Potential of Telenominae in biocontrol with egg parasitoids (Hym., Scelionidae)

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ABSTRACT

This literature review is an attempt to draw the attention of biocontrol workers to Telenominae, a group of egg parasitoids which may often compete with Trichogramma for the same hosts.

Taxonomy of Telenominae is still not well understood and identifications may prove rather difficult since the old species are often hardly recognizable, many recent ones have been inadequately described and a large number are still underscribed. Biotaxonomic studies are scanty and obviously reflect the above situation. Host records from many pests and some successful applications in different ecosystems prove they may be important control agents and in several cases more effective than Trichogramma.

Present knowledge on Telenominae, although scarce in comparison with that on Trichogramma, clearly indicates this group as being much more promising for biological control of crop and forest pests than was suspected, however, further thorough bio-taxonomic research for applications is still necessary.
The purpose of this communication is to provide a concise review of Telenominae focusing on some biotaxonomic and applied aspects so that biocontrol workers can be acquainted with the potential of this group of egg parasitoids, compared with Trichogramma, for pest management programs.

The use of arthropod eggs as hosts by parasitoids has evolved in the Hymenoptera at least fourteen times and has been reported in the families Ichneumonidae, Evanidae, Encolpidae, Aphelinidae, Encyrtidae, Eulophidae, Eupelmidae, Eurytomidae, Mymaridae, Pteromalidae, Tetracampidae, Torymidae, Trichogrammatidae, Platygastroidae and Scelionidae. Of these, only the Trichogrammatidae, mymarids and scelionids are composed entirely of species that specialize in this way of life.

The Scelionidae is by far the most diverse group of egg parasitoids at least in terms of numbers of species. For comparison, Doutt and Viggiani (1968) reported that the family Trichogrammatidae was made up of 341 described species in 63 genera; 49% of these genera were monotypic (31 of 63), with an average of 5.4 species per genus. Contrast this with the economically most important group of scelionids, the Telenominae. This subfamily contains over 600 described species classed into 13 genera (46%); but averages 46.2 species per genus; a nearly ninefold increase. The figures for either group are not exact nor final, but they do provide some understanding of the magnitude of the task lying ahead for those of us interested in the telenomines. On the basis of our systematic work on the Telenominae, we estimate that the number of described species in this subfamily represents only 10-25% of the number actually in existence. The group may therefore contain as many as 6,000 species!

A basic knowledge of the systematics of a group is a prerequisite for substantial advances in our understanding of other aspects of its biology. The dangers associated with misidentifications are well-documented in the history of biological control (see, e.g., Rosen, 1977). The best known telenomine fauna is that of the Palearctic region (Kozlov, 1967; Kozlov and Le, 1977; Kozlov, 1978), but even in western Europe the discovery of new species is still a common occurrence. Our knowledge of the Nearctic fauna is much less complete; studies are only now underway to pick up where William H. Ashmead left off at the turn of the century (see Johnson, in press). The tropical regions of the world are the least studied. Papers by Nixon (1935, 1937, 1943) and Dodd (1913) have made significant, but only preliminary steps towards a better understanding of the Old World tropics. The Neotropical region is practically an untouched area of study. A great deal of work clearly remains to be done before we can claim to have an adequate understanding of the species and relationships
within the Telenominae.

Telenomines are all parasitoids of insect eggs; hosts belong primarily to the Lepidoptera and Heteroptera, but can also be found among the Homoptera, Diptera and Neuroptera. Most species are solitary; some species that attack relatively large hosts (e.g., sphingids, triatomine reduvids) are gregarious; usually less than ten individuals complete development within a single egg.

Host specificity varies widely among species. For example, Telenomus californicus ASHMEAD is known only from the eggs of the douglas-fir tussock moth, Orgyia pseudotsugata (MCDOUGAUGH) (Lepidoptera: Lymantriidae). Telenomus clisiocampae RILEY is restricted to the eggs of the genus Malacosoma HUBNER (Lepidoptera: Lasiocampidae). At the other end of the spectrum, Telenomus podist ASHMEAD has been reared from field-collected eggs of twelve genera in the families Pentatomidae and Scutelleridae (Heteroptera). Telenomus alsophilae VIERECK has been reared in the laboratory from the eggs of seventeen genera of Geometridae and Noctuidae (Lepidoptera) (PEDEE 1977; JOHNSON’S observation). Telenomus remus NIXON has accepted, in laboratory, eleven Noctuidae and one Pyralidae over thirty nine tested species of Lepidoptera of various families (WOJCIK et al., 1976). Telenomines, in general, do not have as wide a host range, either as a group or as individual species, as does the Trichogramma-tidae.

