BIOLOGY OF *TRIARTHRIA SETIPENNIS* (FALLÉN) (DIPTERA: TACHINIDAE), A NATIVE PARASITOID OF THE EUROPEAN EARWIG, *FORFICULA AURICULARIA* L. (DERMAPTERA: FORFICULIDAE), IN EUROPE

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Abstract

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Triarthria setipennis is a tachinid parasitoid of the European earwig (*Forficula auricularia*) and following introduction from Europe has become established in British Columbia and Newfoundland, where it provides low levels of control. Populations of *T. setipennis* were surveyed in central Europe during 1989–1991 and individual insects reared to identify available biotypes that may be more effective than biotypes already established in Canada. Additional information is provided on parasitoid biology; this could facilitate new introduction of *T. setipennis* which could be used to augment existing or introduced populations in Canada for the control of *F. auricularia*. Microclimatic conditions and sufficient territory space for pairs are important to elicit mating activity. Older males mated readily with newly emerged females. The gestation period of mated females is on average 19 days. *Triarthria setipennis* is ovolarviparous and lays its eggs close to potential hosts. Chemicals are involved in the host-finding and host-acceptance response of the females. Females lay on average 235 eggs. The oviposition period lasts 4–5 days. Once a first-instar larva contacted a host, it mounted it and tried to penetrate through the intersegmental skin between the head and thorax, or on the thorax or abdomen; this process takes less than 3 min. Only 16.7% of the parasitoids manage to penetrate the host successfully. The duration of larval development is variable, taking from 2 weeks to 2 months during June and July. Most pupae were obtained during August. Overwintering occurs in the pupal stage. In Germany and in the northwestern part of Switzerland there is one full and a partial second generation per year. The first generation of *T. setipennis* in southern Austria shows a long emergence period and the individuals differ markedly in colour. The highest rate of parasitism in the field was 46.9%.

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Résumé

Triarthria setipennis, un tachinide parasitoïde du Perce-oreille européen (*Forficula auricularia*), a été importé d'Europe et est maintenant bien établi en Colombie-Britannique et à Terre-Neuve où il assure une lutte mitigée contre les perce-oreilles. Des populations de *T. setipennis* ont été inventoriées dans le centre de l'Europe de 1989 à 1991 et des individus ont été élevés séparément dans le but de permettre l'identification de biotypes qui pourraient être plus efficaces que les biotypes déjà établis au Canada. Des information sur la biologie du parasitoïde pourront également faciliter de nouvelles importations de *T. setipennis* qui viendront s'ajouter aux populations déjà établies au Canada ou aux populations importées pour lutter contre le perce-oreille. Des conditions micro-climatiques particulières et un espace territorial suffisant sont essentiels au déclenchement de l'accouplement. Les mâles plus âgés s'accouplent volontiers aux femelles fraîchement métamorphosées. La période de gestation dure 19 jours en moyenne. *Triarthria setipennis* est ovolarvipare et pond ses oeufs dans le voisinage d'hôtes potentiels. La détection des hôtes et la reconnaissance de leurs propriétés par les femelles se font par l'intermédiaire de substances chimiques. Les femelles pondent 235 oeufs en moyenne. La ponte dure de 4 à 5 jours. Lorsqu'une larve de premier stade entre en contact avec un hôte, elle y monte et tente d'y pénétrer en perçant le tégument intersegmentaire entre la tête et le thorax ou entre le thorax et l'abdomen. Ce processus nécessite 3 min tout au plus. Seulement 16,7% des parasitoïdes réussissent à pénétrer leur hôte. La durée du développement larvaire varie, de 2 semaines à 2 mois, en juin et en juillet. La plupart des nymphes ont été d'abord observées en août et c'est au stade de nymphe que l'insecte survit à l'hiver. En Allemagne et dans le nord-ouest de la Suisse, le parasitoïde produit une génération complète et une seconde génération partielle chaque année. Dans le sud de l'Autriche, l'émergence de la première génération de *T. setipennis* s'étend sur une longue période et il y a une grande variation dans la coloration des insectes. Le taux le plus élevé de parasitisme observé en nature a été de 46,9%.

