Full Length Research Paper

Effects of five different hosts on the longevity capacity of Gypsy moth under laboratory conditions and in the field

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Food consumption, survival rate, age specific longevity and fecundity of gypsy moth were studied on five different host species, including apple (*Malus domestica*), black poplar (*Populus nigra*), white poplar (*Populus alba*), oak (*Quercus* sp.) and pear (*Prunus communis*) under laboratory and field conditions in Yasooj area. The obtained results indicated that the total consumed leaf surface by a larva on apple (*M. domestica*) was the highest with the amount of 1014 cm^2. First instar larvae did not survive long following consumption of small amount of white poplar and pear leaves. Age specific survival and longevity were significantly different on apple and black poplar compared with oak in laboratory conditions. No significant differences were found between age specific longevity of gypsy moth on apple and black poplar under the experimental conditions. Host preference for apple and black poplar was distinctly higher than oak. The average weight of female pupae developed on apple, black poplar and oak were 1440, 1320 and 1100 mg respectively and as fertility rate of female moth is directly related to the weight of female insects, fertility rate of adult moth developed on apple with the average female weight of 1440 mg and 3.19 was higher than the moth developed on black poplar and oak with the fertility index of 2.59 and 2.41 respectively. The results indicate the presence of feeding deterrents in white poplar and pear.

Keywords: *Lymantria dispar*, food resources, physiological characteristics, laboratory condition, Yasooj, Iran.

INTRODUCTION

Lymantria dispar L. (Lep: Lymantriidae) is one of the main pests of forest decorative trees in Eastern United States, some parts of Europe and Asia (Barbosa and Capinera, 1977; Tadic, 1981; Weseloh, 1985). This pest is one of the main leaf eaters of deciduous trees in the whole Northern hemisphere (Morris, 1959; Sharov et al., 1995). This insect is spread out in the mild climate regions of Northern Africa, Russia, Japanese Isles, from 20 to 57 degrees latitude from South East Asia to Norway (Campbell, 1976; Campbell and Torgersen, 1993; Smitley et al., 1995). Inadvertently, it has been brought to

America from Europe in 1868 or 1869, and has been spread out to the South and West and quickly covered most forests in the Eastern part of America and Canada (Elkinton and Liebhold, 1990; Weseloh, 1994). In some parts of America where this insect has established itself, the damage to the trees and biological environment has attracted a huge budget to defeat those (Liebhold and Elkinton, 1988a, b). This insect can use a wide range of trees as host; fruit trees such as apple, pear, and peach and so on as well as non-fruit trees such as willow, pine and others (Rajabi, 1986; Abaee, 1985). In the first years

of arrival in a new region, the larvae will feed one of the main hosts such as chestnut. Later on that the population grows other hosts such as willow, aspen and apple will be used as well (Barbosa and Capinera, 1977). Conditions, location and the type of the host play a major role in the plague (Lance et al., 1987). Gypsy moth can use more than 477 different trees and plants as host (Hohn et al., 1993).

The food intake of a single larva is quite high. In former Yugoslavia, the mean consumption of leaf surface is 856 cm2 (Leonard, 1974). Total eating of a larva on *Quercus acutissime* are 700 - 1000 cm^2 for male and 1100 – 1800 for female. 60% – 70% of food consumption takes place at the last instar of the larva period. In 1990, Liebhold and Elkinton have measured the food intake of larvae by weighing their excrete (Elkinton and Liebhold, 1990).The results have shown that 80% of the excretes were at the last instar of larva period and the females excrete 70% more than the males (Elkinton and Liebhold, 1990).

Gypsy moth, which long lasts in the forests of Iran was seen first in Gilan forests by Afshar in 1937 Afshar, 1937). It has been seen in the Northern forest in the same years (Afshar 1937; Rajabi, 1986). Gypsy moth has been a plague on apple trees in Kohkiluyeh and Boyer-Ahmad province in 1987 and caused serious damage (Moghadam, 1989). It has been reported as one of the major pests of apple trees in Kohkiluyeh and Boyer-Ahmad province in 1989 (Moghadam, 1989). In Iran, Gypsy moth uses about 38 different kinds of fruit and non-fruit as well as ornamental trees. Among agricultural trees stone-fruit and seed-fruit carry the most economical importance. The most important fruit garden hosts are apple, quince, pear, peach and cherry. Among the major wild forest trees are willow, spruce, oak, etc. The growth of this insect on different hosts has been reported in many areas in the northern forests of Iran by Mr. Abaee (Behdad 1987; Moghadam, 1989).