The details of host-parasitoid interactions have only begun to be explored. EBERHARD (1975) has discussed in fascinating detail the evolution of subsocial behavior in a heteropteran, Antiteuchus tripiterus limbativentris RUCKES (Pentatomidae), and its relationship with its two egg parasitoids, the telenomines Trissolcus bodkini (CRAWFORD) and Phanuropsis semiflaviventris GIRAILT. DARLING and JOHNSON (in press) discuss the evolution of oviposition characteristics in Malacosoma, in particular the function of an accessory gland secretion and its influence on the moths' egg parasitoids. Very promising work is proceeding in the Soviet Union on the study of host-parasitoid and inter-parasitoid relationships in the cohort of telenomines attacking agriculturally important Pentatomidae (see, e.g., BULEZA and MICHIEV, 1978; MICHIEV, 1980; VIKTOROV and KOCHETOVA, 1973; VIKTOROV et al., 1975; VOROMIN, 1981). Investigations into host-finding behavior, particularly those isolating the cues used by the wasps to locate their hosts, may provide important insights into questions concerning the evolution of host specificity, host shifts and sympatric speciation. They may also open up new prospects for the manipulation of Telenominae using kairomones as it has been tried in Soviet Union (VIKTOROV et al.,
1975) where the parasitism percentage of wheat pentatomids by *Trissolcus grandis* THOMS. and *Telenomus chloropus* THOMS. was 3-4 times higher in plots treated with female wheat bug extracts than in untreated plots.

The strategy of phoresy enhances parasitoid searching and dispersal abilities and renders freshly laid eggs available to it. This is more common in *Scelionidae* than in any other group of egg parasitoid, and in *Telenomus* are included species phoretic on crop and forest pests (CLAUSEN, 1976). The two new cases which will be mentioned later prove that this behavior is more common than was suspected.

WILSON (1961) led the study of telenomine behavior with his report on intermale and interfemale aggressiveness and territoriality in *Trissolcus basilis* (WOLLASTON). In this species a male actively excludes all other males from a host egg mass from which female wasps are emerging. In this way he alone inseminates all of these females. A female will likewise drive away any other females from a newly-discovered host egg mass; she therefore is the only wasp able to oviposit in those eggs. The behavior of *Telenomus remus* NIXON, described by SCHWARTZ and SERLING (1974) is in sharp contrast with this finding: no intrasexual aggressive behavior at all was observed. WAAGE (1982) has noted that the size of the host egg mass and the parasitoid behavior affects the mating structure of the population (i.e., degree of inbreeding) and has thereby been able to test hypotheses concerning the relationship between inbreeding and sex ratio.

The use of species of *Telenominae* as biological control agents has so far met with only limited success, and only a dozen species have been introduced in different countries according to a recent world review (CLAUSEN et al., 1978). We believe that this is in large part due to our ignorance in the area of systematics. There have, however, been cases in which telenomines have provided successful control. Outstanding examples are the use of *Telenomus alsophilae* against *Oxydia trychiata* (Guenee) (Lepidoptera: Geometridae) in Colombia (DROOZ et al., 1977) and *Trissolcus basilis* against *Nezara violacea* (L.) (Heteroptera: Pentatomidae) in Australia (CALTAGIRONE, 1981). Host records from many pests or potential pests, the naturally occurring high rates of parasitism and some successful applications in different ecosystems prove that telenomines may be important control agents.

Many *Telenominae*, being parasitoids of *Heteroptera*, virtually do not compete with *Trichogramma* and their host associations can be summarized as follows. *Heteroptera Pentatomids* are attacked by *Trissolcus*, *Psix* (JOHNSON, unpublished), *Telenomus* and *Phanuropolis*; *Lygaeids* by *Eumicrosoma*; *Plataspids*
by Archiphanurus (BIN, unpublished); Coreids by Protelenomus; Coreids, Rho-palids, Aradids, Mirids, Reduviids and other families by Telenomus.

