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## Burrknobs as Food Source for Larval Development of *Grapholita molesta* (Lepidoptera: Tortricidae) on Apple Trees

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**ABSTRACT** *Grapholita molesta* (Busck) is one of the main pests of apple trees, and lives on their shoots and fruits. In southern Brazil, the insect is also found on old branches and structures similar to aerial roots, so-called burrknobs. This study evaluated the development and population growth potential of *G. molesta* fed on burrknobs, compared with apple fruit cultivar. Fuji and a corn-based artificial diet. The study was carried out in the laboratory under controlled temperature ( $25 \pm 1^\circ\text{C}$ ), relative humidity ( $70 \pm 10\%$ ), and photophase (16 h). The biological parameters of the immature and adult stages were determined, and a fertility life table was constructed. Insects fed on burrknobs showed a longer duration and a lower survival for the egg-to-adult period (29.3 d and 22.5%) compared with those that fed on apples (25.1 d and 30.0%) and artificial diet (23.9 d and 54.8%). Insects reared on aerial roots had a lower pupal weight (10.0 mg) compared with those reared on either artificial diet (13.7 mg) or apple cultivar. Fuji (12.4 mg). The fecundity and longevity of males and females did not significantly differ for the three foods. Based on the fertility life table, insects reared on burrknobs had the lowest net reproductive rate ( $R_0$ ), intrinsic rate of population growth ( $r_m$ ) and finite rate of increase ( $\lambda$ ), compared with insects reared on artificial diet and apple fruit. Burrknobs support the development of the complete cycle of *G. molesta*, which allows populations of this pest to increase in orchards.

**KEY WORDS** Lepidoptera, oriental fruit moth, biology, fertility life table

Apples, *Malus domestica* (Borkhausen 1803) (Rosaceae), are grown in the temperate climate of southern Brazil, with a growing area close to 37,000 ha (IBGE 2008). One of the more important insect pests requiring attention from apple growers is *Grapholita molesta* (Busck 1916) (Lepidoptera: Tortricidae), commonly known as “grafolita” or oriental fruit moth. In Brazil, *G. molesta* is one of the main pests of stone-fruit trees (plum, peach, and nectarine), and it was first observed on apple trees in 1982. In 1985, up to 90% of fruits were damaged by the pest in some orchards, demonstrating its rapid adaptation to different crops (Reis Filho et al. 1988). Attacks by this insect were frequently reported in the region of Fraiburgo, state of Santa Catarina (SC), Brazil, and were attributed to the close proximity of stone-fruit orchards to the apple trees (Kovaleski and Botton 2003, Kovaleski and Ribeiro 2002). However, in recent harvests, significant damage was also reported in São Joaquim, SC, and in Vacaria,

state of Rio Grande do Sul (RS), important fruit-growing centers in Brazil (Kovaleski and Botton 2003, Arioli et al. 2007). The increase in damage caused by *G. molesta* in apple trees could be explained by three hypotheses: 1) reduction in the number of applications of insecticides against key pests of the crop, mainly the South American fruit fly *Anastrepha fraterculus* (Wiedemann, 1830) (Diptera: Tephritidae) and the apple leafroller *Bonagota cranaodes* (Meyrick) (Lepidoptera: Tortricidae), after the implementation of the program Integrated Production of Fruits (PIF); 2) the utilization mainly of organophosphate insecticides to control pests in apple orchards could have led to selection of resistant populations; and 3) low efficiency of these insecticides against the pest and inadequate use of sex-pheromone traps (Kovaleski and Botton 2003, Arioli et al. 2005) and the high capacity for population growth of *G. molesta* feeding on apples (Silva et al. 2010). In addition to these factors, the potential for population growth of *G. molesta* is higher in apple than in peach fruit, even though the latter is traditionally recognized as the host of this pest (Silva et al. 2010).

