ECOLOGY, BEHAVIOR AND BIONOMICS

Effects of Larval Diet on the Development and Reproduction of *Argyrotaenia sphaleropa* (Meyrick) (Lepidoptera: Tortricidae)

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Efeito da Alimentação Sobre o Desenvolvimento e a Reprodução de *Argyrotaenia sphaleropa* (Meyrick) (Lepidoptera: Tortricidae)

RESUMO - O efeito de seis dietas naturais sobre o desenvolvimento e a reprodução de *Argyrotaenia sphaleropa* (Meyrick) foi avaliado em laboratório, a 23 ± 1ºC de temperatura, 70 ± 10% de UR e fotofase de 16h. As larvas foram criadas sobre três tipos de dietas (folhas de primavera, folhas de verão e frutos) de duas plantas hospedeiras (macieira e videira). O desenvolvimento larval, número de ínstares, sobrevivência, peso de pupas, fecundidade e fertilidade variaram em função das dietas. Em folhas de macieira de primavera foram observados a menor duração do desenvolvimento larval, o maior peso de pupas e a maior fecundidade e fertilidade dos adultos. Em frutos, a duração do desenvolvimento larval foi maior do que em folhas. A menor sobrevivência das lagartas foi registrada sobre frutos de macieira. Nos tratamentos com maior número de ínstares as lagartas geralmente apresentaram um incremento na duração do período de desenvolvimento. A duração do desenvolvimento larval (4 em 6 tratamentos) e de pupa (5 em 6 tratamentos) foram dependentes do sexo. Em todas as dietas as fêmeas depositaram maior número de ovos no primeiro dia de oviposição. Os resultados obtidos reforçam a hipótese de que as larvas de *A. sphaleropa* alimentam-se inicialmente sobre folhas tanto na maçã como na videira, passando depois para os frutos, onde provocam danos severos.

PALAVRAS-CHAVE: Insecta, lagarta-enroladeira, planta hospedeira, biologia

ABSTRACT - The effect of six natural diets on the development and reproduction of *Argyrotaenia sphaleropa* (Meyrick) was measured under laboratory conditions, at 23 ±1ºC temperature, 70 ± 10% RH, and photoperiod of 16L:8D. Larvae were reared on three types of diet (spring leaves, summer leaves and fruits) from two different host plants (apple tree and grapevine). Larval development, number of instars, survival, weight of pupae, fecundity, and fertility varied as a function of diets. The shortest time span of larval development, the greatest pupal weight, and the greatest adult fecundity and fertility was observed on insects feeding on spring apple leaves. The duration of larval development was longer on fruits than on leaves. The lowest larval survival occurred on apple fruits. Larvae with a higher number of instars generally had an increase in the time span of larval development. Larval development time span (4 out of 6 treatments) as well as pupal development time span (5 out of 6 treatments) was sex dependant. On all diets the females deposited the highest number of eggs on the first day of oviposition. The results obtained reinforce the hypothesis that the larvae of *A. sphaleropa* first feed on both apple and grapevine leaves, and then move to the fruits, where they cause serious damage.

KEY WORDS: Insecta, tortricid moth, host plant, biology

Argyrotaenia sphaleropa (Meyrick) is a native species with polyphagous habits, which acts as a major pest on apple orchards and vineyards in South Uruguay. Recently, it has also come to prominence in Brazil for the damage it causes to *Diospyros kaki* L., limiting or impairing fruit production (Manfredi-Coimbra *et al*. 2001). The female lays the eggs in masses on the leaves, and when the larvae emerge they disperse in search of suitable feeding sites. Similarly to many other tortricids, the larvae of this species settle on shoots, foliage and fruits, causing variable degrees of damage. On apple trees, the larvae often feed on shoots, concomitantly connecting the leaves with silk threads; they damage fruit surface, thus ruining its commercial value. On grapevines the highest damages take place on bunches after the veraison. The larvae damage the grape berries, and cover the area with silk filaments to which excrement and other remains of their activity adhere. The extent of the damage increases because they cause injuries that result in bunch rot. In Uruguay this species has been known as an apple tree pest since the 1950s (Ruffinelli & Carbonell 1953), and for more than 25 years it has also been common on grapevines. Aspects related to the importance of this pest in Uruguay, and the efforts in controlling it were reported by Núñez *et al*. (1998).

