsutama*** in having three, short, flagellum-like, follicular adherences on the cephalic end.

Following oviposition, the eggs are free within the host egg (Fig. 4, B) but later attach to the brain or midgut of the host larva (Jeon, 1983). There is good agreement

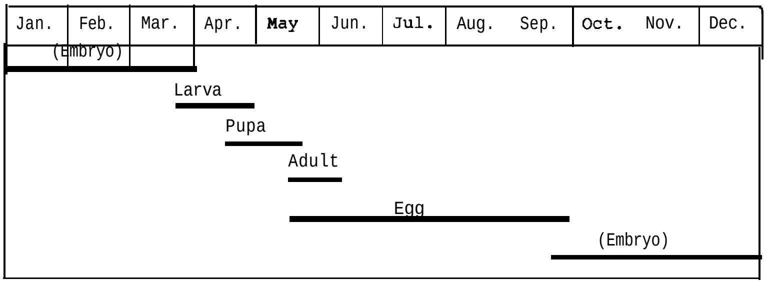

Fig. 2. Life-cycle of *Platygaster matsutama* at Taech'ŏm area, 1983-84.

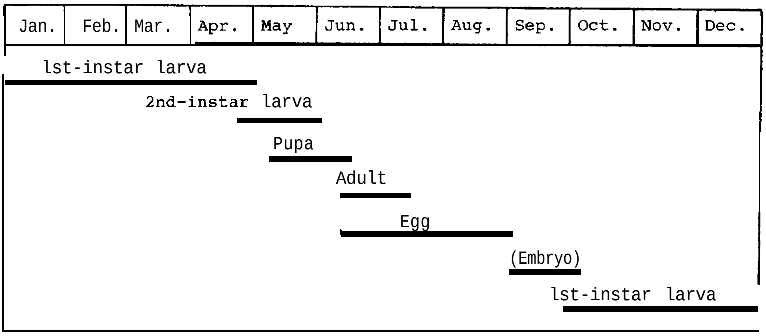

Fig. 3. Life-cycle of *Inostemma seoulis* at Hongch'ŏn area, 1983-84.

with the observations of Dumbleton (1934, 1935) on the eggs of *Platygaster demades* (Walker).

Embryonic development

The eggs develop monembryonically. Shortly after growth commences, many paranuclear masses form, and the developing *P. matsutama* embryo becomes encysted within host tissues and absorbs sustaining nutrients from them (Fig. 4, E). *P. matsutama* overwinters as an embryo, and embryonic development accelerates in the spring.

The *P. matsutama* eggs never hatch until after the host has reached larval maturity. When the first instar is completely formed, it breaks away from the surrounding trophamnion and initiates feeding.

The larva

The form of the *P. matsutama* larva, its developmental stages, and the embryonic development as well are essentially similar to those of *P. ornatus* Kieffer (Marchal, 1906), *P. hiemalis* Forbes (Hill, 1926), and *P. manto* Walker (Postner, 1973). When fully devoloped, the *P. matsutama* larva (Fig. 4, F) is white, devoid of setae, hymenopteriform, and about 0.7 mm wide by 1.8 mm long. The mandibles (Fig. 4, G) are 0.0375 mm long, attenuated, and nearly straight. There are three thoracic and seven abdominal segments. There are spiracles on the second and third thoracic segments and on the second abdominal segment, and there is a large discoidal body in the first abdominal segment.