[Traduit par la Rédaction]

Introduction

The European earwig, *Forficula auricularia*, is native to Europe, western Asia, and the northern fringe of Africa, and was accidentally introduced into North America at the beginning of this century (Clausen 1978). In the United States, it was first found in the Pacific Northwest in 1907 (Crumb et al. 1941). In Canada, the earwig was first reported in Vancouver, British Columbia, in 1916 (McLeod 1954). When the European earwig reaches high population densities, it can become a major pest in gardens and a perpetual nuisance in households.

Two European species of the family Tachinidae (Diptera) are the most important parasitoids of the earwig in central Europe: the dominant earwig parasitoid, *Triarthria setipennis*, and the less abundant *Ocytata pallipes* (Fallén). *Triarthria setipennis* is an ovolarviparous species, laying relatively few eggs from which maggots hatch immediately after oviposition (Herting 1960).

In the 1920s, specimens of *T. setipennis* were collected in the Mediterranean region and released in Oregon where they became established (Spencer 1945). Releases of parasitoids from the Oregon population were later made in British Columbia (1934–1939), Ontario (1939–1941), and Newfoundland (1951–1953) (McLeod 1962). *Triarthria setipennis* became established in British Columbia and Newfoundland but did not reach high population densities (Mote 1931; Dimick and Mote 1934; Spencer 1947). This was partly attributed to poor adaptation of the parasitoid to local climatic conditions. For this reason, additional releases of *T. setipennis* collected from Switzerland, Germany, and Sweden by the International Institute of Biological Control (IIBC) were made in the 1960s on the grounds that the climates at the sites of parasitoid collection in these countries were similar to the climates at the sites of parasitoid release in Canada. This operation was followed by an average increase in parasitism from 0.3% in 1955 to 2.1% in 1965, 12.0% in 1975, and 13.1% in 1985, and was coincident with reduced earwig numbers in Newfoundland (Morris 1971, 1981; Morry et al. 1988).

Earlier studies have described the life cycle of *T. setipennis* during the biological control campaign in Oregon from 1927 to 1937 but other parameters were not examined. The IIBC European Station resurveyed natural enemies of *F. auricularia* during 1989–1991 to clarify further the biology of *T. setipennis* in central Europe and possibly identify new effective biotypes for inoculative releases in Canada. Reported herein are the results of studies of the following parameters: pupal development, adult emergence, mating, reproductive potential, host location, oviposition behaviour, parasitoid attack, and larval development and seasonal incidence of parasitism of *T. setipennis* in central Europe. This additional knowledge will facilitate future implementation and evaluation of release of *T. setipennis* in North America.

Material and Methods

Seasonal Incidence of Parasitism. Three hundred and seventy-five earwig traps, made from 12-cm black plastic flowerpots filled with wood shavings, were set up in 34 apple orchards in Germany, Switzerland, Austria, and France (Fig. 1). The traps were fixed 1–2 m above