In apple trees, four or five generations of *G. molesta* are seen per annual harvest, with flight activity of adults beginning in August and lasting until May (Reis Filho et al. 1988, Nora and Hickel 2002). The highest population densities of adults occur in the spring and

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summer, coinciding with the crop's fruiting period. In autumn and winter, in regions of temperate climate, the insect enters diapause (Omelyuta 1978); however, the occurrence of diapause in apple-growing areas of southern Brazil needs to be better evaluated.

Kovaleski and Ribeiro (2002) found that last-instar larvae of *G. molesta* remain in diapause under the bark and in burrknots during the winter. Arioli (2007) reported that the larvae feed on burrknots, and suggested that these structures are a food source that is present in orchards in periods of food scarcity (absence of fruits and shoots) and also during harvest. The oriental fruit moth can complete its biological cycle in these structures, allowing a more rapid growth of the population in the orchard, which makes it difficult to control the pest by the use of sex pheromones (disruption of mating) or even insecticides, mainly during preharvest when the populations in the orchards are very large.

Burrknots are structures consisting of incompletely differentiated parenchymatous tissue (Chrun et al. 1992). These tissues form above-ground, and are normally found on stems and branches lignified in the grafting region and in locations where large branches have been removed in pruning. These structures are formed more often in scion cultivars such as 'Early Smith,' 'Jonagold,' 'Springdale,' 'Imperial Gala,' 'Gala,' and 'Fuji' on rootstocks M7, M9, M26, MM106, MM111, and Mark (Barden and Marini 1999, Kudela et al. 2009). Conditions of low light and high humidity and temperature also favor their development (Perry and Cummins 1990).

Among the factors that favor the population growth of *G. molesta* in commercial orchards is food availability, since the insect is polyphagous and feeds on various plant structures, preferring species of the family Rosaceae as hosts (Salles 2001). Theoretically, in apples, one food source for the development and shelter of the species during the winter or even during a lack of regular food (blossoms and fruits) would be the aerial roots. Therefore, information on the growth potential of *G. molesta* on aerial roots could lead to better understanding of the population dynamics of the insect in apples, as well as helping in the control of this pest in commercial orchards. Therefore, the current study evaluated the development of *G. molesta* in the larval stage in burrknots, compared with feeding on the typical diet (apple) and a corn-based artificial diet, and also evaluated its population growth potential.

### Materials and Methods

The study was conducted in the Entomology Laboratory of Embrapa Clima Temperado, under controlled conditions of temperature ( $25 \pm 1^\circ\text{C}$ ), relative humidity ( $70 \pm 10\%$ ) and photophase (16 h). The insects used in the experiments were from a laboratory-maintained population, bred according to the technique developed by Arioli et al. (2010).

The burrknots were collected from commercial apple orchards, cultivar Gala, located in the municipality

of Lages, Santa Catarina, Brazil ( $27^\circ 48' \text{S}$ ,  $50^\circ 19' \text{W}$ ), transported to the laboratory wrapped in damp paper, and stored in polypropylene containers. These structures were placed in individual 500-ml plastic cups containing a 2-cm layer of a 2% agar solution in water + nipagin (methyl parahydroxybenzoate) on the bottom, to keep the plant tissue moist during larval development and to avoid contamination by microorganisms. The burrknots were placed in contact with the still-liquid solution, so that one-third of the knot was immersed in the solution. The solution was allowed to set for 24 h, and then 20 recently eclosed larvae ( $<12$  h old) were transferred (using forceps) onto these plant structures, for a total of 160 larvae per treatment. The cups (repetitions) containing the larvae were closed with a perforated plastic cover to allow aeration and to prevent the larvae from escaping.

The artificial diet used for the biological study was composed of ground corn (224 g), wheat germ (56 g), beer yeast (60 g), biological yeast (Fleischmann, AB Brasil Industria e Comercio de Alimentos Ltda, Pederneras, São Paulo, Brazil) (60 g), ascorbic acid (8 g), benzoic acid (3.6 g), nipagin (2.8 g), formaldehyde (1 ml), agar (32 g), and distilled water (900 ml) prepared according to the technique proposed by Arioli et al. (2010). The diet was placed in glass tubes (8.5 cm in length  $\times$  2.5 cm in diameter), filled to one-third their height with the diet, and stoppered with hydrophobic cotton. Two larvae up to 12 h old were transferred to each tube, totaling 80 tubes with two larvae each.