During the feeding period, the larva increases somewhat in size and develops fat

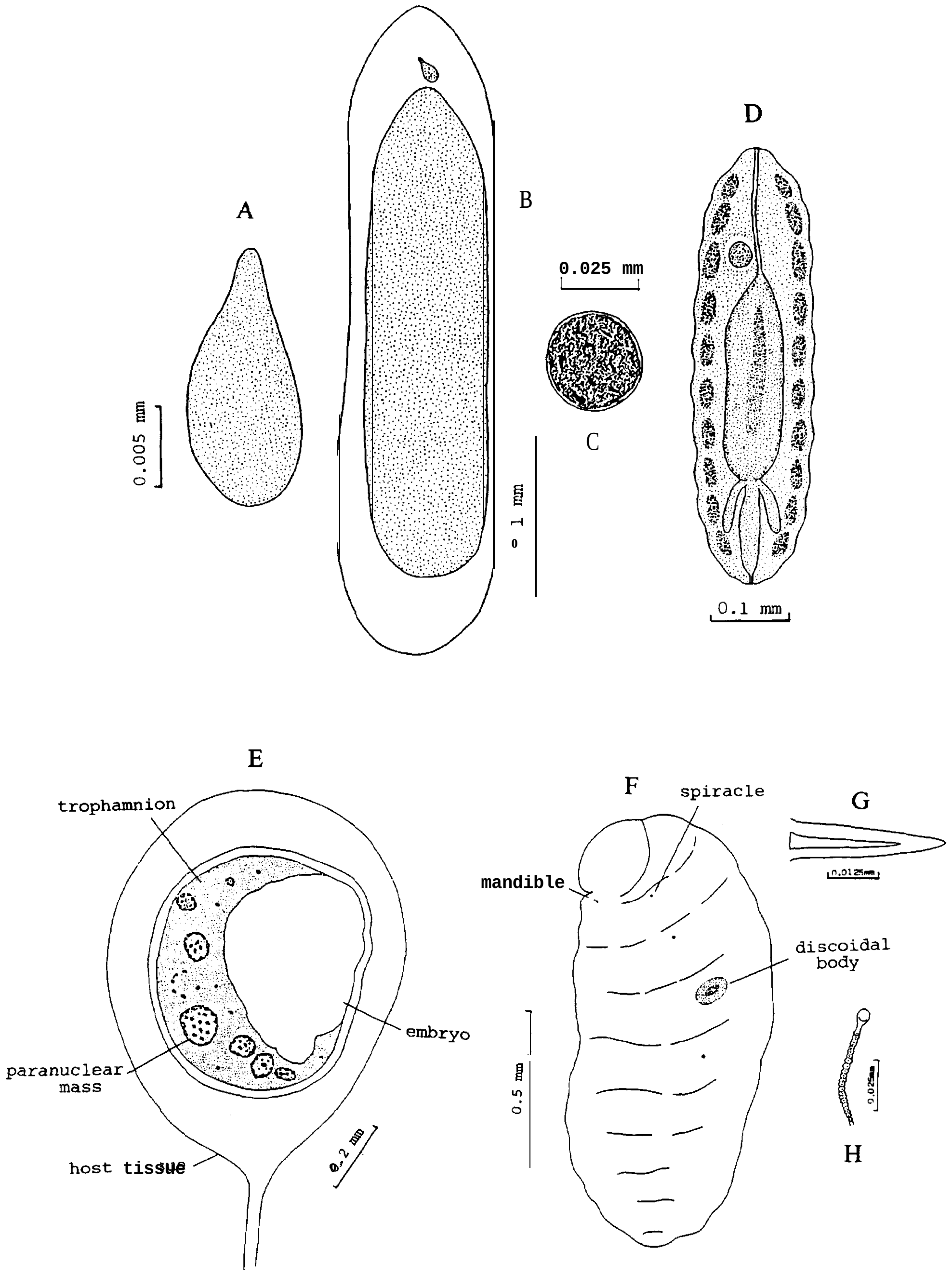

Fig. 4 (a). Developmental stages of *Platygaster matsutama.* A : Egg before oviposition, B : Egg immediately after oviposition in host egg, C : Encysted egg, D : *Thecodiplosis japonensis* larva containing a *Platygaster matsutama egg*, E : Embryo surrounded by trophamnion and host tissue, F : Lateral view of a larva, G : Mandible, H : Spiracle.