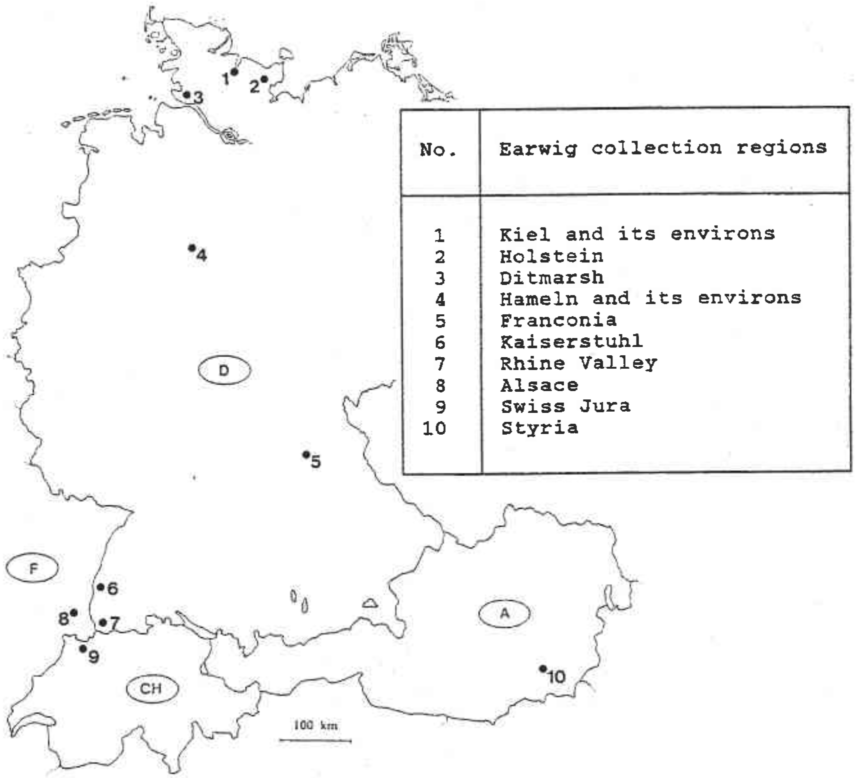

FIG. 1. Geographic location of earwig collection regions in central Europe (D, Germany; F, France; CH, Switzerland; A, Austria).

the ground, on apple trees (one trap per tree), around Ditmarsh (six sites with 10 traps each), Kiel (four sites with 10 traps each), Holstein (three sites with 10 traps each), and in the Rhine Valley (two sites with 15 traps each) in Germany and in the Swiss Jura (one site with 15 traps) in Switzerland. Earwig populations were sampled every 2–3 weeks for parasitism from May until October 1989–1991. Single collections also were made in Lower Saxony at Hameln in Germany (one site with 10 traps), around Franconia in Bavaria in Germany (nine sites with 10 traps each), in Baden-Württemberg at the Kaiserstuhl in Germany (two sites with 15 traps each), in the Alsace in France (four sites with 10 traps each), and in Styria in Austria (two sites with 15 traps each).

Rearing and Food of Earwigs. Earwigs collected from the traps were kept in 10-L plastic buckets to obtain emerged parasitoids. To prevent the active earwigs from escaping, the rim of each bucket was painted with "Fluon"(polytetrafluoroethylene). Cardboard egg containers were added to the buckets to provide hiding sites during the day. Originally, Getzendaner's (1936) diet of ground carrots and ground grass with three parts of fish meal and six parts of meat meal was used as earwig food. A more diversified diet of sliced carrots, cabbage, dandelion and lettuce leaves, apples, plums, raisins, and nuts resulted in higher survival and was used after 1989. Dead insects (mostly muscid flies) and sausage were provided as animal protein. The rearing buckets were kept in an outdoor insectary in Kiel, northern Germany, where the earwigs lived under conditions of natural photoperiod and temperature. The buckets were checked daily to determine the emergence date of mature parasitoid maggots from their host.

Pupal Development. Newly emerged parasitoid larvae were placed in individual plastic tubes, 45 mm long and 15 mm diameter and closed with a foam-rubber stopper. The pupae were kept in the insectary described above, where they overwintered and developed to adults.

Rearing Adult *Triarthria setipennis*. *Triarthria setipennis*, upon emergence, was kept in cylindrical, 2-L transparent plastic cages recommended by Katsoyannos (1975) for rearing tephritids. The top of each cage was 12.5 cm in diameter with three openings. One, occupying two-thirds of the top, was covered with gauze. The two other openings were 2 cm in diameter and closed with foam-rubber plugs when not being used to handle flies. Two dental cotton wicks saturated with water and a cube of sugar were placed in each cage, as food for the adult flies. The sugar cube also served as a rough humidity guide because, if it dissolved, humidity was too high. Paper strips with honey–agar jelly were also provided as food. The jelly was made up of 10 g honey, 20 g sugar, 0.55 g agar, and 130 mL water. These ingredients were brought to a boil and then stored in the refrigerator for up to 2 weeks (Quednau 1993).