For the development of *G. molesta* on apples, individual fruits of the Fuji cultivar were placed in 300-ml plastic cups. Two recently eclosed larvae ( $<12$  h old) were placed on each fruit. Netting material was placed over the container, and fixed on the sides with a rubber band to prevent the larvae from escaping before they pupated and to exclude other insects, in accordance with the method of Silva et al. (2010).

In the three hosts (burrknots, artificial diet, and Fuji apple), the duration and survival of the stages of egg, larva, and pupa, length of the egg-to-adult period, weight of pupae at 24 h of age, and sex ratio were determined. In the adult stage, the periods of preoviposition and oviposition, longevity, and fecundity of males and females were determined. The sex ratio (SR) was obtained based on the formula:  $SR = \frac{\text{♀}}{\text{♀} + \text{♂}}$ . The biological parameters for the adult stage were obtained from 20 couples for each treatment. The couples were placed in individual 300-ml plastic cups, with the opening covered with a petri dish. The adults were fed a solution of 10% honey, supplied by capillary action using hydrophilic cotton (Soft Plus cotton balls produced by Orlando Antonio Bussioli-ME, Rio Claro, São Paulo, Brazil), in small acrylic containers (10 ml). The food was changed every 2 d. The couples were evaluated daily, and the mortality and number of eggs placed on the inside wall of the cage were recorded. Once the oviposition was established on the inner side of the cage, this was replaced by another cage.

**Table 1.** Duration and survival (mean  $\pm$  SE) of the stages of egg, larva, and pupa and egg-to-adult period of *Grapholita molesta* reared on different hosts

Biological parameter	Stage/period	Artificial diet	Apple cv. Fuji	Burrknots
Duration (days)	Egg	3.42 $\pm$ 0.18a <sup>a</sup>	3.57 $\pm$ 0.18a	3.75 $\pm$ 0.19a
	Larva	14.75 $\pm$ 0.14c	15.87 $\pm$ 0.14b	19.14 $\pm$ 0.15a
	Pupa	5.75 $\pm$ 0.18b	5.63 $\pm$ 0.18b	6.43 $\pm$ 0.19a
	Egg-to-adult	23.92 $\pm$ 0.23c	25.07 $\pm$ 0.23b	29.32 $\pm$ 0.24a
Survival (%)	Egg	77.44 $\pm$ 8.18a	55.00 $\pm$ 10.56a	56.15 $\pm$ 7.27a
	Larva	83.75 $\pm$ 4.92a	73.75 $\pm$ 4.92a	52.82 $\pm$ 5.26b
	Pupa	84.57 $\pm$ 3.93a	73.26 $\pm$ 3.93a	75.86 $\pm$ 4.20a
	Egg-to-adult	54.84 $\pm$ 4.84a	29.97 $\pm$ 4.84ab	22.50 $\pm$ 5.18b

Temperature 25  $\pm$  1°C, relative humidity 70  $\pm$  10%, and photophase 16 h.

<sup>a</sup> Means followed by the same letter in the row do not differ according to Tukey's test ( $P \leq 0.05$ ).

Parallel to the study of the development of the immature stages, an experiment was performed to determine the number of larval instars on the three foods. Ten larvae were transferred to containers with the three different foods, with a total of 40 repetitions for each treatment. The surviving larvae in each repetition were removed daily, after which the width of the head capsule of the larvae was measured, using an ocular micrometer mounted in a stereomicroscope. To determine the number of instars, the multimodal frequency curve of the head-capsule measurements was used, and hypotheses tested on the linearized model of Dyar's law were formulated by means of the program MOBAE (Modelos Bioestadísticos para a Entomologia) (Haddad et al. 1995).

