Platynota rostrana (WALKER) (TORTRICIDAE) AND *Phidotricha erigens* RAGANOT (PYRALIDAE): ARTIFICIAL DIET EFFECTS ON BIOLOGICAL CYCLE

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ABSTRACT

The lepidopterans *Platynota rostrana* (Walker) (Tortricidae) and *Phidotricha erigens* Raganot (Pyralidae) have been found frequently in citrus groves in São Paulo State in recent years. Since in Brazil, the fertility cycle of these two species is largely unknown, as are details of the damage wrought by them in crops, this research studied these aspects of the two species, which were kept under laboratory conditions (temperature 25 ± 2 °C, 70 ± 10% RH, 14 h photophase) and on an artificial diet. The duration of the biological cycle (egg-adult) for *P. rostrana* was 38.3 days and total viability was 44.0%; for *P. erigens* these values were 32.5 days and 63.6%, respectively. Both species showed five larval instars. Females of *P. rostrana* laid an average of 308 eggs, whereas those of *P. erigens* laid an average of 106 eggs. In both species, female pupae were heavier than males. Male and female longevity for both species was nearly 10 days. Based on the data obtained, the artificial diet produced better results in *P. rostrana* than in *P. erigens*. If these species, which have the potential to reach pest status in the citrus groves of São Paulo State, could be reared on an artificial diet, research on their control by alternative methods would be easier.

Keywords: Tortricidae, Pyralidae, damage, citrus pests, rearing technique.

RESUMO

Ciclo biológico em dieta artificial e danos de *Platynota rostrana* (Walker) (Tortricidae) e *Phidotricha erigens* Raganot (Pyralidae), pragas potenciais de *Citrus* spp.

Os lepidópteros *Platynota rostrana* (Walker) (Tortricidae) e *Phidotricha erigens* Raganot (Pyralidae) têm sido constatados com freqüência nos pomares cítricos do Estado de São Paulo, nos últimos anos. O objetivo deste trabalho foi estudar a biologia das duas espécies, em condições de laboratório (temperatura 25 ± 2 °C, UR. 70 ± 10% e fotofase de 14 h) em dieta artificial, elaborar uma tabela de vida de fertilidade e descrever os danos causados no campo, devido ao desconhecimento destes aspectos biológicos dos referidos insetos no Brasil. A duração do ciclo biológico (ovo-adulto) de *P. rostrana* foi de 38,3 dias e a viabilidade total de 44,0%, enquanto para *P. erigens* foi de 32,5 dias e 63,6%, respectivamente. Ambas as espécies apresentaram cinco ínstares e as pupas de fêmeas foram mais pesadas do que as de machos. As fêmeas de *P. rostrana* colocaram, em média, 308 ovos e as de *P. erigens* 106 ovos. A longevidade de machos e fêmeas das duas espécies foi próxima de 10 dias. Pela tabela de vida de fertilidade concluiu-se que *P. rostrana* tem melhor desempenho em dieta artificial que *P. erigens*. É possível criar estas espécies em dieta artificial, facilitando o desenvolvimento de pesquisas relacionadas ao seu controle por métodos alternativos, caso elas assumam o *status* de pragas nos pomares de São Paulo.

Palavras-chave: Tortricidae, Pyralidae, danos, citrus, técnica de criação.

INTRODUCTION

Citriculture in São Paulo is now based on high-yield technology, which is comparable - and in many cases superior to - to that used in First World countries. In keeping with this development, techniques and control methods used in pest management have also evolved. However, substantial pest damage caused mainly by mites, fruit flies, the citrus fruit borer, the citrus leafminer, leafhoppers, and several other insects in citrus groves continues and, depending on the location, can cause annual losses of up to 10% (Gallo *et al*., 2002).

Pest control represents additional citrus production costs, *e.g.*, approximately 92.5 million dollars were spent in 1999 with insecticides and miticides in Brazil (Ferreira, 2000). The magnitude of pest damage resulted in the creation in 1977 of Fundecitrus (Citriculture Defense Fund), an organization of citrus growers and processors that sponsors research related to citrus production, and principally the phytosanitary problems affecting it.