Cages for Mating. *Triarthria setipennis* does not mate readily in captivity. Mating can be induced in big cages, so a special field cage (180 by 180 by 220 cm) was designed. This field cage consisted of a green gauze tent supported by jointed plastic tubes of 40 mm diameter. The bottom was a PVC sheet with holes to allow rainwater to drain. Access to the cage was through a zip door on one side of the gauze tent. It was possible to enclose small apple trees in the field with the cage.

The duration of mating and conditions during mating including temperature and relative humidity, as measured with a hydrothermograph, and the observed degree of sun/shade were recorded.

Oviposition and Reproductive Potential. To determine the length of the preovipositional period, mated females were checked daily for their readiness to lay eggs. The reproductive potential of females was determined as follows. Mated females were kept in cages as described by Katsoyannos (1975) with a cardboard disk of 2.5 cm diameter. These disks were cut out of cardboard egg containers which had been kept in the earwig rearing buckets for up to 14 days. During this time cardboard egg containers were loaded with a combination of earwig body odour and earwig faeces. The colouration of the containers changed from white to light reddish-brown. Earwig faeces was removed from cardboard egg containers with a brush. Disks were checked daily for the presence of L1/eggs of *T. setipennis* and replaced. After the females died they were dissected and the remaining viable eggs in the uterus were counted. The same observation cages and odour-loaded disks were used to determine the searching behaviour of the females for oviposition sites. Individual females were offered one oviposition disk with or without earwig odour for 3 h. After a resting period in an odour-free room for 1 h, the other oviposition disk (with or without odour) was offered. The oviposition disks were offered in a randomized sequence and the eggs laid were counted.

Parasitoid Attack and Larval Development. Observations of attack by parasitoid larvae were made in the laboratory following the release of a *T. setipennis* female in a 30- by 30- by 57-cm observation cage with 150 earwigs. The earwigs were kept in a 20- by 20- by 8-cm transparent plastic container with a cardboard egg container inside the observation cage. Each test lasted 72 h and the earwigs were reared to measure the rate of parasitism.

Maggots were obtained from odour-loaded cellulose disks exposed to gravid females and from dying flies dissected in a 0.8% NaCl solution in small Petri dishes. The maggots or mature eggs containing developed larvae with mouthparts were transferred onto the earwig with a fine hair brush (Scaramuzza 1930) to obtain data on the larval development

TABLE 1. Earwig collections by region during 1989–1991, and rates of parasitism by *Triarthria setipennis**

		Month of collection					
		July		August		September	
Region/country	Year	Earwig, *n*	*T.s.*, %	Earwig, *n*	*T.s.*, %	Earwig, *n*	*T.s.*, %
Ditmarsh (D)	1989	—	—	60	13.6	621	1.9
	1990	1019	11.3	5935	6.4	1544	2.1
	1991	6195	7.4	5633	9.9	2246	4.7
Area Kiel (D)	1989	×	×	4558	1.2	×	×
	1990	1800	2.7	3952	6.2	1479	—
	1991	955	0.6	3022	4.6	1026	1.8
Holstein (D)	1990	448	12.3	451	9.1	59	—
	1991	510	0.8	337	7.1	161	6.2
Rhine Valley (D)	1989	×	×	2514	0.2	1014	—
	1990	×	×	994	2.1	×	×
	1991	10022	3.8	3498	2.1	×	×
Swiss Jura (CH)	1989	×	×	50	—	113	1.8
	1990	1619	20.7	253	12.6	×	×
	1991	794	4.4	210	4.5	×	×

* × = no collection, — = no parasitoid reared, *T.s.* = *Triarthria setipennis*, D = Germany, CH = Switzerland.

and parasitization success rate in female/male and immature hosts. Hosts were dissected periodically during larval development of *T. setipennis*.