With the data obtained, a fertility life table was determined for the different foods, estimating the mean generation time ( $T$ ), net reproduction rate ( $R_0$ ), intrinsic rate of population growth ( $r_m$ ), and finite rate of increase ( $\lambda$ ). Life-table parameters and their respective standard errors were estimated using the Jackknife method (Meyer et al. 1986) as described by Maia et al. (2000). Statistical analyses were performed with the SAS computer program 'lifetable.sas' in the SAS System environment (SAS Institute 2002).

The experiments were performed using a fully randomized design. The data for pupal weight and the periods of preoviposition and oviposition were transformed to  $\sqrt{(x + 0.5)}$ . Following the test for normality, all variables were submitted to analysis of variance (ANOVA) and the means compared by Tukey test ( $P < 0.05$ ), using the PROC GLM program of the SAS Institute (2002). The sex ratio of *G. molesta*, calculated for larvae reared on each of the food types, was compared individually to the 1:1 proportion, by means of the  $\chi^2$  test.

## Results

The duration of the embryonic period of *G. molesta* did not differ significantly among the food types ( $F = 0.33$ ;  $df = 2, 20$ ;  $P = 0.7232$ ), and ranged from 3.4 d for the insects reared on the artificial diet to 3.8 d for those reared on burrknots (Table 1). For the remaining stages of development, significant differences were observed; the duration of development of larvae fed on burrknots was longer compared with those fed on

the other foods, which also differed from each other ( $F = 0.23$ ;  $df = 2, 20$ ;  $P = 0.0001$ ). For the pupal stage, significant differences were observed ( $F = 9.47$ ;  $df = 2, 20$ ;  $P = 0.0013$ ), and the insects fed on burrknots had a longer pupal stage compared with those reared on the other foods (Table 1). The increase in the duration of the larval and pupal stages for insects fed on burrknots resulted in a longer egg-adult period compared with the insects reared on apple and the artificial diet, which in turn, also differed significantly from each other ( $F = 136.92$ ;  $df = 2, 20$ ;  $P = 0.001$ ) (Table 1).

The viability of the eggs did not differ significantly among the foods ( $F = 1.24$ ;  $df = 2, 33$ ;  $P = 0.3017$ ) (Table 1). The viability of the larval stage differed significantly ( $F = 9.47$ ;  $df = 2, 20$ ;  $P = 0.0013$ ), and was over 75% for the insects reared on the artificial diet and apple (Table 1). Survival in the pupal stage was not adversely affected by the food used by the larvae ( $F = 2.26$ ;  $df = 2, 20$ ;  $P = 0.1307$ ), ranging from 73.0 to 85.0% (Table 1). For the egg-adult period, significant differences in viability were observed ( $F = 8.74$ ;  $df = 2, 20$ ;  $P = 0.0019$ ), and viability was highest for insects reared on the artificial diet.

The number of instars for insects fed on the artificial diet, Fuji apples or burrknots remained constant at five ( $Y = -1.3784 + 0.3001x$ ,  $R^2 = 0.9999$ ,  $K = 1.35$ ;  $Y = -1.1783 + 0.2729x$ ,  $R^2 = 0.9999$ ,  $K = 1.31$ ;  $Y = -1.6684 + 0.3715x$ ,  $R^2 = 0.9999$ ,  $K = 1.45$ , respectively), where  $K$  is Dyar's constant.

The food eaten in the larval stage resulted in pupae with significantly different weights ( $F = 1.61$ ;  $df = 2, 20$ ;  $P = 0.0001$ ), while the sex ratio did not differ significantly between the treatments (Table 2).

The insects that were fed on burrknots in the larval stage showed a longer preoviposition period than those fed with Fuji apples, and in both hosts the duration did not differ from that of insects fed the artificial diet ( $F = 1.28$ ;  $df = 2, 34$ ;  $P = 0.001$ ) (Table 3). For the oviposition period, no significant difference in duration was observed ( $F = 0.93$ ;  $df = 2, 34$ ;  $P = 0.4045$ ).