A. sphaleropa specimens have been reared in laboratory many times in recent years, and differences in the development and reproduction of this species have been observed depending on whether apple or grapevine was used as food source. These differences occurred even on the same host, depending on whether the rearing was done on leaves or on fruits and, in the case of leaves, depending on the season: spring or summer. Quantity and quality of food play an important role in the biology of Lepidoptera, affecting aspects like development rate, variation in the number of instars, pupal weight, fecundity and mortality (Wigglesworth 1965, Cisneros & Barnes 1974, Pashley *et al*. 1995). Although a number of studies on the biology of this species had been carried out in Peru (Gonzáles Bachini 1956), Uruguay (Bentancourt & Scatoni 1986) and Brazil (Manfredi-Coimbra *et al*. 2001) the information available is rather scarce, and do not reflect the consequences that different diets can have on its biology. Due to the fact that *A. sphaleropa* is so prevalent in apple orchards and vineyards in Uruguay, this study was carried out in order to study the effect of six natural diets (apple tree and grapevine leaves and fruits) on its development and reproduction.

Materials and Methods

The study was carried out on larvae and pupae collected from apple orchards and vineyards in fruit-growing areas near Montevideo. Leaves from these crops were used to feed the colonies in the laboratory. The studies were done with the first generation larvae collected in the field and kept on the same food (apple and vine) from which they were collected. The rearing conditions were: 23 ± 1ºC temperature, 70 ± 10% R.H., and 16h light. To maintain relative humidity, closed glass boxes with a saturated solution of sodium chloride were used (Winston & Bates 1960). For the tests, apple leaves and fruits (Red Delicious) and grapevine leaves and fruits (Muscat of Hamburg) were used as food sources. The tests on leaves were done in the spring (November-December) and in the summer (January-February). The tests on fruits were started in February, when the worst attacks in the field start.

The methodology for rearing this species as described below has already been used for years in the Entomology Laboratory of the College of Agronomy University of the Republic, Uruguay (Bentancourt & Scatoni 1986). The rearing on different hosts was initiated at the larval stage, although the procedure varied depending on whether the rearing was on leaves or on fruits. In the former case, the recently hatched larvae were individually placed into clear plastic boxes (70 mm in diameter x 30 mm deep) containing new apple or grapevine leaves arranged on top of filter paper. Fresh food was provided whenever necessary. Cephalic capsule was measured and the number and duration of larval instars were determined. Two tests with 50 larvae each were performed. The rearing on fruits was done in clear plastic boxes (80 mm in diameter and 90 mm deep) covered with polythene sheets (Rolopac ®), each one containing an apple or a piece of a bunch of grapes. The apples used were similar in size (approx. 60 mm in diameter), color and shape. The bunches of grapes chosen were collected between 15 and 30 days prior to the harvest, and the rachis was cut so as to leave pieces 60 to 70 mm in length. Two recently ecloded larvae were placed in each box. Observation on fruits is more difficult than on leaves since the larvae are not easily exposed, thus the duration of each instar was not evaluated, so as not to hinder development. Therefore the duration on larva was measured from the eclosion of larvae until pupation. The fruit was removed only when it lost turgidity or when the rotting process began. This latter process eventuality occurred more frequently on grapes. A total of 60 larvae per test were reared.

The larvae fed on leaves normally pupated in the substrate itself. On the other hand, when reared on fruits, especially apples, it was common to find the pupae on the sides of the rearing boxes. Once the pupae had formed they were individually transferred to plastic boxes (60 mm in diameter) on top of moistened filter paper. Within 48h they were sexed and weighed. The pupal duration was registered. As the adults emerged they were paired and each couple was individually placed into glass boxes (90 mm in diameter and 100 mm deep) lined inside with paraffin paper. A diet of 10% honey solution, daily replaced, was used to feed the adults. A minimum of 12 couples was formed per treatment. Fertilized females laid their eggs on paraffin paper. Generally one female laid one to three egg masses per night. The egg masses were individually placed into plastic boxes under conditions similar to those described for the pupae. The number of eggs per mass was counted and the number of eggs hatched was recorded. Couples that did not oviposit or that laid a low number of non-viable eggs were eliminated from the test.