The massive application of chemical products has cleared the way for new pests because of biological imbalances between herbivorous insect populations and their natural enemies (parasitoids, predators, and pathogens). Thus, formerly secondary insects have frequently acquired pest status in various regions of São Paulo State. This is apparently happening in Itapetininga and Casa Branca, SP, with the tortricid *Platynota rostrana* (Walker) and the pyralid *Phidotricha erigens* Ragonot, which feed on citrus shoots and fruits.

To contain this development, alternatives to chemical control have been sought, such as that for the citrus fruit borer, *Ecdytolopha aurantiana* (Lima, 1927), for which sex pheromone monitoring has already been implemented (Bento *et al*., 2001; Leal *et al*., 2001). Such innovations require basic research on these new pests and on methods for their year-round laboratory maintenance. The objective of this work was to study *P. rostrana* and *P. erigens* under laboratory conditions and fed an artificial diet, and to describe in situ citrus damage, so as to be prepared should these insects acquire pest status in São Paulo State citriculture.

MATERIAL AND METHODS

Platynota rostrana (Walker) and *Phidotricha erigens* Ragonot were reared in the Insect Biology Laboratory of the **Departamento de Entomologia, Fitopatologia e Zoologia Agrícola of the Escola Superior de Agricultura "Luiz de Queiroz"** (ESALQ), of the **Universidade de São Paulo** (USP), in Piracicaba, SP. They were studied under controlled temperature conditions (25 ± 2 °C), RH (70 ± 10%), and photophase (14 h). Description of damage caused by these species was based on field observations made in the municipalities of Itapetininga and Casa Branca, SP.

To begin breeding, caterpillars and pupae of these two species were collected in Itapetininga (SP) in citrus groves belonging to Citrovita, one of Brazil's largest producers of orange juice concentrate. In the laboratory, the caterpillars were fed young leaves and citrus shoots until pupation. The pupae were placed individually in acrylic Petri dishes (diameter, 6.0 cm; depth, 1.5 cm) containing a cotton wad soaked in water to maintain adequate moisture during pupal development.

Upon emergence, pairs were confined in PVC cylindrical containers (diameter, 10.0 cm; height, 10.0 cm) with glass lids at the top and bottom) that were lined, with plastic material for *P. rostrana* and paper toweling for *P. erigens*, to provide a suitable egg-laying substrate. The adults were fed a 10% honey solution by capillary action from a small glass container containing a cotton dental roll. The solution was replaced and egg masses removed daily by excising the substrate section upon which eggs had been laid. The eggs were treated for 5 min with 1% copper sulfate ($CuSO_4$) solution to control microorganisms. The egg masses were then placed in acrylic dishes covered with plastic film and then in an incubator until the caterpillars hatched. Following hatching, the caterpillars were transferred with a brush to glass vials (diameter, 2.5 cm; height, 8.0 cm) containing the artificial diet (Table 1), prepared according to Parra (2000).

Two hundred recently-hatched caterpillars, which included both species, were placed in glass vials (diameter, 1.5 cm; height, 8.0 cm). During the larval stage, measurements included length, viability, and number of instars, determined daily by measuring the head capsule width of 25 caterpillars, using an ocular micrometer attached to a stereoscopic microscope. Number of instars was based on calculations described by Parra & Haddad (1989). Measurements included pupal stage duration in males and females, and viability and weight

TABLE 1
Composition of artificial diet used for rearing *Platynota rostrana* and *Phidotricha erigens*.