The fecundity of *G. molesta* did not differ significantly between treatments ( $F = 0.33$ ;  $df = 2, 20$ ;  $P = 0.7232$ ), although the observed values were 211  $\pm$  5.90, 290  $\pm$  9.70, and 313  $\pm$  6.65 eggs for insects fed the artificial diet, Fuji apples, and burrknots, respectively.

**Table 2.** Weight of pupae and sex ratio (mean  $\pm$  SE) of *Grapholita molesta*, reared on different hosts in the laboratory

Host	Weight (mg) <sup>a,b</sup>	Sex ratio <sup>c</sup>
Artificial diet	13.69 $\pm$ 0.24a	0.66a
Apple cv. Fuji	12.35 $\pm$ 0.11b	0.64a
Burrknobs	10.00 $\pm$ 0.04c	0.57a

Temperature 25  $\pm$  1°C, relative humidity 70  $\pm$  10%, and photophase 16 h.

<sup>a</sup> The data were transformed by the formula  $\sqrt{(x + 0.5)}$ .

<sup>b</sup> Means followed by the same letter in the column do not differ according to Tukey's test ( $P \leq 0.05$ ).

<sup>c</sup> Sex ratio of progeny of *G. molesta* reared on each host and compared individually to the 1:1 ratio,  $\chi^2$  ( $p \leq 0.05$ ).

With regard to the longevity of males and females fed during the larval stage on the artificial diet, Fuji apples, and burrknobs, no significant differences were observed ( $F = 0.64$ ;  $df = 2, 34$ ;  $P = 0.5343$  and  $F = 0.93$ ;  $df = 2, 34$ ;  $P = 0.4046$ , respectively). These values were  $20.4 \pm 1.18$  and  $17.5 \pm 1.19$ ;  $18.0 \pm 1.82$  and  $16.3 \pm 1.82$ ;  $16.8 \pm 0.94$  and  $15.9 \pm 0.94$  d, respectively.

With respect to the parameters of population growth, based on the fertility life table, significant differences were observed for the three foods evaluated (Table 4). The mean generation time ( $T$ ) was longer for the insects reared on burrknobs of apple, differing significantly from those fed the artificial diet and Fuji apples. Insects fed the artificial diet and Fuji apples had a higher net reproductive rate ( $R_0$ ) in relation to the value obtained for the insects fed on burrknobs. Consequently, the insects fed the artificial diet and Fuji apples showed higher values of the intrinsic rate of increase ( $r_m$ ) and finite rate of increase ( $\lambda$ ), compared with the insects fed burrknobs.

## Discussion

*G. molesta* fed as larvae on burrknobs were able to develop and reproduce, although they performed poorly compared with insects reared on Fuji apples and a corn-based artificial diet. In general, the burrknobs had a stronger influence on the development of the immature stages, because no differences in longevity or fecundity were observed.

The duration of the embryonic period of *G. molesta* ranged from 3.4 d for insects reared on the artificial diet, to 3.8 d for those reared on burrknobs. These periods are similar to the 3.07 d reported by Grellmann

**Table 3.** Duration (mean  $\pm$  SE) of the periods of preoviposition and oviposition of *Grapholita molesta* reared in the larval phase on different hosts, in the laboratory

Host	Preoviposition (days) <sup>a,b</sup>	Oviposition (days) <sup>a,b</sup>
Artificial diet	3.44 $\pm$ 0.99ab	6.67 $\pm$ 0.70a
Apple cv. Fuji	2.91 $\pm$ 1.32b	7.18 $\pm$ 0.93a
Burrknobs	4.53 $\pm$ 0.91a	6.32 $\pm$ 0.64a

Temperature 25  $\pm$  1°C, relative humidity 70  $\pm$  10%, and photophase 16 h.

<sup>a</sup> The data were transformed by the formula  $\sqrt{(x + 0.5)}$ .