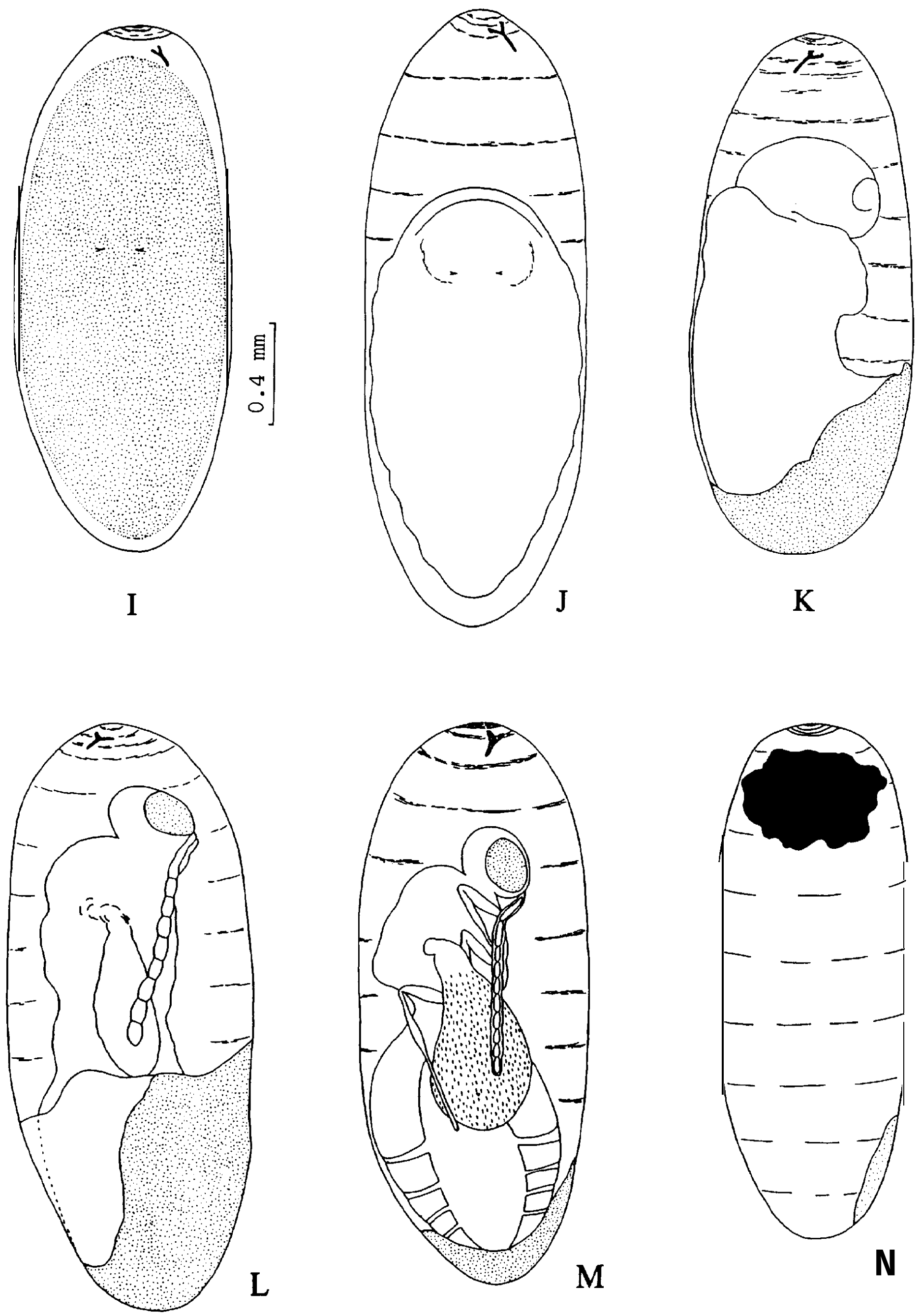

Fig. **4(b).** Developmental stages of *Platygaster matsutama* (continued). I : Early stage of prepupa, J : Prepupa, K : Early stage of pupa, L : Pupa M : Pupa, N : Host puparium, showing exit hole made by its parasitoid, *Platygaster matsutama.*

bodies but does not molt. There are no changes in mandibular size or shape. After killing the host larvae by entirely consuming the body contents, the ***P. matsutama*** larva enters the prepupal stage (Fig. 4, I, J) within the oblong, yellowish-brown integument of the host puparium.