Data were submitted to the Generalized Linear Model (McCullagh & Nelder 1991), supposing a Poisson distribution with a logarithm link function for the counting variables (number of eggs, duration of development periods, fecundity and fertility) and binomial distribution with a logit link function for the proportions (survival). Maximum likelihood estimates and tests of the model were done with F test or Chi-square statistics. For the continuous variables (weight of the pupae and width of the cephalic capsule) the General Linear Models (ANOVA) and the Tukey test for the mean comparisons were used. The analyses were performed using the GENMOD procedure of the SAS (1997) statistical analysis system.

Results

Variability in the Number of Instars and Width of Cephalic Capsule. The number of instars of *A. sphaleropa* varied as a function of diet and season (spring or summer) (Table 1). The majority of larvae fed on apple leaves had five instars, while most of those fed on grapevine leaves passed through six instars. On both diets the predominance of larvae with six instars was even more marked in those reared in the summer. On both apple tree and grapevine, only a low percentage (or percent) of the larvae had seven instars. Since the number of

Table 1. Percent *Argyrotaenia sphaleropa* (Meyrick) (Lepidoptera: Tortricidae) larvae with different numbers of instars reared on apple and grapevine spring or summer leaves used as feeding diet.

	Instars					
	V		VI		VII	
Diet	Apple	Grapevine	Apple	Grapevine	Apple	Grapevine
Spring leaf	86.5	30.3	5.4	69.7	8.1	-
Summer leaf	81.3	3.4	18.7	89.6	-	6.9

larvae with seven instars was low, these were not included in the statistical analysis. In previous tests a similar trend was observed, with a marked predominance of larvae with five and six instars. Likewise, respecting sex no statistically significant differences were found in the number of molts. Variability in the number of molts affected the duration of larval development, since larvae with six instars needed two or three more days to pupate.

Larvae with the same number of molts had a similar mean width of cephalic capsule. For this reason, the size of the cephalic capsule for larvae with five and six instars is shown in Table 2 without considering diet. The mean width of the cephalic capsule was similar in the first two instars. However, in the third instar it differed among the series studied when individuals of the same sex were compared. On the other hand similarities between males of five instars and females of six instars were actually found. In the fourth or fifth instars, similarities between the series were not observed. The larvae that completed their development in six instars had a smaller cephalic capsule than those that did so in five instars. In the fifth instar, when the width of the cephalic capsule was less than 0.9 mm, the larvae went through one more molt. For the same sex, the final size of the cephalic capsule was slightly greater in larvae of six instars.

Duration of the Development Period and Weight of Pupae. The duration of larval development differed with the source of food used, and in the case of larvae reared on leaves, with the season in which the tests were carried out (spring or summer) (Table 3). Larvae fed on apple tree and grapevine leaves had a shorter period of development as compared to those fed on fruits. The largest differences in the rate of development were obtained among larvae fed on spring apple leaves and apple fruits. Larval development was different between larvae fed on apple and grape and between larvae fed on spring or summer apple leaves, but this was not the case between those fed on grapevine leaves in the two seasons. Female larvae lasted longer than male ones. The differences between the sexes were significant except for larvae reared on apple tree and grapevine spring leaves. Diet showed little effect on the duration of the pupal stage. The only statistically significant differences were found for female pupae reared on apples (7.1 ± 1.01 days) and those reared on grapes (7.9 ± 0.66 days). The mean duration of the pupal

Table 2. Mean (± SE) width (mm) of the cephalic capsule in *A. sphaleropa* larvae that completed their development in five or six instars.