Some Telenomus species are also associated to Homoptera Fulgorids and some others being parasitoids of Diptera Tabanids may assume a medical and veterinary importance.

The largest number of Telenomus species, however, attack Lepidoptera and many of these hosts are shared with Trichogramma. For this purpose we have restricted our review to the Telenomus species associated with the most significant crop and forest lepidopteran pests recorded in world literature over the last ten years.

Pyraloid rice, sugar cane and maize borers are attacked by both Trichogramma and Telenomus and the problem is so vast that it cannot be discussed, even superficially. We only wish to stress that this large Telenomus complex needs to be revised in the whole sub-tropical and tropical area for its economic importance. As a contribution to this goal we (BIN & JOHNSON, unpublished) have redescribed Telenomus alecto (CRAWF.), for its effectiveness against Diatraea saccharalis (F.) in South America, and described four new species for their promising results. Two of them are particularly interesting since they are phoretic on their hosts, Scirpophaga melanoclysta (MEYRICK) in Ivory Coast (COCHEREAU, in litt.) and Tryporyza innotata WLK. in Indonesia. The other two species are associated with Eldana saccharina WLK. and Maliapha separatella RAG. in Ivory Coast and Chilo sacchariphagus (BOY.) in India. Telenomus ostriniae CHEN & WU (WU et al., 1979), recently described in China, is also interesting because it is the first Telenomus recorded from a pest such as Ostrinia nubilalis (Hub.).

Noctuid pests of various genera are effectively controlled by several Telenomus and some Trichogramma as shown by the following examples.

Sesamia cretica LED., infesting a susceptible and a relatively resistant sugarcane variety in Upper Egypt, has been parasitized by a Telenomus sp. and the parasitism rate was about 74 % for both (TEMERAK & NEGM, 1979). In the same country, further comparison among sugarcane, sorghum and maize, showed that the same Telenomus sp. is the key mortality factor because more than 65 % of the egg masses were parasitized and from 69 to 78 % of these were completely destroyed (TEMERAK, 1981). There is another new species and interesting host record, T. sesamiae WU & CHEN from a Sesamia sp. (WU et al., 1979) in China. The genus Platytelenomus, very likely nothing but a flattened adaptation of Telenomus, is also associated with Sesamia such as P. hylas NIXON reared from S. arctica in Sudan (NIXON, 1935) and P. Busseolae (GAH.) from Sesamia sp.
on sugarcane in Ghana (SCHIEBELREITTER, 1980). Spodoptera species infesting maize, cotton, cauliflower and other horticultural crops are controlled by means of Telenomus remus NIXON successfully introduced into and established in several countries: United States (Florida) (WOJCICKI et al., 1976), Barbados (ALAM, 1978), Trinidad (YASEEN, 1981), Antigua and neighbouring islands (IRVING, 1978), Surinam (SEGEREN et al., 1981), New Zealand (Rep. Dept., 1977), Israel (GERLING, 1972) and India (PATTEL et al., 1979). Maximum rates of parasitism are 60 % on cauliflower plots in India, with weekly releases (PATTEL et al., 1979), and 80 % on maize in Barbados (ALAM, 1981). Mass rearing and sampling methods have been developed in New Zealand (BOARDMAN, 1977) and Florida (WADDILL, 1977).

Heliothis species may be controlled by both Telenomus and Trichogramma as happens in Botswana (ROOME, 1973) and in North America (Texas) where Telenomus heliothidis ASHM. and Trichogramma pretiosum RIL. have been tested on H. virescens (F.) (ABLES et al., 1981). A Telenomus sp., close to triptus NIXON, although its parasitism averaged only 8 % has been bred in Australia from the 92.7 % of H. punctigera WLLGR. and H. armigera (HB.) eggs (TWINE, 1973), so showing a high searching ability.

For Mamestra brassicae (L.) in Eastern Europe a Telenomus sp. is less effective than Trichogramma evanescens WESTW., nevertheless it helps to hold the population in check (KAREZHOV, 1970; BIROVA, 1973, 1976).

The Sphingid Manduca sexta (JOH.) is more effectively parasitized by Telenomus sphingis (ASHM.), 75 %, than by Trichogramma minutum RIL., 25 %, when its eggs are laid on some hairy solanaceous plants. This plant-parasitoid interaction shows how Telenomus, since it is larger in size than Trichogramma, can be more effective in reaching host eggs on hairy surfaces (RABB & BRADLEY, 1968).

