Parasitoid Complex of the Gypsy Moth (*Lymantria dispar*) in the Increase-phase Populations in Korea

Lee, Jang-Hoon* and Robert W. Pemberton

1Research Institute for Natural Science, Dongguk University, Seoul 100-715, Korea
2Invasive Plant Research Laboratory, United States Department of Agriculture, Agricultural Research Service, 3225 College Ave., Ft. Lauderdale, Florida 33314 U.S.A.

**ABSTRACT:** The species composition of the parasitoid complex and the degree of parasitism by each species were analyzed for gypsy moth (*Lymantria dispar*) populations in the increasing phase. Total of 7,826 mid-late instar larvae and pupae were collected and reared from two collection sites in Gangwon Province, Korea. Two tachinid flies (*Blepharipa schineri* and *Parasetigena silvestris*), and the ichneumonid wasp (*Coccygomimus disparis*) were the most abundant parasitoids, in the order of decreasing importance. Other parasitoids occurring included *Coteisa melanoscelus*, *Cotesia scheaferi*, *Glyptapanteles liparidis*, *Brachymeria lasus*, and *Exorista* spp. The low incidence of the NPVirus is hypothesized to be an important factor in determining degree of parasitism rate by *P. silvestris* and *B. schineri*, and their relative dominance in the parasitoid complex.

**Key words:** Gypsy moth, Increase-phase population, Natural enemies, NPV, Parasitism

**INTRODUCTION**

*Lymantria dispar* L., gypsy moth (hereafter referred as to GM) populations usually experience a cyclic pattern of abundance, described to have the following phases: as innocuous (latent), increase (pre-culmination), outbreak (culmination), and post-outbreak phase (post-culmination) (Campbell 1978, Schonherr 1988, Elkinton and Liebhold 1990). Berryman (1996) reported that parasitoids are frequently involved in this cyclic population dynamics of this univoltine moth, and parasitoids invariably kill a consistently high proportion of lepidopteran immature stages during the decline phase than the increase phase.

Gypsy moth populations in the Republic of Korea (South Korea) are sporadic and usually very low levels where they did occur, making it difficult to study their natural enemies (Pemberton et al. 1993). At times, relatively high gypsy moth populations occur in a small area, but they collapse into the innocuous level, mainly due to infections of NPV (Nuclear Polyhedrosis Virus), within following year or two. For this reason, the phase related parasitoid mortality of GM populations can not be validly assessed, because density dependent pathogen infections masks parasitoid induced mortalities (Pemberton et al. 1993).

Larvae and pupae from GM populations in the increasing phases were collected from low NPV infection sites in Gangwon Province in 1993. The GM populations at these sites decreased to the innocuous phase two years later in 1995. Our objectives were to define components of parasitoid complex, and to determine the patterns of parasitism by the most abundant parasitoids in increasing GM populations.

**MATERIALS AND METHODS**

**Season Long Collections**

Collections were made from two different sites located in Gangwon Province, which are 50 km apart from each other. The Yongdae-ri site (Book-Myeon, Injae-Gun, Gangwon Province), bounded by 128° 21' 12" and 128° 21' 16" E and by 38° 11' 52" and 38° 11' 30" N (elevation 340 ~ 370 m), is located on the north west side of Mt. Surak near Highway 44. GM larvae and pupae were collected from this site weekly during from late May to early July 1993. Tree species composition in the Yongdae-ri sites consisted of *Prunus* *sargentii* Rehder and *P. persica* (L.) Batch, *Salix pseudo-lasiogyne* Lév, *Robinia pseudoacacia* L., and *Betula platyphylla* Sukatschev.

The Doochon site, the area between Yeoknae and Juan-ri (Doochon-Myeon, Hongchon-Gun, Gangwon Province), bounded by 128° 21' 12" and 128° 21' 16" E and by 38° 11' 52" and 38° 11' 30" N, is of East side of Mt. Gari. GM larvae and pupae were collected from this site weekly during from late May to early July 1993. Tree species composition in the Doochon sites consisted of *Praunus* *sargentii* Rehder and *P. persica* (L.) Batch, *Salix pseudo-lasiogyne* Lév, *Robinia pseudoacacia* L., and *Betula platyphylla* Sukatschev.

The Doochon site, the area between Yeoknae and Juan-ri (Doochon-Myeon, Hongchon-Gun (Highway 44), bounded by 37° 50' 16" and 37° 51' 19" N, 128° 00' 44" and 128° 01' 11" E (230 ~ 250 m), is of East side of Mt. Gari. GM larvae and pupae were collected from this site weekly and six samplings were made from May 27 to July 08. The tree species in Doochon-Myeon sites were *Populus seiboldii* Miqel, *Salix pseudo-lasiogyne* Lév, *Quercus* spp., *Larix gmelini* var. *principisrurentitii* (Mayr) Pilger *Robinia pseudoacacia*, and

* Corresponding author; Phone: +82-2-2260-3511, e-mail: ecojhl@dongguk.edu
Morus bombycis Koidz.