Two or more larvae are frequently found in a single host. Normally, they all reach maturity and emerge as adults. On the other hand, symparasitism by ***P. matsutama*** and I. *seoulis* is uncommon ; ***P. matsutama*** survives, but I. *seoulis* dies in the first stadium.

The pupa and adult

Initially the ***P. matsutama*** pupa (Fig. 4, M) is white ; the eyes soon darken, and the entire body, with the exception of the integuments between the abdominal plates, gradually assume the shiny black coloration of the adult. At a laboratory temperature of 20°C, the duration of the pupal stage averaged 30.6 days. The adult female (Fig. 5, A) ranges in length from 1.2 mm to 1.75 mm. Yoshida and Hirashima (1979) gave the distinguishing adult characters of ***P. matsutama.***

INOSTEMMA SEOULIS LIFE STAGES AND DEVELOPMENT

The Egg

The egg (Fig. 6, A) of *I. seoulis* is hyaline, highly refractive, lemon-shaped, and bears a long stalk on the anterior end. The length of the body of the egg is 0.055 mm immediately after oviposition, and the stalk is twice as long as the body. Marchal

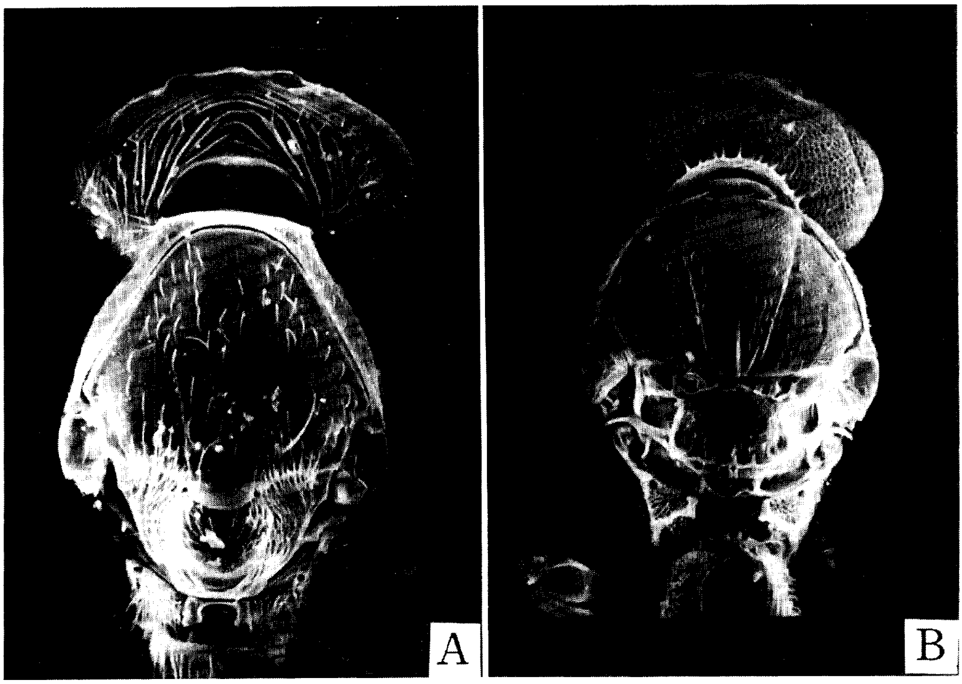

Fig. 5. Parasitic wasps of the pine gall midge. A : *Platyguster matsutama,* B : *Inostemma seoulis.*