Laboratory results on host preference of this insect confirmed that the host plays a major role in growth and spreading of this insect. A diet of Acer, Oak, a mixture of these and an artificial diet has shown a significant difference in the mean excrete weight, the weight of pupae, the growth period of each life stage (Barbosa, 1978; Campbell, 1977; Carter et al., 1994). Larvae of this insect on preferred hosts have eaten considerably more than the ones on non-preferred hosts and had heavier pupae (Barbosa and Capinera, 1977). Studies have also revealed that the period of different life stages on preferred hosts are shorter than the non-preferred. For example the growth of this insect on *Quercus alba* completes eight days earlier than *Betula pendul* (Morris, 1963). The death rate on preferred hosts are considerably lower (37.7% on apple and oak) than non-preferred hosts, 55.5% on maple (Podoler and Rogers, 1975).

Laboratory studies in 1990 – 1993, have shown that *Taxodium distichum* complies with all this characteristics and is known as the best host for Gypsy moth. According to these studies 83% of the first instar larvae could survive the first instar and the female pupae weight was 1100 (Campbell and Torgersen, 1993).

In the last decades, the damage caused by this pest has been measured in different part of the world. In New Jersey, the destroyed hosts had an increase, from 6% in the first year to 67% in the fourth year (Liebhold and Elkinton, 1988a, b). Larvae damage the trees directly by eating the leaves and causing leaf-fall. Extensive leaf-fall causes a reduction of starch in the root which consequently reduces the yearly development. The rapid growth of pest population results in even higher physiological damage, chemical changes in root and eventually higher growth hindrance. Losing leaves has an effect on the reproduction of the plant in fruit trees as well as non-fruit trees (Campbell, 1976; Campbell, 1977; Ferguson et al., 1994; Price, 1984).

In this study, the effects of five different hosts on the longevity capacity of Gypsy moth under laboratory conditions and in the field (in Yasooj, Iran) has been compared and presented.

MATERIALS AND METHODS

In order to determine the average length of the larva and pupae stages, the author have used the Barbosa and Capinera method (Barbosa and Capinera, 1977). To study the amount of daily diet and the total intake of each larval instar, the eggs were collected from the nature. After disinfection, they have been set in a petri-dish (10 × 15 × 20 cm). Then, ten larvae right after hatching egg has been transferred to another bowl (10 × 15 × 20) with apple leaves. To keep the leaves fresh, the branches of the host plant were placed in small bottles of water.

To calculate the food intake in each larval instar, the leaves were projected on a grid paper; one square millimeter of a fresh leaf has been weighed and multiplied by the surface of total eaten leaves to get the total biomass of consumed food.

Survival, length of different larval instars and reproduction index of Gypsy moth on five hosts has been measured under laboratory condition of 34 ± 2 ˚C, 50% - 60% relative humidity, 10 hours darkness and 14 hours light using neon lamps in two consecutive years.

Criteria for choosing the best host for Gypsy moth were as follow:

1. Survival rate of more than 80% of the larvae in the first larval instar on a host.

2. A growth period less than 41 days from hatching date to pupae.

3. Having female pupae heavier than 1099 milligram.

4. Production of 350 oocytes in the ovary of adult females after 48 – 60 hours.

Table 1. Average number of larvae in second and third larval instar on a single leaf in Yasooj region counted on 100 leaves in May of 1997 and 1998

Host Plant	Mean Value ± SD	
	1997	**1998**
Malus domestica	2.15 ± 1.06	2.36 ± 1.38
Populus nigra	1.65 ± 0.94	1.86 ± 0.98
Quercus sp.	1.25 ± 0.82	1.44 ± 0.91
Rubus sp.	1.20 ± 0.83	1.12 ± 0.75
Populus alba	0.91 ± 0.83	1.1 ± 0.9
Pyrus communis	0.85 ± 0.25	0.82 ± 0.23
Prunus avium	0.75 ± 0.29	0.80 ± 0.24
Prunus armeniaca	0.70 ± 0.31	0.65 ± 0.34
Prunus domestica	0.62 ± 0.35	0.58 ± 0.24
Rosa sp.	0.36 ± 0.15	0.42 ± 0.12

Table 2. Gypsy moth larva's daily consumption of apple leaves in square centimeter (cm^2) in different instar stages

