TRICHOGRAMMA (HYMENOPTERA: TRICHOGRAMMATIDAE) FAUNA IN CERTAIN AREAS OF ARKANSAS AND NORTH CAROLINA

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ABSTRACT

Trichogramma fauna in the Portland, AR and Clinton, NC areas was surveyed from 1980 to 1983. Trichogramma exiguum Pinto and Platner, T. minutum Riley, T. pretiosum Riley, and T. retorridum Girault were found in the Portland area. Trichogramma exiguum, T. minutum, T. pretiosum, and an undescribed species were found in the Clinton area. Trichogramma exiguum and T. pretiosum were the two most common native species in both areas, with T. exiguum slightly more abundant than T. pretiosum.

INTRODUCTION

The genus Trichogramma has a worldwide distribution and contains over 90 nominal forms, most of which are found in the Holarctic region (X. F. Pang, and A. C. F. Hung, unpublished information). Adult Trichogramma are minute parasitic wasps that lay their eggs in the eggs of other insects, primarily Lepidoptera. Although Trichogramma wasps have been mass-reared and released for biological control worldwide for over 70 yrs (Ridgway et al. 1981), the systematics of this group is still not well understood. This is due mainly to the minute size of these wasps and the relatively uniform morphology of species within this genus. Since the application of male genitalia morphology and experimental hybridization techniques (Nagarkatti and Nagaraja 1968, 1971), Trichogramma biosystematics has advanced considerably. The designation of neotypes for T. pretiosum Riley and T. minutum Riley and the designation of lectotypes of Pinto et al. (1978) for several often misidentified North American species further clarified the taxonomy of Trichogramma of this continent.

Proper selection of species and/or forms most suitable for each particular host and habitat is essential for the effective use of Trichogramma in biological control (Kot 1979, Voronin and Grinberg 1981). Unfortunately, male genitalia morphology and hybridization experiments cannot be used to characterize biotypes. Recently, the methods of investigation in Trichogramma biosystematics were improved by combining studies of genital structure and hybridization experiments with isozyme analysis (Hung 1982, Jardak et al. 1979, Pintureau and Babault 1982, Pintureau and Voegele 1980).

On the basis of the male genitalia, Nagarkatti and Nagaraja (1977) recognized 36 biparental species in this genus and classified them into the following nine species groups: australicum, minutum, euproctidis, flandersi,

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japonicum, agriae, maltbyi, parkeri, and achaeae. Subsequently, Voegele and Pintureau (1982) cited 64 "valid" species and 20 species of doubtful taxonomic status. They divided the genus into 14 species groups, namely maxacallii, flandersi, achaeae, maltbyi, euproctidis, principum, parkeri, agriae, japonicum, pinneyi, kalkae, chilonis, minutum, and evanescens.

The North American species, T. platneri Nagarkatti was treated differently by the authors of these two species group classification systems. This species was described by Nagarkatti (1975) who considered it morphologically identical to T. minutum. It was, therefore, placed in the minutum group by Nagarkatti and Nagaraja (1977). However, Voegele and Pintureau (1982) morphologically separated T. platneri from T. minutum and placed the former in the pretiosum subgroup of their evanescens group. Other systematic approaches, such as isozyme analysis, may further clarify these proposed relationships.

Ridgway et al. (1981) reported 11 biparental species of Trichogramma from the continental United States. Since then Pinto et al. (1983), Platner and Oatman (1981), Thorpe (1982), and Pinto and Oatman (1985) have added nine more species to this list (Table 1).