Components	Amount*
Beans	56.25 g
Wheat germ	45.00 g
Soybean protein	22.50 g
Casein	22.50 g
Yeast	28.15 g
Vitamin solution[1]	06.75 mL
Ascorbic acid	02.70 g
Sorbic acid	01.35 g
Methylparahydroxybenzoate (nipagin)	02.25 g
Tetracycline	84.75 mg
Formaldehyde 40%	02.70 mL
Agar	17.50 g
Distilled water	900.00 mL
([1]) **Vitamin solution**	
Niacinamide	1.00 mg
Calcium pantothenate	1.00 mg
Thiamine	0.25 mg
Riboflavin	0.50 mg
Folic acid	0.25 mg
Biotin	0.25 mg
Vitamin B_{12}	0.02 mg
Inositol	20.00 mg

* Amount sufficient for 75 diet tubes.

at 24 h of age for both species. After emergence, *P. rostrana* was classified by gender according to wing size and coloration (females: larger, brown-colored wings; males: smaller, light-brown wings with black costal margins). *P. erigens* was classified by gender in the pupal stage, based on Butt & Cantu (1962). Observations were made for 20 pairs of each species, with daily evaluations of male and female longevity, fecundity, pre-oviposition duration and oviposition period, and gender ratio, according to GR = ♀ / ♀ + ♂.

Egg stage duration and viability were calculated for the second egg mass, which were obtained by removing them from the moistened filter paper lining the acrylic dishes (diameter, 6.0 cm; depth, 1.5 cm).

Fertility parameters were based on observations of 20 pairs of both species. These data included duration of developmental period (egg-adult), total viability, gender ratio, pre-oviposition period, number of eggs/day, and daily male/female mortality, all of which figured in quantifying the growth capacity of both species maintained on an artificial diet that was based on Silveira Neto *et al*. (1976) and modified by us.

RESULTS AND DISCUSSION

Life cycle

For the embryonic period and the larval and pupal stages of *Platynota rostrana* (Walker), durations of 8.5, 21.4, and 8.4 days were found, with viabilities of 79.8, 73.0, and 75.0%, respectively. Duration of the biological cycle (egg-adult) was 38.3 days, and total viability was 44.0% (Table 2). The embryonic period, larval, and pupal stages of *Phidotricha erigens* Ragonot showed durations of 5.5, 16.7, and 10.3 days, and viabilities of 71.7, 94.5, and 92.6%, respectively. The egg-adult developmental period lasted 32.5 days. That total viability was 63.6% (Table 2) while Singh (1983) recommends one of 75%, was interpreted by us as a consequence of adaptation to the artificial diet, which is expected to occur as one generation succeeds another (the study of *P. rostrana* was carried out with second-generation insects, while this adjustment usually happens between the 5th and 7th laboratory generations). A finding relevant to the adaptation process is that these insects, which were kept in the laboratory for several generations after the study was concluded, retained a high egg-laying capacity (Nava, D. E., personal observation).

For *P. rostrana* mean pupal weight was 493 mg for females and 334 mg for males. This was also true for *P. erigens* (females, 232 mg; males, 200 mg), but in this case the difference was less. According to Slansky & Scriber (1985), lepidopteran females are usually heavier than males, reflecting the greater food intake of female caterpillars, which often go through an additional instar in relation to males since, according to Slansky & Scriber (1985), females are responsible for oviposition.

Fecundity for *P. rostrana* was recorded as 308 eggs laid over approximately 6.6 days, with a 2.3-day preoviposition period. The mean longevity of males and females was 10.9 and 10.5 days, respectively, with a gender ratio of 0.47 (Table 3). *P. erigens* laid 105.8 eggs in 5.1 days, with a 2.7-day preoviposition period. Mean longevity for females was 9.8 days; males lived 9.2 days for males. Gender ratio was 0.56 (Table 3).

The number of instars for *P. rostrana* and *P. erigens* was constant (five), and molting was very well characterized by head capsule peaks in width (Figs. 1a and 1b). In both species, caterpillar head-capsule growth exemplified Dyar's rule (Dyar, 1890), with growth-rate values (1.50 and 1.47) falling between 1.1 and 1.9 (the values given by Dyar). The coefficient of correlation was near 1.000, indicating a high degree of reliability (Table 4).

The fertility parameters (Table 5) showed a mean generational longevity (T) of 43.0 days for

TABLE 2
Duration and mean viability (± SEM) for egg, caterpillar, and pupal stages, and biological cycle (egg-adult) of *Platynota rostrana* and *Phidotricha erigens*, reared on artificial diet. Temp. 25 ± 2 °C, RH 70 ± 10%; 14 h photophase.