Collections at all sites were made along roadside trees and overstory of neighboring forests and extended up to twenty meters into forests. The areas of collection were 2,000 m². Thirty trees of the species listed above each collection site spaced with 10 m interval were selected for each of the sampling sites. Burlap bands were set on trees at breast height to facilitate collections of larvae and pupae one week before initial collections. The bands provide refuges for larvae during the day and pupation sites, both of which concentrates the larvae and pupae, making them easier to collect. Generally, for any week's collection, larvae and pupae were collected by one collector for one hour for each collection sites. This procedure was followed until the end of the season. Eggs began to hatch in both areas after about early May. First collections were made during the week of May 27 and the last collections during the week of July 7.

Rearing

The collection and rearing procedures were similar to those followed by Pemberton and Lee (1996). The larvae and pupae collected from burlap bands, then taken to the laboratory where they were reared in screen-toped plastic boxes (20.5 by 28 by 16.5 cm in groups of up to 30 individuals and fed Quercus spp. leaves. To minimize mortality due to nuclear polyhedrosis virus (NPV), all leaves were disinfected in a sodium hypochlorite solution and well rinsed before placed in the rearing boxes. The containers were checked every other day for parasitoid emergence. Also noted were the numbers of gypsy moth larvae killed by disease including the Nuclear Polyhedrosis Virus, those that died from unknown causes, and those that successfully developed to adult stage. Parasitoid identifications were made by the authors, by comparison with authoritative determined voucher material from the former USDA-ARS Asian Parasite Laboratory collection. Dead hosts were kept for ca. two weeks because some parasitoids emerge from dead hosts. If no parasitoids were observed to emerge, host material was dissected to determine the cause of death.

Gypsy Moth Population Estimation and Analysis

Gypsy moth population estimates were made for each site by calculating the hourly density (number of larvae and pupae collected per person per hour). Parasitism also was analyzed in terms of host population phase affinities. In order to determine the population phase, egg mass density (eggs masses are usually on tree trunks and major branches), the ratio of new to old egg masses, the ratio of adult female to males emerged during rearing, and hourly density of immature stages were used. The egg mass density and the ratio of new to old egg masses were determined by egg mass counts during five min long walks (n = 4) (Schneeberger 1987). Although five min walks are very practical and convenient for relative abundance of egg mass density, they are not recommended for estimation of absolute density (Liebhold et al. 1991).

Indices of parasitism for each parasitoid and each site to evaluate their importance were used in this study (see Pemberton et al. (1993) for details). The percentages of parasitism by each species were calculated by dividing the number of emerged individuals of each parasitoid species by the number of collected GM larvae and / or pupae. These parasitism percentages for individual parasitoid species were added to yield combined parasitism rates for collection dates, sites, and ultimately the whole study. Total parasitism (season-long parasitism) is the number of individuals parasitized by all parasitoids in the samples of a season-long collection at a particular site divided by the total individuals collected. Thus average season-long parasitism is the average parasitism in the two season long collections from the sites. Gregarious parasites emerging from a single larva (Cotesia schaeferi (Marsh) and Glyptapanteles liparidis Bouché) were counted as one parasite. Parasite-host associations were generally determined by the cocoon aggregations on or near the host cadavers.

Statistical analyses were performed using SAS 9.1 (SAS Institute 2004). Differences of relative frequencies were tested by cross table $\chi^2$ analysis. Percent data were arcsin-transformed and tested for significance of difference by one-way ANOVA; means were compared using Tukey’s studentized range (HSD) test [PROC GLM (SAS Institute 2004)].

RESULTS AND DISCUSSION

A list of common parasites we recovered from the larvae and pupae of L. dispar at increasing population sites in Gangwon Province is presented in Table 1. At Yongdae-ri, a total of 4,339 larvae and pupae were collected from May 27 to July 8 and at Doochon sites, a total of 3,487 larvae and pupae were collected at the same dates. The hourly collection of larvae and pupae per person averaged 361 at Yongdae-ri and 303 at Doochon. The gypsy moth population at both Yongdae-ri and Doochon were both determined to be in the increasing phase. The sites had 57.5 and 41.3 egg masses per 5 min walk, and to the best our knowledge, GM population were not high in recent years. The determination of increasing phase was supported by the fact that old egg masses were rare at the sites and by female biased emergence with the rate of females to males, 1.2 and 1.6 in Yongdae and Doochon sites, respectively (Table 1). The predicted buildup of the populations actually took place at these sites during the following the year (1994), and then collapsed in 1995, when no new egg masses could be found during