Results

Seasonal Incidence of Parasitism. Most parasitoid pupae were obtained between the end of July and the end of August. From 1989 to 1991 parasitism ranged from 6.4 to 13.6% in Ditmarsh and from 1.2 to 6.2% in the area at Kiel; from 1990 to 1991 parasitism ranged from 7.1 to 9.1% in Holstein and from 0.2 to 2.1% in the Rhine Valley. Parasitism of collections obtained in the Swiss Jura in 1990 was 20.7% in July and 12.6% in August (Table 1). Parasitism of single collections in different regions was 8.3% in August 1989 and 46.9% in August 1991 in the Hameln area; 0.8% in August 1989 and 1.7% in September 1989 in Franconia; 6.4% in September 1989 in the Kaiserstuhl; 1.5% in August 1989 in the Alsace; and 13.5% in August 1990 in Styria.

Pupal Development. The larva pupates soon after emergence and usually not far from the body of the host, often under bark or other places frequented by earwigs.

In northern Germany, overwintering pupae under local temperature conditions took between 265 and 337 days to develop [302 ± 0.4 (mean ± SE), $n = 672$]. Those pupae giving rise to the second generation took an average of 17 days (±0.4 SE, min = 13, max = 21, $n = 34$) to develop into adults. In samples from southern regions, the pupal stage lasted only 251 days (±2.4 SE, min = 213, max = 314, $n = 78$) on average under the temperature regime for overwintering flies, and for 18 days (±0.2 SE, min = 8, max = 25, $n = 375$) for the summer generation.

Adult Emergence. In northern Germany in 1991, 543 adults of the first generation emerged from 7 June to 13 July and 35 adults emerged from a partial second generation from 12 to 25 August. A much larger second generation was recorded from the southern localities. From

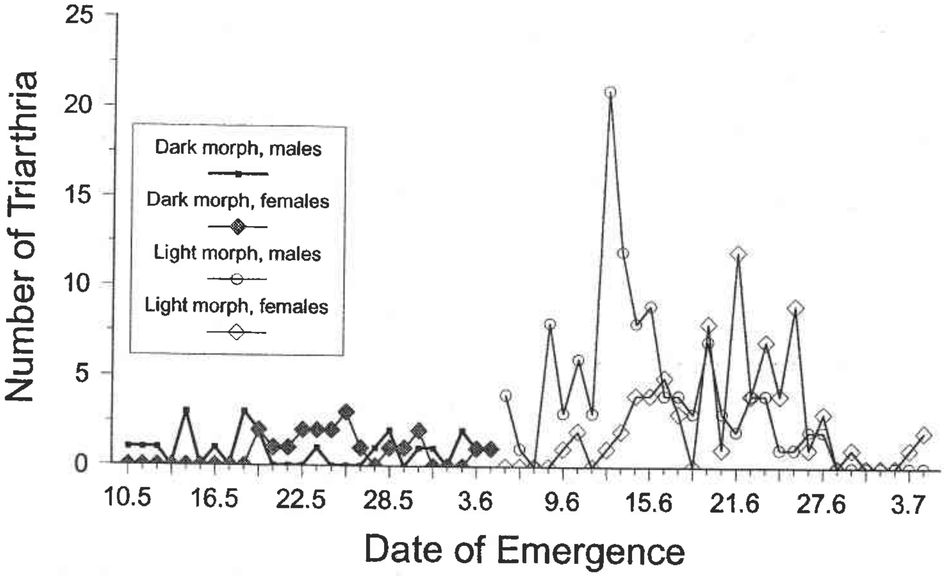

FIG. 2. Emergence period of dark-coloured and light-coloured individuals of the first generation of *Triarthria setipennis* in the Styria region in Austria.

an earwig collection at Delémont on 12 July 1990, a total of 336 pupae was obtained and 176 developed into adults in the same year.