Number of instars/sex	Instars I	II	III	IV	V	VI
5 males	0.21 ± 0.00 a	0.31 ± 0.00 a	0.47 ± 0.00 bc	0.72 ± 0.01 b	1.06 ± 0.01 c	-
5 females	0.21 ± 0.00 a	0.31 ± 0.00 a	0.48 ± 0.00 c	0.77 ± 0.01 c	1.15 ± 0.01 d	-
6 males	0.21 ± 0.00 a	0.31 ± 0.00 a	0.44 ± 0.00 a	0.63 ± 0.01 a	0.83 ± 0.01 a	1.12 ± 0.01 a
6 females	0.21 ± 0.00 a	0.31 ± 0.00 a	0.46 ± 0.00 b	0.66 ± 0.01 a	0.89 ± 0.01 b	1.20 ± 0.01 b

Numbers within columns followed by the same letter are not statistically different at the 5% level of probability, according to the Tukey-Kramer test.

Table 3. Duration (days) (mean ± SE) of development period for eggs, larvae, pupae and total development period of *A. sphaleropa* reared on different apple and grapevine plant parts used as feeding diet.

Diet	Egg	Larva		Pupa		Total	
		Female	Male	Female	Male	Female	Male
Apple							
Spring leaf	7.5 ± 0.04 b	18.6 ± 1.24 a A	17.3 ± 0.98 a A	7.7 ± 0.80 ab A	8.4 ± 0.68 a B	34.3 ± 1.69 a	33.7 ± 1.37 a
Summer leaf	7.5 ± 0.05 b	25.3 ± 1.19b A	22.9 ± 1.28 b B	7.5 ± 0.66 ab A	8.4 ± 0.77 a B	40.6 ± 1.55 b	39.4 ± 1.68 b
Fruit	7.8 ± 0.08 c	39.1 ± 2.36d A	35.7 ± 2.44 d B	7.1 ± 1.01 a A	8.7 ± 1.48 a B	54.3 ± 2.78 d	51.3 ± 3.58 d
Grapevine							
Spring leaf	7.5 ± 0.06 b	24.3 ± 1.37 b A	22.7 ± 1.07 b A	7.6 ± 0.79 ab A	8.3 ± 0.64 a B	40.0 ± 1.83 b	39.1 ± 1.40 b
Summer leaf	7.4 ± 0.06 a	25.6 ± 1.83 b A	22.7 ± 1.23 b B	7.8 ± 0.77 ab A	8.4 ± 0.77 a B	40.0 ± 1.75 b	37.9 ± 1.65 b
Fruit	7.8 ± 0.05 c	30.6 ± 1.27 c A	27.7 ± 1.05 c B	7.9 ± 0.66 b A	8.1 ± 0.65 a A	46.3 ± 1.60 c	42.5 ± 1.50 c

Numbers within columns followed by the same lower-case letter or within rows followed by the same upper-case letter are not statistically different at 5% probability, according to the Chi-square test.

stage was sex dependent. Male pupae lasted longer than the female ones, except on grapes. The egg stage varied between 7.4 days (summer grapevine leaves) and 7.8 days (apples). Although differences in the duration of egg stage between different diets were observed, this fact does not seem to be biologically very significant and can be accounted for by the low standard error computed as a consequence of counting all eggs laid by the females.

Female pupae reared on apple leaves in the spring were heavier than those reared on other food sources (Table 4). Besides, the male pupae reared on the same diet and in the same season were heavier, although there are no statistically significant differences from those reared on grapevines. The weight of pupae was sex dependent. Except for those reared on spring and summer grapevine leaves, the weight of the female pupae was higher than that of the male ones.

Survival. Larval survival was greater on leaves than on fruits (Table 5). These results are in line with the shorter larval development time, which occurred on leaves of both apple tree and the grapevine. The highest mortality of larvae occurred on apple fruits. From the very beginning the larvae on this host sough refuge in the stem or calyx cavity, and it was even common for them to penetrate through the calyx orifice into the inner fruit. This prevented observation from outside, but their presence was detected by the fresh excrements, which fell from the orifice. However, a high percent of larvae did not manage to survive, particularly in the first instars. On grapes, as on apples, most larvae died during the first days. However, they were better adapted on grapes than on apples and once they had passed this first stage, survival was high, similar to that observed on leaves. Similar to larvae, the lowest pupae survival was on apples, although statistically significant differences were not observed with pupae reared on spring apple leaves. Egg viability was above 94%in all cases, with no statistical differences among the different diets.