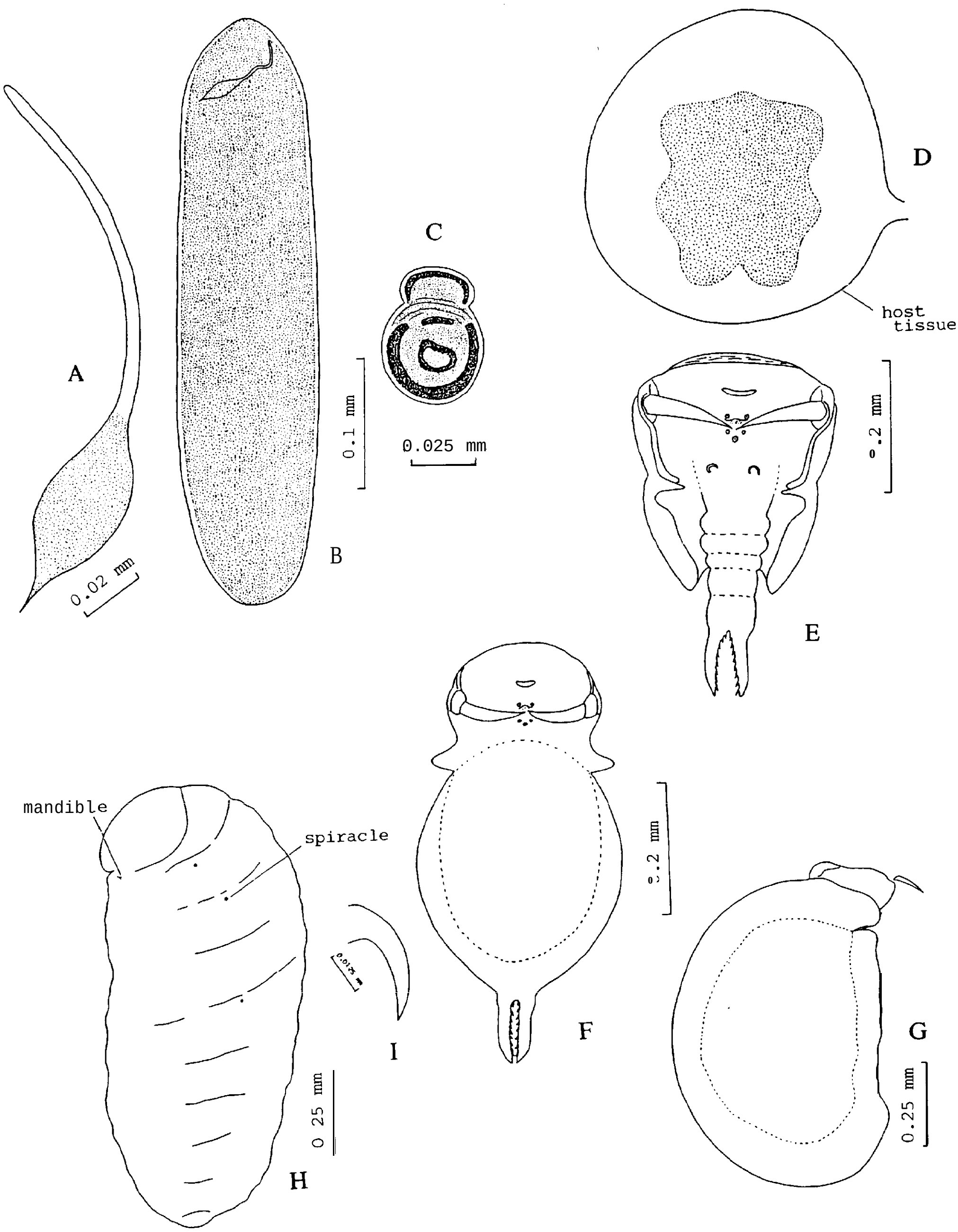

Fig. 6. Developmental stages of *Inostemma seoulis*. A : Egg before oviposition, B : Egg immediately after oviposition in host egg, C : Embryo, D : Early stage of 1st instar larva surrounded by host tissue, E : First instar larva, F : The latter stage of 1st instar larva, G : Second instar larva immediately after moulting, H : Lateral view of mature larva, I : Mandible.