An interesting case was observed in the southern regions. In the Styria region in 1990, 309 *T. setipennis* puparia were obtained in mid-August and 53 developed into adults by early October, which is probably a partial third generation. Adults emerged from 10 May to 4 July 1991 from the remaining hibernating pupae. The individuals on the emergence curve differed markedly in colouration on the dorsal side of the thorax and the palps (Fig. 2). There is a fairly long period when dark morphs emerge, and then a single peak with typical protandry when light morphs emerge. Individuals emerging from 10 May to 4 June ($n = 42$) were dark with three black spots in front of the suture line on the thorax (Fig. 3A). Those emerging from 6 June to 4 July ($n = 184$) were much lighter and had four indistinct spots (Fig. 3B).

In a single collection of 336 earwigs in Franconia in September 1989, 1.7% were parasitized, typical for the late season. On this occasion, three individuals of the dark form were reared.

Mating. Microclimatic conditions and sufficient territory space for pairs of the light and dark morphs were important to elicit mating activity. The best results were obtained in a field cage placed in the half-shade of trees where the relative humidity was between 60 and 80%. A higher proportion of mating pairs (85%, $n = 94$) was observed in the shady than in the sunny areas of the cage. Matings among adults of the first generation were most frequent between 1200 and 1600 hours (67%, $n = 74$), and when the temperature range was between 16 and 24°C (85%, $n = 95$). Copulation was not observed below a temperature of 14°C. Although freshly emerged females mated more readily, individuals as old as 17 days were observed in copulation.

The period of mating observations of the dark morphs lasted from 27 May to 30 May 1991. The duration of mating varied from 15 to 33 min for the dark morphs, with an average of 22.2 min (±1.4 SE, $n = 17$) at a mean temperature of 18.8°C (±0.7 SE, $n = 17$).

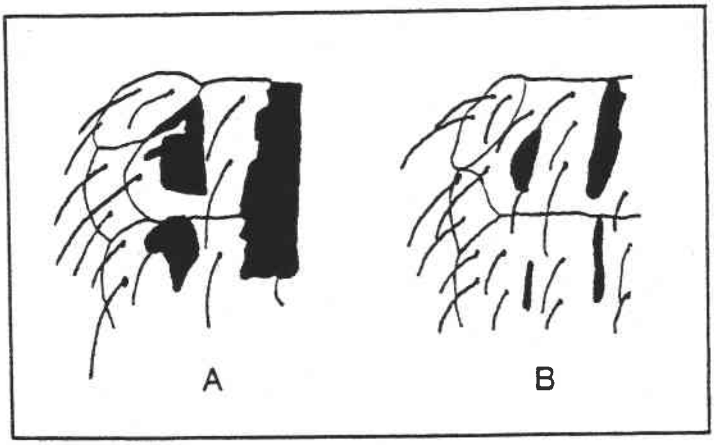

FIG. 3. The differences in colour postulated by Van Emden (1954) to separate species in the genus *Triarthria*: (A) *T. setipennis* (Fallén) (thorax with three broad black vittae in front of the suture line); (B) *T. spinipennis* Meigen (thorax with four narrow black vittae in front of the suture line).

The range of copulation duration was approximately 11–72 min for the light morphs, with an average of 28.5 min (±1.8 SE, $n = 66$) at a mean temperature of 19.9°C (±0.4 SE, $n = 66$). The observation period lasted from 9 June to 5 July 1991.

The Wilcoxon two-sample test showed no significant differences ($Z = -1.33, P = 0.184$) in the duration of mating between morphs. Power of the test ($1 - \beta$) as estimated for an equivalent *t*-test for unequal sample sizes exceeded 0.99. That is, the probability of committing a Type II error was 0.01 (after Zar 1984).

Oviposition and Reproductive Potential. Females of the light morphs were gravid after a preovipositional period of 19.1 days (±0.4 SE, $n = 38$) at a mean temperature of 18.7°C (±0.2 SE). They searched for the resting places of the nocturnal earwigs and laid their eggs close to, but never directly on, the host.