Effects of Diet on Reproduction. Data on longevity, pre-oviposition and oviposition periods as well as on fecundity and fertility of adults of *A. sphaleropa* for each of the diets tested are shown in Table 6. Females reared on spring apple leaves had the highest fecundity and fertility while the lowest fecundity and fertility occurred on summer apple leaves, although not statistically different. The females normally mated on the first or second night after emergence, but if they did so the first night they frequently did not begin oviposition until the following day. Thus the pre-oviposition period was normally two days, although on grapes and spring grapevine leaves the females took nearly one day longer, on average before commencing oviposition. The oviposition period varied between 6.5 and 11.1 days, with maximum numbers for specimens reared on spring apple tree and grapevine leaves, although statistical differences between apples and summer apple leaves were not observed. On all the food sources, the females lived longer than the males. The greatest female longevity was 18.9 days on summer grapevine leaves, not statistically different from those obtained on the other two apple diets. The lowest longevity was 13.0 days on spring grapevine leaves, not statistically different from longevity on apple and grape fruits. Fecundity was not related to female longevity.

The influence of diet on the mean number of eggs daily laid by the females are shown in Fig. 1. Females reared on spring apple leaves laid significantly ($P< 0.05$) more eggs than the other females in the first three days, except for those

Table 4. Mean weight (mg) (mean ± SE) of *A. sphaleropa* pupae reared on different apple and grapevine plant parts used as feeding diet.

Diet	Apple		Grapevine	
	Female	Male	Female	Male
Spring leaf	28.3 ± 0.92 a A	16.9 ± 0.76 a B	18.9 ± 0.89 b A	15.7 ± 0.72 ab A
Summer leaf	16.7 ± 0.76 b A	13.1 ± 0.86 b B	16.5 ± 0.86 b A	15.0 ± 0.83 ab A
Fruit	20.0 ± 1.21 b A	12.9 ± 1.31 b B	19.4 ± 0.74 b A	13.7 ± 0.64 ab B

Numbers within columns followed by the same lower-case letter or within rows followed by the same upper-case letter are not statistically different at 5% probability according to the Tukey-Kramer test.

Table 5. Survival (%) (mean ± SE) of eggs, larvae and pupae of *A. sphaleropa* reared on different apple and grapevine plant parts used as feeding diet.

Diet	Egg	Larva	Pupa
Apple			
Spring leaf	95.7 ± 0.27 a	77.3 ± 6.32 b	90.9 ± 5.00 ab
Summer leaf	94.9 ± 0.43 a	73.8 ± 6.78 b	96.8 ± 3.17 b
Fruit	97.9 ± 0.40 a	36.5 ± 7.65 a	73.3 ± 11.41 a
Grapevine			
Spring leaf	96.5 ± 0.41 a	76.2 ± 6.57 b	96.9 ± 3.07 b
Summer leaf	99.5 ± 0.15 a	77.8 ± 6.93 b	96.4 ± 3.09 b
Fruit	95.7 ± 0.37 a	56.0 ± 5.56 a	93.2 ± 3.80 b

Numbers within columns followed by the same letter are not statistically different at the 5% level of probability, according to the Chi-square test.

Table 6. Longevity, pre-oviposition and oviposition periods, fecundity and fertility (mean ± SE) of *A. sphaleropa* reared on different apple and grapevine plant parts used as diet.

Diet	Pre-oviposition (days)	Oviposition (days)	Longevity F (days)	Longevity M (days)	Fecundity (total eggs)	Fertility (viable eggs)
Apple						
Spring leaf	2.0 ± 0.41 a	11.1 ± 0.96 b	17.6 ± 1.21 bc	15.7 ± 1.14 b	460.8 ± 6.20 a	441.1 ± 6.06 a
Summer leaf	2.1 ± 0.42 a	9.7 ± 0.90 ab	17.3 ± 1.20 bc	13.3 ± 1.05 ab	218.4 ± 4.27 c	207.2 ± 4.15 c
Fruit	2.0 ± 0.63 a	9.8 ± 1.40 ab	15.8 ± 1.78 abc	15.6 ± 1.77 b	255.6 ± 7.15 bc	250.2 ± 7.07 bc
Grapevine						
Spring leaf	2.7 ± 0.57 ab	6.5 ± 0.90 a	13.0 ± 1.27 a	10.7 ± 1.33 a	289.3 ± 6.43 b	279.1 ± 6.31 b
Summer leaf	2.1 ± 0.48 a	11.1 ± 1.11 b	18.9 ± 1.45 c	14.2 ± 1.26 ab	266.2 ± 5.77 bc	265.0 ± 5.75 bc
Fruit	2.9 ± 0.47 b	8.0 ± 0.78 a	15.7 ± 1.10 ab	14.0 ± 1.13 ab	259.4 ± 4.85 bc	248.3 ± 4.75 bc