Other significant examples are recorded among orchard, shade tree and forest defoliating lepidoptera (cfr. also ANDERSON, 1976 and references therein).

Several species of Dendrolimus are attacked by both Telenomus and Trichogramma, either of them being more important. Telenomus bombycis MAYR was the most effective parasite of Dendrolimus pini (L.) in Hungary (BENEDEK, 1969) as was T. gracilis MAYR for D. superans (BTLR.) (=sibiricus CHTV.) in Siberia (BOLDARIEV, 1969). This last Telenomus in also particularly interesting for its phoretic behavior (KOLOMIETS, 1957; KOLOMIETS & KOVALENOK, 1958). Telenomus dendrolimi (MATS.) and Trichogramma dendrolimi MATS. prefer the lower and the
upper part of the crown respectively, so their action on D. spectabilis BUT.
in Japan is complementary (Hirose et al., 1968; Hirose, 1969). In Vietnam,
the aggregate actions of a Telenomus sp. and a Trichogramma sp. on D. punctatus (MLK.) were also the most important regulatory factors (Bassus, 1974).

Malacosoma neustria (L.) in Soviet Union is so intensively parasitised by Telenomus laeviusculus (Ratz.), from 13 to 80 %, that it has been reared and redistributed in orchards (Aksyutova et al., 1977; Rilishkene et al., 1980). In Romania 37 % of the eggs are destroyed (Teodorescu, 1980).

Drya antique (L.) during European outbreaks is satisfactorily controlled by Telenomus dalmarini (Ratz.) alone (Wellenstein et al., 1973; Skatulla, 1974) or jointly with Trichogramma cacoeciae March. (Niemczyk et al., 1978). This Telenomus, already known in North America, is now recorded also in Chile where its parasitism rate varies from 62 to 87 % (Carillo et al., 1977; Santis De et al., 1979).

Orgya antiqua (L.) during European outbreaks is satisfactorily controlled by Telenomus dalmanni (Ratz.) alone (Wellenstein et al., 1973; Skatulla, 1974) or jointly with Trichogramma cacoeciae March. (Niemczyk et al., 1978). This Telenomus, already known in North America, is now recorded also in Chile where its parasitism rate varies from 62 to 87 % (Carillo et al., 1977; Santis De et al., 1979).

Leucoma salicis (L.) is attacked by Telenomus nitidulus (Thoms.) in Belgium (NeF., 1976), in Romania (Teodorescu, 1980) and in the Soviet Union (Kolomiets, 1971; Dondikov, 1974) with parasitism percentages ranging from 23, to 60 and up to almost 100 %. Also in North America there is a Telenomus sp. and it competes with Trichogramma minutum Ril. for the same host (Wagner et al., 1980).

From Euproctis species have been reared some Telenomus which can exert a satisfactory control. So T. phalaenariwm (Nees) is the main parasite of E. similis (Pues.) in Bulgaria (Germanov, 1975) and T. euproctis Wl. can be used as one of the effective means in the integrated control of the tea lymphtriid, E. pseudoconspersa Strand, in China (Wang, 1981).

Other cases could be added to this list which does not claim to be complete but simply illustrate a situation by means of some significant examples.

In conclusion, there are clear indications that 1) many Telenominae are important agents for controlling certain host groups not attacked by Trichogramma; 2) Telenomus and Trichogramma can be complementary or interchangeable for certain hosts and niches although further investigation is still necessary; 3) many Telenomus share with Trichogramma the same hosts so that preliminary tests are indispensable in evaluating which one offers the best alternatives.
The potential of *Telenominae* and *Trichogramma* cannot be properly and fully utilized until a basic knowledge of their taxonomy, host associations, strategy, etc. has been repeatedly examined and stressed in the literature.

Therefore, we believe that a programme of intensive taxonomic and biological research should be planned to prepare reliable keys, host indexes and other information indispensable for pest population management.

Finally, because of the existence of other egg parasitoids sharing similar problems and techniques we also hope that all these projects can be coordinated in an ad hoc working group on egg parasitoids.

**BIBLIOGRAPHIE**


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