Instar Stage	Minimum (Days)	Maximum (Days)	Daily Average ± SD	Total ± SD
First stage	0.42	0.56	0.40 ± 0.17	20.2 ± 0.32
Second stage	0.7	0.95	0.8 ± 0.73	40.2 ± 0.71
Third stage	1.21	1.58	1.37 ± 0.11	68.7 ± 0.12
Fourth stage	1.68	2.75	2.19 ± 0.28	109.8 ± 0.20
Fifth stage	2.77	3.65	3.26 ± 0.23	163 ± 0.21
Sixth stage	10.75	13.83	12.26 ± 0.93	612 ± 1.02

After cleaning, the eggs were disinfected with 0.25% sodium hypochlorite solution. Then each mass of eggs were placed in a petri-dish (10 × 15 × 20) under laboratory condition. In the next step, five cages (1 × 1 × 0.1 m) each for a different host plant were provided. To prevent escaping of larvae, the cages were walled by textile nets. Each cage was carpeted with sanitized leaves and branches of host plant (disinfected with sodium hypochlorite solution of 0.25%) and 100 larvae have been released to enjoy the party. The cages were inspected daily to measure death rate, growth stages, the first appearance of pupae and adult insects and number of laid eggs. The cages were cleaned and new leaves and branches been added every other day.

As an additional study, the relation between Gypsy moth and different trees in fruit gardens of Yasooj has been preliminary investigated. The host preference of the insect has been measured by considering two criteria:

a. Counting the larvae of the second and third larval instars on hundred leaves of each host.

b. Calculating the total eaten surface of leaves by one larva on a specific host tree.

RESULTS AND DISCUSSIONS

The second and third larval instars of Gypsy moth were observed in Yasooj (Kohkiluyeh and Boyer-Ahmad Province of Iran) during the five months of March to July. The growth and population of the insect was higher on the trees at the edge of the garden and close to the creeks. The damage of the pest was significantly higher on some plants, which was showing the favorite plants of the insect. Research conducted by counting larvae of the second and third larval instar on 100 leaves in May of 1997 and 1998 reveals that the most preferred trees in order are *Malus domestica*, *Populus nigra*, *Quercus* sp., *Rubus* sp, *Populus alba*, *Pyrus communis*, *Prunus avium*, *Prunus armeniaca*, *Prunus domestica* and *Rosa* sp. (Table 1). The results of eaten leaf-surface of apple tree at each larval instar are presented in Table 2. The total consumption during the whole larval stage is 1014 cm^2.

Determining the most suitable host for Gypsy moth under Laboratory conditions:

Table 3. Larval survival rate, Number of Pupae and insects appeared on different hosts under lab. Condition

Host	Year	Survival in different instar stages in percentage (%)						Number of Pupae	Number of insects	Percentage of Pupae turning into insects
		1	2	3	4	5	6			
Malus domestica	1997	83	81	79	72	66	63	61	60	98
	1998	87	85	84	84	83	83	83	82	99
Populus nigra	1997	82	80	80	80	80	80	80	76	95
	1998	77	75	74	73	73	73	73	70	96
Quercus sp.	1997	74	72	67	64	58	56	54	54	100
	1998	69	66	65	65	63	61	61	45	74
Populus alba	1997	52	45	30	12	5	2	0	0	0
	1998	61	50	20	20	10	4	0	0	0
Pyrus communis	1997	56	24	12	3	0	0	0	0	0
	1998	49	22	11	4	2	0	0	0	0

Results of experiments conducted in 1997

Survival of the larvae

One of the criteria to define the best host for Gypsy moth is survival rate of more than 80% of the larvae in the first larval instar. Larvae's survival rate on apple and *Populus nigra* in the first larval instar has been registered as 83% and 82% respectively. Survival rate on *Quercus* sp., *Populus Alba* and *Pyrus communis* were 74%, 52% and 56% respectively (Table 3). The results prove that only apple and *Populus nigra* can fulfill this norm. Besides, the results show a significant difference in the average endurance from larvae to pupae on different hosts, apple 61%, *Populus nigra* 80% and *Quercus* sp. 54%.

Length of the growth period

Number of days elapsed till the appearance of the pupae was 48 days for apple and 47 days for *Populus nigra* and *Quercus* sp. which was not a significant difference and none could fulfill this Miller and Hanson norm to be recognized as best host for gypsy moth. I would like to mention here that the period of time needed for larvae to become a pupa depends considerably on surroundings temperature.

Length of time needed till appearance of a complete insect

Number of days between the laid eggs date and the break out of a complete insect of larvae on *Quercus* sp. was the shortest, only 56 days. Numbers of days needed for larvae on apple and *Populus nigra* to become a complete insect were 61 and 59 respectively.