[1]Numbers within columns followed by the same letter are not statistically different at 5% probability, according to the Chi-square test.

reared on apples during the first day, and grapes on the third day. The highest number of eggs laid in one day was 116, on spring apple leaves. On all diets, the maximum number of eggs was laid on the first day of oviposition, when the females laid between 20.2% (spring grapevine leaf) and 28.5% (apples) of the total eggs, while on the fourth day the percentages of eggs laid varied between 49.9% (summer grapevine leaf) and 66.1% (grape fruits).

Discussion

The quantity and quality of food have a direct influence on essential aspects of the biology of insects (Frank & Dietz 1987, Hagley & Barber 1992, Pashley *et al*. 1995). Results of this study indicated that natural diets (apple and grapevine) have direct consequences on the development of immature stages (or instars) and on some physiological activities of *A. sphaleropa* adults. The mean duration of larval development for both sexes changed as a function of diet. On spring apple leaves, larval development period was 17.3 days and 18.6 days, for male and female larvae, respectively. In general, these results agree with those found by Manfredi-Coimbra *et al*. (2001), who reported a duration period of 19.3 days for larvae of both sexes reared on artificial diet at 22ºC. On the other diets, the duration of larval development was, in all cases, above that reported. Larvae reared on fruits took a longer time to complete their development than those reared on leaves. On apple, the highest differences were observed between fruits and spring leaves. On the former diet the larvae required between 18.3 days (males) and 20.6 days (females) more than on leaves. The cycle from egg to emergence of adult was approximately 34 days on spring leaves, 40 days on summer leaves, and 53 days on fruits. On the other hand, larvae reared on grapes lengthened their cycle between five and six days as compared to those fed on leaves. On grapevine, the cycle from egg to emergence of adults was approximately 39 days on spring or summer leaves, and 44 days on fruits. Both on apple tree and grapevine, the male larvae completed their development in a shorter time than the female. The differences varied between 1.2 days on spring apple leaves and 3.5 days on apple fruits. This trend was the opposite for pupae; the male pupae lasted longer than females, with differences of 0.2 days on grapes and 1.6 days on apples. Thus, the cycle from egg to adult emergence generally differed between sexes by approximately one or two days, and was longer for females than for males. Similar results were found by Fedde (1980) who reported a slightly longer larval period for females of *Ennomos subsignarius* (Hübner) than for males, as well as for pupal development, which was longer for males than for females. Hathaway *et al.* (1971) reported that the average duration of the development of *Cydia pomonella* L. (from the emergence of larvae until the emergence of the adults), on immature apples and at a constant temperature (26.7ºC), was 32.1 days for females and 31.1 days for males.

The number of larval instars varied from five to seven, but the presence of individuals with seven instars was not very