(1906) illustrated the very similar egg of *Inostemma piricola* Kieffer. Immediately after oviposition, the *I. seoulis* egg is free in the egg (Fig. 6, B) or the first instar of the host but later attaches to the nervous system (Fig. 7, A) (Jeon, 1983).

Embryonic development

The eggs develop monembryonically. Shortly after embryonic development commences, paranuclear masses form, and the developing embryo (Fig. 6, C) encysts within the tissues of the host. As with *P. matsutama*, the egg does not hatch until after the host has reached larval maturity (i.e. instar 3 is fully grown), but *I. seoulis* differs from *P. matsutama* in overwintering as a first instar rather than in the egg stage.

The primary larva

The first instar (Fig. 6, E) is cyclopean in form, with the cephalic region slightly longer and considerably wider than the caudal region. The caudal region has a bifurcate appendage. The buccal opening in circular and above the mandibles, which are 0.11 mm long, falcate, and curved near the apical extremities.

Two or more first instars are often found within a single host, but only one survives. In the spring, after having overwintered, the fully developed first instar (Fig. 6, F) breaks away from the surrounding host tissue and molts.

The second instar (Fig. 6, G)

Feeding is initiated right after the molt to the second (final) larval instar. When mature, the second instar is white, hymenopteriform, devoid of setae, and about 0.7 mm wide by 1.8 mm long. There are three thoracic segments, seven abdominal segments, and spiracles on the second thoracic, third thoracic, and second abdominal segments. The mandibles (Fig. 6, I) of the second instar are 0.035 mm long and slightly curved. Although Marchal (1906) did not illustrate the mature larva of *I. piricola*, his description of it and his account of larval development in the species indicate that it is very similar to the mature larva of I. *seoulis*.

The pupa and adult

The *I. seoulis* pupa is very similar to that of *P. matsutama*. The adult female (Fig. 5, B) is black, ranging in length from 1.28 mm to 1.72 mm. Yoshida and Hirashima (1979) gave the distinguishing characters of I. *seoulis* adults.

PARASITIC POSITION OF *P. MATSUTAMA* AND *I. SEOULIS* IN THE HOST LARVA

The larva of *Platygaster matsutama* prefers to attach either the ganglion or stomach of the host larva, but that of *Inostemma seoulis* attaches only the ganglion of the host larva (Fig. 7).

THE ADULT EMERGENCE PERIODS

Study site A

In 1984, the periods of adult emergence in the field (Figs. 8 and 9) were May 14 through July 5 for *T. japonensis*, May 14 through June 20 for *P. matsutama* (peak