Females of the light morph laid eggs during the daytime on *F. auricularia* odour-loaded cellulose disks. In a comparison of the acceptance of oviposition disks with and without earwig odour, the oviposition disk with odour received the highest number of eggs/L1. There were significant differences between both oviposition sites (Wilcoxon two-sample test, $Z = -2.547$, $P = 0.0108$). This experiment shows that there is a chemical involved in the host-finding and host-acceptance response of the females.

The potential fecundity on average was 235 eggs per female of the light morph (±11.3 SE, $n = 37$), with a range of 107–385 eggs. The period of egg deposition normally lasted 4–5 days.

For 30 days after mating, females of the dark morph laid no eggs. Females were interested in *F. auricularia* odour-loaded cellulose disks and in hiding sites where earwig adults were present. However, these offered places were not accepted by females as oviposition sites. Females were then dissected and maggots or mature eggs containing embryos with mouthparts were found.

Parasitoid Attack of the Host. Maggots hatched immediately from the fragile chorion and moved away from the site of oviposition, erecting and swaying their bodies at short intervals. The first-instar larvae that emerged on the odour-loaded disk did not move away. Once a first-instar larva contacted a host, it mounted it and tried to penetrate through the intersegmental skin between the head and thorax, or on the thorax or abdomen. This process

TABLE 2. Life history parameters examined for *Triarthria setipennis*

Parameters examined	Data set
Pupal development	302 days/17 days (North) 251 days/18 days (South)
Adult emergence	7 June – 13 July/12–25 Aug. (North) 10 May – 4 July (dark/light morphs) (South)
Duration of mating	28.5 ± 1.8 SE min
Preoviposition period	19 ± 0.4 SE days
Reproductive potential	235 ± 11 SE eggs
Oviposition period	4–5 days
Attack rate	16.7%
Larval development	33.9 ± 0.5 SE days

usually took less than 3 min. If successful, the maggot remained attached with its hind stigmata to its entrance hole.

Studies to determine the parasitization success of first-instar larvae showed that in the presence of 150 hosts at the oviposition site, only 16.7% ($n = 25$) of parasitoid maggots managed to penetrate the host. In many instances, earwigs successfully fended off the tachinid larvae with their antennae or legs.

Larval Development. The larval period inside the body of the host varied. Some larvae completed their development in 14 days, and others remained within their hosts for over 63 days. The average larval period under approximate field conditions was 33.9 days (±0.5 SE, $n = 409$) at a mean temperature of 18.9°C (±0.3 SE).

Second-instar larvae appeared about 10 days after successful attack. Fully grown third instars ($n = 28$) left the living host through the intersegmental skin and formed a pupa within 7 h. The abandoned earwig hosts lived for several more days without taking food and finally died.

Discussion

This paper gives more precise data on the biology and ecology of *T. setipennis* from central Europe and confirms several of the former results of Mote et al. (1931) describing the biological control campaign in Oregon from 1927 to 1937. Mote et al. (1931) and O'Hara (1994) found that it was difficult to induce mating in the laboratory. The present study showed that successful matings can be achieved outdoors in large screen tents. Other authors have commented on the preoviposition period: Atwell and Stearns (1927) recorded 12–15 days, Getzendaner (1936) recorded 15 days, and Mote et al. (1931) recorded 13–23 days for preoviposition and an oviposition period that lasted 3–5 days under Oregon conditions. These results were confirmed by my study for central Europe (Table 2). The number of generations per year was given as one by Phillips (1983) in England, two by Mote et al. (1931) in the United States, two to three by Getzendaner (1937) in Canada, and two in central Europe and in warm regions of central Europe with a partial third generation (Tschorsnig and Herting 1994). In Germany and in the northwestern part of Switzerland, I observed one full generation and a partial second generation.