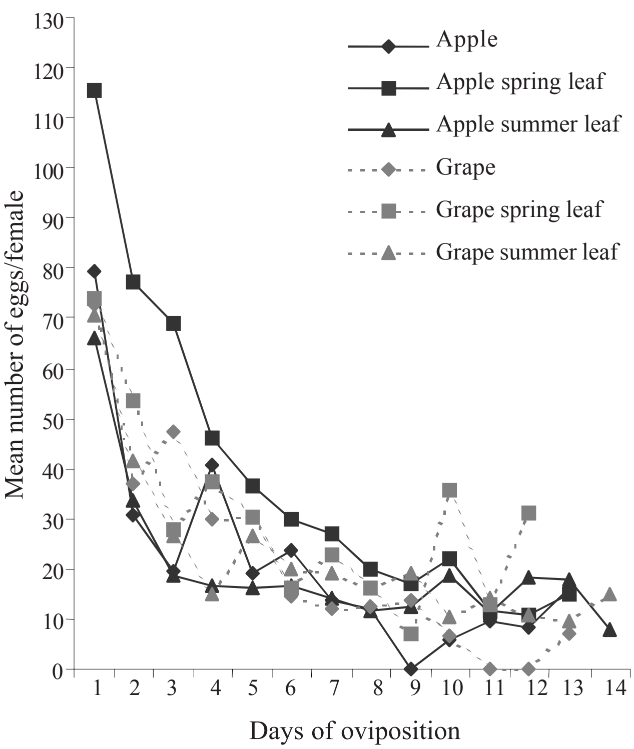

Figure 1. Distribution of eggs laid throughout the oviposition period by *A. sphaleropa* reared on six different diets.

common, and it does not seem reasonable to attribute this to differences in diets. On the other hand, the predominance of larvae with five or six instars was a function of diet, since the larvae reared on grapevine leaves usually molted one time more than those reared on apple leaves. Gonzales Bachini (1956) reported that on cotton the larvae developed through five instars. Independently of diet, summer larvae were more likely to go through one more molt than spring larvae. This variation in the number of instars with the season seems to result from differences in the nutritive quality of the leaves. Morris (1967) and Morris & Fulton (1970) reported that the summer generation of *Hyphantria cunea* Drury went through a greater number of instars due to the lower nutritive quality of the leaves in that season. The number of instars also influenced the duration of larval development period. Larvae with six instars required two or three more days to complete development than those with five instars . Morris & Fulton (1970) reported that in *H. cunea* development extended for two or three days when the larvae had seven instars instead of six instars. Ali *et al*. (1990) found that when larvae of *Spodoptera frugiperda* (J.E. Smith) completed their development in more than six instars, they took a longer time to develop than those which pupated in the sixth instar.

Caution is needed when interpreting laboratory data in the context of fitness in the natural environment (Rausher 1988, Pashley *et al*. 1995). Nevertheless, spring larvae seems to find adequate food on the new leaves of the apple tree, which allows the duration of this stage to be comparatively short due to the higher rate of development and to the lower number of instars. Similarly, on this diet the females laid an average of 460 eggs, which is 205 eggs more than on fruits, and 242 eggs more than on summer leaves. This high reproductive potential among spring females can cause large increase in the density of the populations, if no reducing factors are in operation. In the summer, the larvae caused severe damage to apple fruits. However, larval mortality was high on this diet, and the duration of larval development was excessively extended. These results reinforce the hypothesis that the small larvae first feed on leaves, and later when they are more developed, migrate to fruits. In fact, the presence of small larvae on fruits is not common, unless a leaf is in contact with the fruit and they feed on both vegetal parts at the same time. This behavior probably reduces the mortality of the small larvae and has an effect on the rate of development, allowing the larvae to reach maturity in a shorter time. Whiting *et al*. (1997) found that the percentage of *Epiphyas postvittana* (Walker) first instar larvae, which established and survived on fruit in the laboratory was low as compared to the percentages obtained for larvae in the third or fifth instars. Coscaron and Gianotti (1960) reported that the larvae of *Argyrotaenia loxonephes*(Meyrick) did not feed on apples until they were several days old. In the laboratory, the larvae only went on feeding on fruits when they were more than 10 days old.

Although similar behavior on grapevine might be expected as that reported on apple tree, the presence of small larvae on the bunches of grapes from February onwards occurred more frequently, and this leads one to suppose that the move to bunches takes place at a younger age. Likewise, it is possible to infer that while the larvae on apple trees show greater dependence on the leaves and it is common for them to feed on both parts at the same time, on grapevine the larvae ignore the leaves once they have settled on the bunches. Results obtained in this study reinforce this hypothesis, since the survival of larvae was greater on bunches of grapes and the duration of larval development period was smaller than that observed on apples.