<sup>b</sup> Means followed by the same letter in the column do not differ according to Tukey's test ( $P \leq 0.05$ ).

et al. (1991), who studied the embryonic development at 26°C. For the larval stage, the longest duration observed for insects fed on burrknobs (19.1 d) in relation to apples (15.9 d) and artificial diet (14.8 d), is greater than the values reported for preferred hosts, such as branches (13.0 d) and fruits (14.0 d) of peach trees (Silva et al. 2010). However, Rosenthal et al. (1994), using the same artificial diet and temperature, found a duration of 20.5 d for larval development of *G. molesta*. This prolongation of the larval stage for *G. molesta* reared on burrknobs in relation to the other foods, is probably related to nutritional inadequacy, which was also reflected in the longer duration of the pupal stage, since the insects fed on burrknobs required about one additional day to reach the adult stage. The increase in the duration of the larval and pupal stages for the insects fed on the burrknobs resulted in a longer egg-to-adult period compared with the insects reared on apples and artificial diet (Table 1). Probably this difference in the duration of the larval and pupal stages and the egg-adult period is related to the quality of the food available to the larvae. The burrknobs, because they are undifferentiated structures, contain cyanogenic glycoside, which in high concentrations is toxic to insects (Zagrobeldi et al. 2004).

The viability of the eggs of *G. molesta* ranged from 79.4 to 55.0% for insects reared on artificial diet and Fuji apples, and was 56.6% for insects reared on burrknobs (Table 1). These values are higher than those reported by Rosenthal et al. (1994), who reared the insects on artificial and natural diets and obtained eggs with viabilities ranging from 26.6 to 53.5%. However, higher viabilities were reported by Marin et al. (2006), who tested an artificial diet based on beans and obtained a viability of 78%; and by Silva et al. (2010), who obtained eggs from insects fed on stems and fruits of peach and apple, with viabilities higher than 76%. In addition, viability rates over 95% were reported by Ivaldi-Sender (1974) and Arioli et al. (2010), for larvae fed on an artificial diet and green apples, respectively. Although there is no apparent explanation and the values vary for insects reared both on artificial diets and on natural hosts, probably the methodology used for obtaining and incubating the eggs may have influenced the viability rate in the different studies. In the current study, the viability of the larval-stage insects reared on artificial diet and apples was above 75%, while for those reared on burrknobs the viability was 52.86% (Table 1). The reduction in viability of the larval stage for insects reared on burrknobs is an indication that this food is not of high nutritional quality for the growth and development of larvae; however, it allows *G. molesta* to develop during periods of the year when no other food such as twigs and/or fruit is available. For the pupal stage, survival was not affected by the food used by the larvae, and ranged from 73.0 to 85.0% (Table 1). Pupal survival values above these were obtained by Yokoyama and Miller (1987), who reared *G. molesta* on a diet based on lima beans (90%); and by Grellmann et al. (1991), who, using a similar artificial diet, obtained 89% pupal viability. Thus, for

**Table 4.** Duration in days of each generation (*T*), net rate of reproduction (*Ro*), intrinsic rate of pop growth ( $r_m$ ) and finite rate of increase ( $\lambda$ ) for *Grapholita molesta*, reared on different food hosts

Host	<i>T</i> (days)	<i>Ro</i>	$r_m$	$\lambda$
Artificial diet	31.10 ± 0.238b <sup>a</sup>	5387.47 ± 816.49a	0.2762 ± 0.007a	1.318 ± 0.009a
Apple cv. Fuji	31.73 ± 0.741b	4131.12 ± 678.04a	0.2623 ± 0.010a	1.300 ± 0.013a
Burrknots	36.94 ± 0.433a	1658.29 ± 334.60b	0.2006 ± 0.007b	1.222 ± 0.009b

Temperature 25 ± 1°C, relative humidity 70 ± 10%, and photophase 16 h.

<sup>a</sup> Means followed by the same letter do not differ according to the two-sided *t*-test ( $P \leq 0.05$ ).

the egg-adult period, insects reared on burrknots showed lower viability (22.5%) compared with insects fed an artificial diet (54.8%) (Table 1).

The food used for the larval development did not affect the number of instars, which remained constant at five. The *K* values obtained here concord with the law of growth proposed by Dyar (1890), which states that the growth of the head capsule occurs geometrically, with a constant ratio for a given species, and is 1.40 on average, and can range from 1.10 to 1.90.