Weight of female pupae

Having female pupae heavier than 1099 milligram is one of the criteria of Miller and Hanson norms to choose the best host. The average weight of female pupae on apple, *Populus nigra* and *Quercus* sp. were 1440, 1320 and 1100 mg respectively (Table 4). So, all these three hosts fulfill this norm. Because the number of laid eggs by the female insect is proportional to the weight of pupae, the reproduction of larvae on apple tree was higher than *Populus nigra* and *Quercus* sp. This is visible in the reproduction index which is the average of female pupae weight over average number of laid eggs. The reproduction rate of female insects which its larva has been on apple, *Populus nigra* and *Quercus* sp. are 3.19, 2.59 and 2.41 in that order.

Average number of eggs laid in each group

The results of this part prove that all three hosts have passed this criterion of Miller and Hanson. The average number of eggs on apple was 451, on *Populus nigra* 508 eggs and on *Quercus* sp. 456 eggs (Table 4).

Results of the year 1998

Survival of the larvae

Larvae's survival rate on apple was more than 80%, but the survival rate of larvae in the first larval instar was 77% on *Populus nigra* and 69% on *Quercus* sp (Table 3).

Length of the growth period

Number of days elapsed from the date eggs laid till the

Table 4. Physiological characteristics of gypsy moth on different hosts under lab. Condition

Host	Year	Number of days to Pupae	Number of days to Insect	Average number of eggs in each group	Number of egg bunches	Average female weight (milligram)	Reproduction index
Malus domestica	1997	48 ± 0.76	61 ± 0.69	451 ± 50.1	15	1440	3.19
	1998	48 ±0.36	61 ± 0. 30	519 ± 56.6	15	1390	2.67
Populus nigra	1997	47 ± 0.38	59 ± 0.32	508 ± 46.6	21	1320	2.59
	1998	47 ± 0.29	56 ± 0.23	453 ± 36.2	11	1350	2.53
Quercus sp.	1997	46 ± 0.55	60 ± 0.43	456 ± 26.6	15	1100	2.41
	1998	50 ± 0.58	63 ± 0.60	475 ± 56.4	8	1120	2.35
Populus alba	1997	0	0	0	0	0	0
	1998	0	0	0	0	0	0
Pyrus communis	1997	0	0	0	0	0	0
	1998	0	0	0	0	0	0

appearance of the pupae was 48 days for apple and 47 days for Populus nigra and 50 days for Quercus sp. which was almost the same as previous year and none could fulfill this Miller and Hanson norm this year as well.

Length of time needed till appearance of a complete insect

In 1998 on the contrary to the previous year, number of days between the laid eggs date and the break out of a complete insect of larvae on Quercus sp. was the longest, 63 days. Meanwhile numbers of days needed for larvae on apple and Populus nigra to become a complete insect were 61 and 56 respectively.

Weight of female pupae

The average weight of female pupae on apple, *Populus nigra* and *Quercus* sp. were 1150, 1390 and 1120 in that order (Table 4). All three hosts fulfill this norm in this year too. The reproduction rate of female insects with its larva on apple, *Populus nigra* and Quercus sp. were 2.67, 2.59 and 2.35 respectively.

Average number of eggs laid in each group

Average number of eggs on apple was 519, on *Populus nigra* 475 eggs and on *Quercus* sp. 453 eggs (Table 4). All three hosts have passed this criterion of Miller and Hanson.

The results of using different hosts as a food resource for Gypsy moth demonstrate a significant distinction in growth of this insect. Quality and quantity of food are basic and major factors in survival of larvae and pupae and ultimately the population of Gypsy moth. The

gathered data in tables 3 and 4 reveals that Gypsy moth cannot survive on *Populus Alba* and *Pyrus communis*. The larvae in the first larval instar die after feeding a little amount of the leaves of these trees. Probably, there are prohibiting substances in these trees which prevents the larvae to grow and complete their lifecycle. The results of studies on the larvae of Gypsy moth in cold regions of Kohkiluyeh and Boyer-Ahmad show that *Lymantria dispar's* larva is mostly adapted to apple leaves as a diet rather than other plants (Tables 3 and 4). According to the outcome of researches, apple and *Populus nigra* are the main hosts of Gypsy moth in Kohkiluyeh and Boyer-Ahmad.

By analyzing the data collected in the years of 1997 and 1998, we can conclude that apple is the best known host for gypsy moth, which caused serious economical damage in this region by feeding on leaves of this tree.

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