TABLE 1. Species of Trichogramma Known to Occur in the Continental United States.[a/]

Species	Distribution	Host	Reference
brevicapillum Pinto and Platner	California	Vanessa Artogeia	Pinto et al. 1978
browningi Pinto and Oatman	California	Trichoplusia Vanessa Agraulis	Pinto and Oatman 1985
californicum Nagaraja and Nagarkatti	California	Hemerocampa	Nagaraja and Nagarkatti 1973
drepanophorum Pinto and Oatman	Mississippi	Limenitis Sphingid	Pinto and Oatman 1985
exiguum Pinto and Platner	California Missouri	Heliothis Trichoplusia Heliothis	Pinto et al. 1978
	Kansas Louisiana		Pinto et al. 1983
	Maryland	Natural Host Unknown	Thorpe 1982, 1984
	Texas	Alabama Anticarsia Celama	Lopez et al. 1982
		Heliothis	Lopez et al. 1982 Segers et al. 1984
fuentesi Torre	Louisiana Texas	Chilo Noctuid	Pinto et al. 1983
inyoense Pinto and Oatman	California	Unknown	Pinto and Oatman 1985
julianoi Platner and Oatman	New York	Sepedon	Platner and Oatman 1981
maltbyi Nagaraja and Nagarkatti	Michigan	Oulema	Nagaraja and Nagarkatti 1973
	Texas	Heliothis	Lopez et al. 1982

TABLE 1. Continued.

Species	Distribution	Host	Reference
marylandense Thorpe	Maryland	Natural Host Unknown	Thorpe 1982, 1984
minutum Riley	California	Manduca	Pinto et al. 1978
	Missouri	Limenitis	Nagarkatti and Nagaraja 1971
		Trichoplusia	Oatman and Platner 1973
	Maryland	Natural Host Unknown	Thorpe 1982, 1984
	Texas	Alabama	Lopez et al. 1982
		Anticarsia	
		Heliothis	
nomlaki Pinto and Oatman	California	Unknown	Pinto and Oatman 1985
nubilale Ertle and Davis	Delaware	Ostrinia	Ertle and Davis 1975
	Maryland	Natural Host Unknown	Thorpe 1984
offella Pinto and Oatman	Louisiana	Chilo	Pinto and Oatman 1985
parkeri Nagarkatti	Missouri	Heliothis	Nagarkatti 1975
	Maryland	Natural Host Unknown	Thorpe 1982, 1984
platneri Nagarkatti	California	Cydia	Nagarkatti 1975
			Oatman and Planter 1973
pretiosum Riley	California	Heliothis	Pinto et al. 1978
		Vanessa	Oatman et al. 1970
		Colias	Oatman and Platner 1973
		Trichoplusia	
	Missouri	Heliothis	
	Alabama	Heliothis	
	Maryland	Natural Host Unknown	Thorpe 1982, 1984
	Texas	Alabama	Lopez et al. 1982
		Anticarsia	
		Celama	
		Heliothis	Lopez et al. 1982
			Segers et al. 1984
semblidis (Aurivillius)	Oregon	Sialis	Nagarkatti 1972
retorridum (Girault)	Iowa	Protoleucania	Pinto et al. 1978
	Maryland	Natural Host Unknown	Thorpe 1982, 1984
thalense Pinto and Oatman	California	Noctuid	Pinto and Oatman 1985
		Heliothis	
		Vanessa	
	Texas	Diatraea	

a/ Modified from Ridgway et al. 1981.

Nine more new species are yet to be described (Thorpe 1984, D. L. Vincent and C. Goodpasture unpublished information). Lopez et al. (1982) and Segers et al. (1984) have studied natural parasitism of Trichogramma species in cotton and corn fields. However, considerable additional effort is necessary to fully determine the endemic species of Trichogramma in agricultural and forestry areas in the United States and to obtain the much needed information on their distribution, biology, and ecology. Only in this way can their potential for use as biological control agents be fully evaluated.

From 1980 to 1983, we surveyed the species of Trichogramma occurring in and around the Pilot Test areas at Portland, AR and Clinton, NC to determine the indigenous species and to obtain information on their relative abundance. The results of our survey are presented here.

MATERIALS AND METHODS

Samples were taken in two ways at both test areas. Egg samples were collected from crop and alternate host plants in representative localities within the pilot test areas at weekly intervals throughout the season of host egg availability. Eggs of laboratory-reared Heliothis virescens (F.) attached to a polyester oviposition cloth were used to sample Trichogramma throughout the season. These cloth strips averaged 1.5 x 5 cm with ca. 100 eggs/strip. Prior to placing the egg cloths in the field, a cesium 137 gamma irradiator was used to irradiate the Heliothis eggs for 6 min. at 400 Krads/h. This was necessary to kill the developing embryos and thus prevent cannibalism of the eggs by Heliothis larvae hatching from unparasitized eggs.