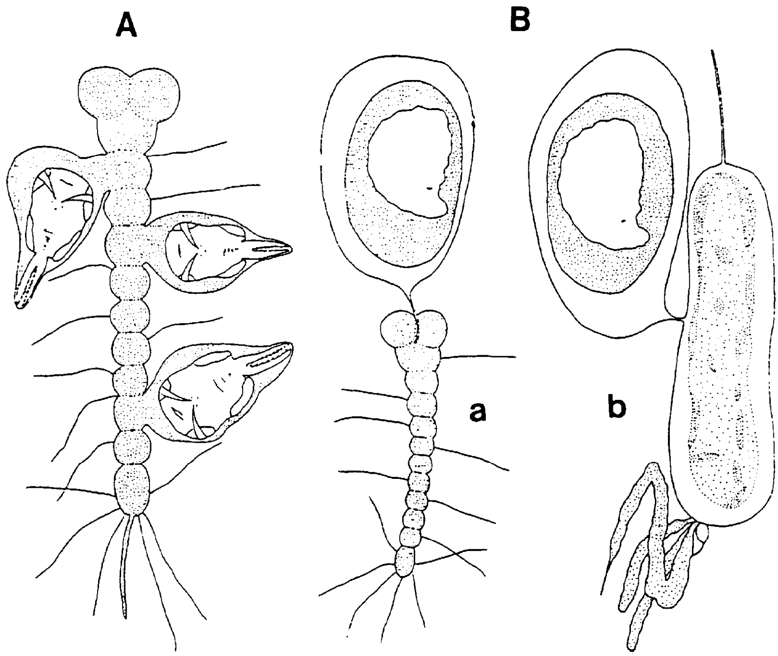

Fig. 7. Locations of parasitoids in host larva. A : *Inostemma seoulis* larvae attached to the ganglia, Ba : *Platygaster matsutama* larva attached to the ganglia, Bb : *Platygaster matsutama* larva attached to the stomach.

between May 30 and June 6), and June 15 through July 2 for *I. seoulis.* The emergence data for 1983 did not differ significantly.

Figure 8 shows that peak emergence of *P. matsutama* coincided with that of the host and that *P. matsutama* emergence declined sharply when host emergence began to decline. The emergence period of *I. seoulis* coincided rather well with the post-peak portion of the host emergence period. Jeon et al. (1981) made similar observations in Saga Prefecture,, Japan.

Study site B

P. matsutama was not found at study site B. In 1984, the *T. japonensis* adult emergence period was May 26 through July 18, and there were two peaks (Fig. 8). *I. seoulis* emerged from June 13 through July 18. The emergence periods were essentially the same in 1983.

THE PARASITE SEX RATIOS

Female : male sex ratios of 38 : 62 for *P. matsutama* and 60 : 40 for *I. seoulis* were based on 2,282 *P. matsutama* adults and 1,535 *I. seoulis* adults collected in field emergence traps in 1983 and 1984 (Tables 1 and 2). Studies in Saga Prefecture, Japan (Jeon et al., 1982) revealed sex ratios of 48 : 52 for *P. matsutama* and 54 : 46 for *I. seoulis*. It is noteworthy that males of *P. matsutama* were preponderant over females in both

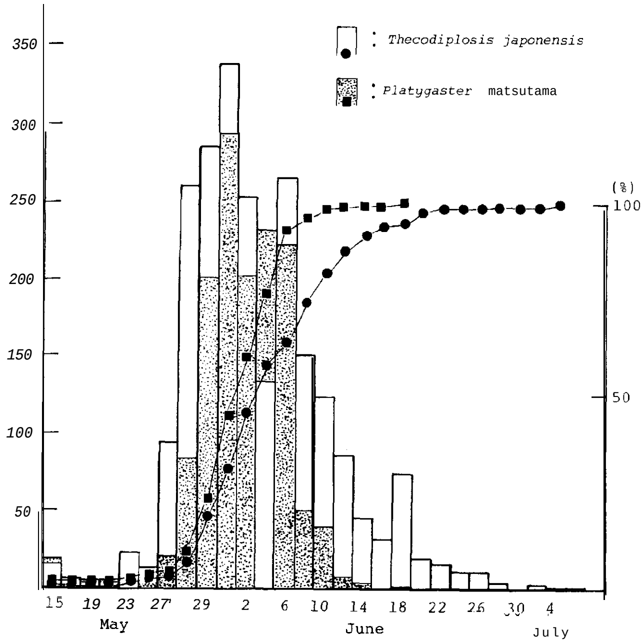

Fig. 8. Field emergence of *Thecodiplosis japonensis* and *Platygaster matsutama* in 1984 at Taech'ŏn area, Korea.