This study has renewed the discussion regarding the existence of two species in the genus *Triarthria*. Van Emden (1954) postulated two separate species on the basis of differences in colour. He called the dark form with three black spots in front of the suture line *T. setipennis* (Fallén), and the light-coloured individuals with four indistinct spots, *T. spinipennis* Meigen. In contrast, the generally accepted opinion is that *T. setipennis* (Fallén) is a single species with colour dimorphism (Herting 1960, 1984; Mesnil 1965). My results indicate that the emergence period of the first brood in southern areas is long and that the individuals differ markedly. Under identical rearing conditions, the dark individuals emerge much earlier than the light individuals, whereas the light individuals from southern and northern regions emerge simultaneously and produce only light-coloured second-generation offspring. If a colour dimorphism with intermediate morphs in the first generation is involved, one would expect that the emergence of the two morphs would be randomly distributed in time. Genetic linkage between the allele of colouration and the allele of the duration of pupal development may explain the distinct emergence periods. An alternative hypothesis is that the dark morph might preferentially attack other earwig species, for example *Forficula decipiens* Gené (Tschorsnig and Herting 1994) and *Chelidura albipennis* Meg. (Thompson 1928), which have previously been determined as hosts of *T. setipennis*. This might be a reason for the fact that the dark morphs refuse to lay eggs on cellulose disks with *F. auricularia* odour, despite the presence of fully developed embryos in their ovaries. Only the light-coloured females laid eggs, after mating was induced in each group of morphs, and their offspring was invariably light-coloured. Collections of dark individuals in September in one of the southern areas in Germany suggest that a second generation of the dark morph may exist. This observation is a further indication of the existence of two species in the genus *Triarthria*. Some doubt remains regarding the hypothesis of colour dimorphism, but there is no definitive support for Van Emden's concept of two species. Further extensive research programmes, including cross-breeding experiments and electrophoresis studies, are necessary to elucidate this problem.

It could be possible that both morphs of *Triarthria* were previously introduced to Canada. If this is the case then long-term field studies should be conducted to determine which morph is the best adapted. Host ranges of the established morph(s) should be determined to assess impact on nontarget organisms. In central Europe *F. auricularia* is known as the common host of *T. setipennis*; *C. albipennis* and *F. decipiens* are rare (Tschorsnig and Herting 1994).

During a survey of natural enemies of the European earwig in central Europe in the 1960s, scientists of IIBC European Station found a high percentage of hyperparasitism. About 65–70% of the tachinid puparia were associated with the pteromalid *Dibrachys cavus* (Walker) (Carl 1962). Ebert (1964) recorded about 85% hyperparasitism of *T. setipennis* in the field caused by *D. cavus* and a less significant ichneumonid, *Phygadeuon scaposus*, and Carl (1965) found 57.5% parasitism by *D. cavus* in 1965. Phillips (1983) mentioned that *D. cavus* and *Phygadeuon vexator* (Thunberg) probably limit the potential effectiveness of *T. spinipennis* in England. The following chalcidoid hyperparasitoid species were reared from *T. setipennis* puparia in 1989–1991: *Dibrachys cavus* (Walker), *Pediobius pyrgo* (Walker), *Eurytoma* sp. (Vidal 1994, pers. comm.). The impact of the hyperparasitoids is unknown, because earwigs were reared in the laboratory for the presence of parasitoid puparia and early removal of puparia and hosts from traps prevented attack by hyperparasitoids.

My 3-year study was too short to carry out life table analyses to demonstrate whether biotic mortality factors have a regulating effect on earwig populations. Mortality by *T. setipennis* dealt with in this study is generally low but nevertheless there may be regulating factors, as was suggested by Morris (1971, 1981) and Morry et al. (1988) following the establishment of *T. setipennis* in Newfoundland. To determine if earwigs are a lesser problem in Newfoundland in the presence of *T. setipennis* than in Nova Scotia in its absence, it would appear logical to study the impact of the parasitoid and, if positive, introduce it into provinces of Canada either from Newfoundland and British Columbia or from Europe.

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