During 1983 in North Carolina, Heliothis spp. eggs were sampled 2-3 times/wk from Trichogramma release and natural control fields by whole plant examination and random collections. Insecticide control fields were sampled less frequently because of the detrimental effects of insecticides on naturally occurring beneficial insects. In the whole plant inspections, entire plants in one m of row at 12 uniformly distributd locations throughout the field were examined and all eggs found were collected. The random egg collections were made by walking along the rows and looking for the eggs on the terminals of the cotton plants. Eggs found were collected by removing small portions of the plant on which the eggs were located. The plant parts were then placed in small plastic containers and were kept in coolers containing Blue Ice or ice. Each afternoon, the eggs collected were processed using techniques similar to those of Hoffman et al. (1970). Eggs determined to be parasitized were removed from the cards and a small amount of Dri-Flo was used to prevent the emerged parasitoids from sticking to the tape to which the plant part containing the eggs was attached.

Parasitized eggs from naturally occurring host eggs and eggs of laboratory reared Heliothis were then individually transferred to size 000 gelatin capsules and held at room temperature and 50-60% RH until Trichogramma wasps emerged. Representative male wasps were slide-mounted in Hoyer's medium for morphological comparison and identification. All other wasps emerged from the same egg were preserved in 75% ethyl alcohol in individual 2-dram vials for future reference.

RESULTS

Portland, AR Pilot Test Area, 1980-1982. From May 12 to June 30, 1980, 58 parasitized eggs were collected from naturally occurring host eggs. Because morphological examinations were based on males, identifications were possible for specimens from only 35 of these eggs. During

the survey period from March 26 to November 18, 1980, 800 egg cloth strips were distributed among the 32 collecting stations, but only 70 strips were subsequently found to have parasitized eggs. The following species were recovered from these parasitized eggs: Trichogramma exiguum, T. pretiosum, T. minutum, and Telenomus heliothidis Ashmead (Table 2). This included five eggs from which both T. exiguum and T. pretiosum were recovered.

TABLE 2. Total Number of Parasitized Eggs (Portland, AR 1980).

Species	No. eggs	%
T. exiguum	36	53.7
T. pretiosum	18	26.9
Telenomus heliothidis	7	10.4
T. exiguum + T. pretiosum	5	7.5
T. minutum	1	1.5

Figure 1 shows the % of laboratory reared Heliothis eggs parasitized by the two most common species, T. exiguum and T. pretiosum, from egg cloths collected at weekly intervals in each month from April to November, 1980.

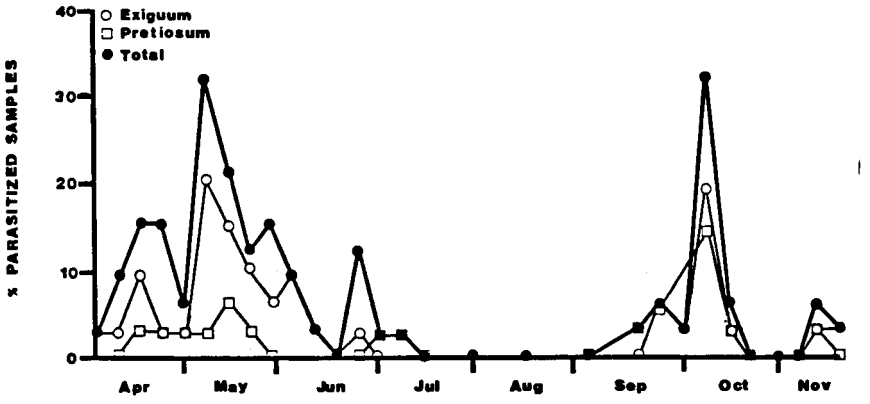

FIG. 1. Percent of parasitism for T. exiguum and T. pretiosum in 1980.