Literature Cited

Ali A., R.G. Luttrell & J.C. Schneider. 1990. Effects of temperature and larval diet on development of the fall armyworm (Lepidoptera: Noctuidae). Ann. Entomol. Soc. Am. 83: 725-733.

Bentancourt, C.M. & I. Scatoni. 1986. Biología de *Argyrotaenia sphaleropa* Meyrick (1909) (Lep. Tortricidae) en condiciones de laboratorio. Rev. Brasil. Biol. 46: 209-216.

Cisneros, F.H. & M.M. Barnes. 1974. Contribution to the biological and ecological characterization of apple and walnut host races of codling moth, *Laspeyresia pomonella* (L.): moth longevity and oviposition capacity. Environ. Entomol. 3: 402-406.

Coscaron, S & J.F. Gianotti. 1960. Una nueva plaga de la fruticultura del Alto Valle del Río Negro y Neuquen: *Eulia loxonephes* Meyrick (Lepidoptera Tortricidae). Rev. Invest. Agrícolas 14: 229-293.

Fedde, V.H. 1980. Development of the elm spanworm, *Ennomos subsignarius*, on artificial diet. Ann. Entomol. Soc. Am. 73: 668-670.

Frank, A.E. & A. Dietz. 1987. Growth and survival of *Galleria mellonella* (Lepidoptera: Pyralidae) larvae fed diets containing honey bee-collected plant resins. Ann. Entomol. Soc. Am. 80: 74-77.

Gonzales Bachini, J.E. 1956. Dos tortrícidos de importancia económica en el cultivo del algodonero en los Valles de la Costa Central. Agronomía (Perú) 22: 7-52.

Hagley, E.A.C. & D.R. Barber. 1992. Effect of food sources on the longevity and fecundity of *Pholetesor ornigis* (Weed) (Hymenoptera: Braconidae). Can. Entomol. 124: 341-346.

Hathaway, D.O., A.E. Clift & B.A. Butt. 1971. Development and fecundity of codling moths reared on artificial diets or immature apples. J. Econ. Entomol. 64: 1088-1090.

Manfredi-Coimbra, S., M.S. Garcia & M. Botton. 2001. Exigencias térmicas e estimativa do número de gerações de *Argyrotaenia sphaleropa* (Meyrick) (Lepidoptera: Tortricidae). Neotrop. Entomol. 30: 553-557.

McCullagh, P.M. & J.A. Nelder Frs. 1991. Generalized linear models. London, Chapman & Hall, 510p.

Morris, R.F. 1967. Influence of parental food quality on the survival of *Hyphantria cunea.* Can. Entomol. 99: 24-33.

Morris, R.F. & W.C. Fulton. 1970. Models for the development and survival of *Hyphantria cunea* in relation to temperature and humidity. Mem. Entomol. Soc. Can. nº 70, 60p.

Nuñez, S., S. García, J. Paullier, C. Pagani & D. Maeso. 1998. Guía para el manejo integrado de plagas y enfermedades en frutales. INIA (Uruguay), Boletín 66, 116p.

Pashley, D.P., T.N. Ardí & A.M. Hammond. 1995. Host effects on developmental and reproductive traits in fall armyworm strains (Lepidoptera: Noctuidae). Ann. Entomol. Soc. Am. 88: 748-755.

Rausher, M.E. 1988. Is coevolution dead? Ecology 69: 898-901.

Ruffinelli, A & Carbonell, C. 1953. Segunda lista de insectos y otros artrópodos de importancia económica en el Uruguay. Rev. de la A. I. A., Uruguay 94: 33-82.

SAS Institute Inc., SAS/STAT®. 1997. Software: Changes and enhancements through Release 6.12, Cary, N.C: SAS Institute Inc. 1167p.

Whiting, D.C., G.M. O'Connor & J.H. Maindonald. 1997. Density and time effects on distribution and survival of light brown apple moth (Lepidoptera: Tortricidae) larvae on Granny Smith apples. Environ. Entomol. 26: 277-284.

Wigglesworth, V.B. 1965. The principles of insect physiology. Methuen, London, 741p.

Winston, P.W. & D.H. Bates. 1960. Saturated solutions for the control of humidity in biological research. Ecology 41: 232-237.

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