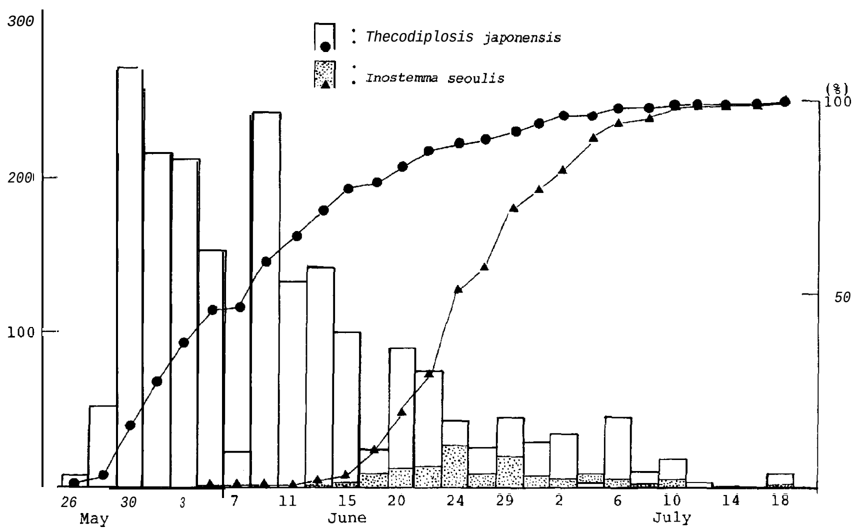

Fig. 9. Field emergence of *Thecodiplosis japonensis* and ***Inostemma seoulis*** in 1984 at Hongch'ŏn area, Korea.

studies. Because it is known that many species of Hymenoptera lay unfertilized (male) eggs on hosts that are not optimal nutritionally, it may be logical to hypothesize a

Table 1. The sex ratio of *P. matsutama.*

Study site	Year	No. of females	No. of males	Sex ratio
A	1983	298	598	33 : 67
	1984	579	807	42 : 58
Total		877	1,405	38 : 62

Table 2. The sex ratio of *I. seoulis.*

Study site	Year	No. of females	No. of males	Sex ratio
A	1983	248	154	62 : 38
	1984	21	21	50 : 50
B	1983	496	342	59 : 41
	1984	161	92	64 : 36
Total		926	609	60 : 40

correlation between the low female : male ratio and the high rate of superparasitism in *P. matsutuma*. The phenomenon merits further study.

THE FECUNDITIES

The ovaries are fully developed and contain mature eggs when the parasite adults emerge. Egg counts were made from ovaries dissected from 20 *P. matsutuma* females and 35 *I. seoulis* females. The eggs are so small and numerous that counts needed to be made by spreading the eggs in fluid on an ocular micrometer disk with a 10 mm × 10 mm square-grid reticle. In the case of *P. matsutama*, it was necessary to count ovaries one at a time.

For *P. matsutuma*, the average number of eggs per female was 1,569, and the range was 1,078 to 2,374, This is substantially below the average of 3,322 eggs per female reported by Hill (1926) for *P. hiemalis*. For I. *seoulis*, the average number of eggs per female was only 555, and the range was 293 to 772.

ADULT BEHAVIOR

The adults of both *P. matsutama* and I. *seoulis* are diurnal and have habits similar to those of *Platygaster hiemalis* and *Inostemma boscii* Jurine (Hill, 1926 ; Myers, 1927). Shortly after emerging from the puparia of the host and working their way out of the soil litter, they mate on the needles of midge-infested pine trees. There is no pre-ovipositional maturation period.

Like the adults of the host, the parasite adults are inactive on rainy days. Otherwise, our observations indicate that they are especially active from 7 : 00 to 15 : 00. At night and on rainy days, the parasites rest on the undersides of leaves of broadleaved plants.

Females of *P. matsutama* oviposit into the eggs of the host, those of I. *seoulis* into either the eggs or the newly hatched larvae. The entire ovipositional act, including local searching, requires about one minute.

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