The 1981 survey (April 10 - November 18) covered five different habitats with three replications for each habitat (Table 3). Parasitism was observed in only 118 (2%) of the 5500 egg cloth strips placed in 15 sample locations. Trichogramma exiguum and T. pretiosum were recovered in 47.5% and 44.1% of the parasitized eggs, respectively. A previously unreported species for this area, T. retorridum, was found in one egg with T. exiguum. Trichogramma pretiosum and T. exiguum were also found mixed in one egg. Table 3 shows the % of each species surveyed in five habitats in the Portland, AR area. Figure 2 shows the % of parasitism by T. exiguum and T. pretiosum at weekly intervals for each month during the survey period.

TABLE 3. Percent Parasitism of Trichogramma in Five Habitats (Portland, AR, 1981).

Species	Cotton		Soybean		Wooded sloughs	Total
	Margins	Fields	Margins	Fields		
exiguum	23	70	29	0	79	47.5
pretiosum	67	30	65	100	10	44.1
exiguum + pretiosum	0	0	0	0	2	0.8
exiguum + retorridum	0	0	0	0	2	0.8
Unknown	10	0	6	0	7	6.8
No. parasitized strips	30	10	31	5	42	118

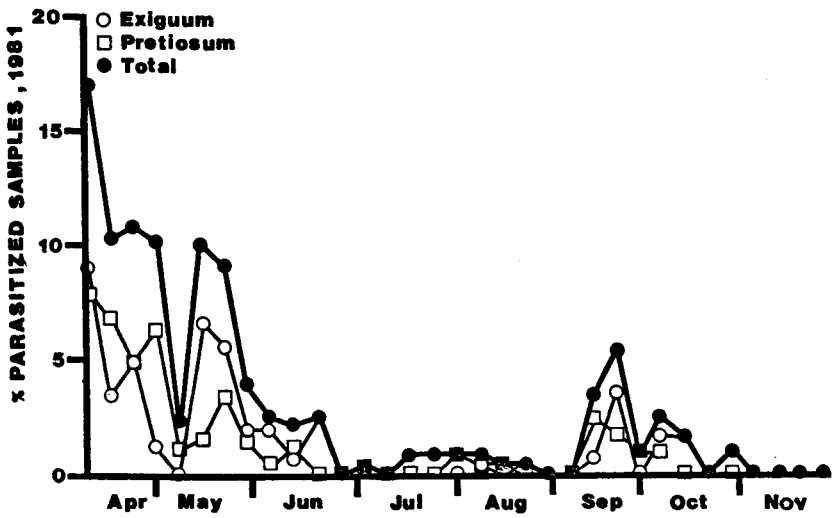

FIG. 2. Percent parasitism for T. exiguum and T. pretiosum in 1981.

The 1982 survey covered only the borders of cotton and soybean fields, and wooded sloughs. Of 1071 egg cloth strips placed in the field, only 150 strips were parasitized. Only T. exiguum and T. pretiosum were collected from all three habitats (Table 4).

TABLE 4. Percent Parasitism in Three Habitats (Portland, AR, 1982).

Species	Cotton margins	Soybean margins	Wooded sloughs	Total
exiguum	60	46	53	53
pretiosum	33	42	41	40
Unknown	7	12	6	7
No. parasitized strips	30	41	79	150

Clinton, NC Pilot Test Area, 1983. The survey (May 26 - August 15) covered all eight Trichogramma release fields, the four natural control fields, nine insecticide control fields, and the surrounding areas. Due to unusually dry weather, only 40 parasitized eggs were recovered during the prerelease period. Four species were collected from this area (Table 5). The fourth species represents an undescribed species first collected in Hexlena, North Carolina and later in Beltsville, Maryland (Vincent and Goodpasture, unpublished information).

TABLE 5. Prerelease and Postrelease % Parasitism in the Clinton, NC Area.