The low mean weight of the pupae of insects reared on burrknots, in relation to those reared on the artificial diet and Fuji apples, is similar to that reported by Rosenthal et al. (1994) who reared *G. molesta* on quince fruit. However, Szöcs and Tóth (1982) obtained a higher value (12.2 mg) when they reared *G. molesta* on a diet based on wheat germ. Although the larvae reared on burrknots fed for a longer period than those on the other foods, this was not sufficient for the pupae to reach the same weight that was recorded on the artificial diet and Fuji apples, indicating a probable effect of antinutritional factors such as cyanogenic glucoside (Zagrobeldi et al. 2004).

The use of burrknots for larval development of *G. molesta* did not affect the sex ratio. This was >0.50, indicating that there were more females than males. Although the sex ratios cited in the literature are close to 0.50, as reported by Rosenthal et al. (1994) for quince (0.45) and by Ivaldi-Sender (1974) for apple (0.60), in the current study, more females than males emerged.

For the preoviposition period, the insects reared on burrknots showed a longer duration (4.5 d) than those fed on Fuji apples (2.9 d). For both foods, the duration did not differ significantly from those of insects fed the artificial diet (3.4 d) (Table 3). This behavior may be related to the lower protein content of burrknots compared with the other foods. The oviposition periods were similar, with a difference of less than 1 d between the treatments.

The fecundity of *G. molesta* fed on the three foods was not affected. The observed values (211.1 ± 5.90, 290.0 ± 9.70, and 313.0 ± 6.65 eggs for insects reared on the artificial diet, Fuji apples, and burrknots, respectively) are higher than those reported by Silva et al. (2010), who reared this insect on branches and fruits of peaches and apples, and obtained a mean fertility ranging from 110 to 202 eggs.

The longevity of males and females reared during the larval stage on the artificial diet, Fuji apples, and burrknots, did not differ significantly. These values are

close to those reported by Silva et al. (2010) who reared *G. molesta* on stems and fruits of apples and peaches (range, 20.6–15.2 d).

With respect to the parameters of population growth, based on the fertility life table, differences were observed for the insects fed the artificial diet and those fed Fuji apples, in relation to the larvae reared on burrknots (Table 4). *G. molesta* reared on burrknots showed the longest mean generation time (*T*) (36.9 d), 5.2 and 5.8 d longer than *T* obtained for insects reared on apples and the artificial diet, respectively. These values are lower than those determined by Arioli et al. (2010), who, using the same artificial diet, obtained a generation time of 39.2 d; and higher than those determined by Silva et al. (2010), who reared *G. molesta* on peach twigs and fruit, and reported values ranging from 25.9 to 21.9 d.

In the burrknots, the lowest values of the net reproductive rate (*Ro*), intrinsic rate of increase ( $r_m$ ) and finite rate of increase ( $\lambda$ ), compared with the other foods, were also recorded. This indicates that the burrknots supported a lower population growth of *G. molesta*.

With respect to the association of insects with the "aerial roots" of apple trees, there are reports of *Synanthedon scitula* (Harris, 1839) (Lepidoptera: Sesiidae) developing in these structures. The species is an important pest of apples in the U.S.A., especially in orchards with a high density of plants (Kain and Straub 2001). According to Kain and Straub (2001) and Bergh and Leskey (2003), the burrknots are chosen as oviposition sites by *S. scitula* because they are a favorable host structure for its development. A similar preference for burrknots as an oviposition site is not known for *G. molesta* on apples.

In the case of *G. molesta*, no damage is attributed to the species when it feeds on burrknots. However, this study demonstrated that the larva of *G. molesta* feeds and may complete its biological development on these structures, which can serve as a food source, allowing it to survive during the winter and the apple flowering period, when no other preferred sources of food such as shoots and fruits are available. This information can help producers to target treatments toward these structures, especially in areas under strong insect population pressure, to reduce infestation levels of *G. molesta* in orchards during the off-season.

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