Species	Prerelease	Postrelease
exiguum	57.5	9.0
minutum	0	0.6
pretiosum	40.0	89.4
T. sp.	2.5	1.0
Total no. of parasitized eggs	40	689

DISCUSSION

Assuming that all species attack the sample eggs at the same rate under the conditions of the study, our surveys showed that T. exiguum and T. pretiosum were the two most common native species found in both Pilot Test areas, with T. exiguum slightly more abundant than T. pretiosum. Data also indicated that both species were lowest in abundance at Portland, AR in July and August (Figs. 1 and 2). This might be due to the increase in insecticide application during these two months. The sudden decline in % parasitism in early May in both 1980 and 1981 might be related to decreased availability of host eggs. The % of parasitism of the postrelease survey in 1983 strongly suggested a high rate of parasitism caused by the release of T. pretiosum; however, we must note that with our morphological approach to species identification we could not determine what % of this postrelease parasitism was due to the released T. pretiosum. Genetic markers (such as allozymes) are needed to distinguish between native and released T. pretiosum before we can reliably assess the % of parasitism by released T. pretiosum. However, a sharp increase in parasitism was directly related to

the release of T. pretiosum. Trichogramma pretiosum was not common in the wooded sloughs. In cotton fields, more T. exiguum were found in the field than along the margins, but T. pretiosum was more abundant along the margins than in the field (Table 3). Although rare, T. minutum was found in both Arkansas and North Carolina Test Areas. This species is more commonly found in an arboreal habitat (Flanders 1929, 1968) and consistently parasitizes egg cloths positioned at greater heights than does T. pretiosum (Thorpe 1985). The occurrence of T. minutum in cotton fields might indicate that a different species is involved. Lopez et al. (1982) reported that, of the male parasites that emerged from eggs of Heliothis spp. and from some associated lepidopterous pests in Central Texas, 60.3% were T. pretiosum, 37.9% were T. exiguum, 0.9% were T. minutum, and 0.9% were T. maltbyi. In the Lower Gulf Coast of Texas, more than 75% of all parasitoids collected from eggs of Heliothis spp. on cotton and corn for over a five yr period were T. pretiosum (Segers et al. 1984). In agroecosystems of central North Carolina, T. exiguum is the most frequently collected species, followed by T. pretiosum and T. minutum (M. Keller, personal communication, February 26, 1985). Trichogramma exiguum, T. maltbyi, T. parkeri, T. pretiosum, T. minutum, and an unidentified species (possibly T. nubilale) were found in the Raleigh, NC area, and again, T. exiguum was by far the most prevalent (M. S. Thomson, personal communication March 4, 1985). However, according to Lopez et al. (1982) and Seger et al. (1984), T. pretiosum is clearly more common than T. exiguum in cotton in Texas. Thorpe (1982, 1984) also found more T. pretiosum than T. exiguum in corn in Maryland.

The three most commonly used Trichogramma species in biological control programs are T. dendrolimi in China (Li 1982), T. evanescens (sens. lat.) in Europe (Hassan 1982, Voegele 1981, Voronin and Grinberg 1981), and T. pretiosum in the United States (Ridgway et al. 1981). The biosystematics of T. evanescens was carried out by Voegele and his associates. As a result of their efforts, we now know that there are two species involved in what had been called T. evanescens, namely T. evanescens and T. maidis (Pintureau and Voegele 1980). In our surveys, we were limited to the use of slide-mounted specimens, and thus could use only the morphology of the male in our species determinations. This morphological approach certainly was not adequate for sibling species discrimination and biotype characterization. Therefore, the species we report here should be considered as morphological species or "look-alikes" and not as biological species in a strict sense. Using cross-mating tests, Thorpe (1984) found 14 biparental and one uniparental species of Trichogramma in a 450m^2 plot of natural, weedy vegetation during 1981 and 1982. It is likely that more species occur in these two Pilot Test areas than we report here based solely on the morphology of slide-mounted specimens. However, these surveys do provide information on the basic local Trichogramma fauna which will serve as a basis for further biosystematic studies.

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