Stages/Period	*P. rostrana*		*P. erigens*	
	Duration (days)	Viability (%)	Duration (days)	Viability (%)
Egg	8.50 ± 0.16	79.8	05.45 ± 0.15	71.7
Caterpillar	21.40 ± 0.28	73.0	16.71 ± 1.65	94.5
Pupa	8.40 ± 0.17	75.0	10.31 ± 1.12	92.6
Biological cycle	38.3	44.0	32.47	62.8

TABLE 3
Duration of pre-oviposition and oviposition periods, fecundity, longevity of males and females, pupal weight, and gender ratio of *Platynota rostrana* and *Phidotricha erigens*, reared on artificial diet. Temp. 25 ± 2 °C, RH 70 ± 10%; 14 h photophase.

Biological parameters		Mean ± SEM	
		P. rostrana	*P. erigens*
Pre-oviposition (days)		2.29 ± 0.16	2.71 ± 0.48
Oviposition (days)		6.57 ± 0.92	5.14 ± 1.46
Fecundity		308.00 ± 91.58	105.8 ± 20.57
Longevity (days)	Male	10.88 ± 0.48	9.20 ± 2.32
	Female	10.54 ± 0.53	9.80 ± 3.10
Pupal weight (mg)	Males	334 ± 12	200 ± 3
	Females	493 ± 20	232 ± 3
Gender ratio		0.47	0.56

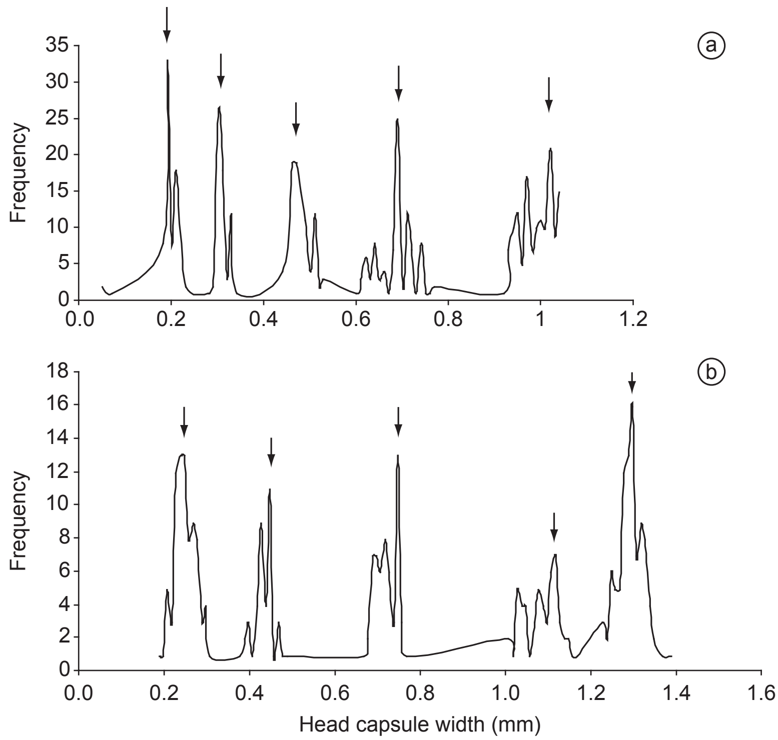

Fig. 1 — Frequency distributions of head capsule widths for *Phidotricha erigens* a) and *Platynota rostrana* b) reared on artificial diet. Arrows indicate the number of instars.

TABLE 4
Mean head-capsule width, Dyar constant, and coefficient of correlation for determining number of instars of *Platynota rostrana* and *Phidotricha erigens* reared on artificial diet. Temp. 25 ± 2 °C, RH 70 ± 10%; 14 h photophase.

Species	Mean head-capsule width					Dyar constant (K)	Coefficient of determination (R^2)
	1st instar	2nd instar	3rd instar	4th instar	5th instar		
P. rostrana	0.25	0.43	0.72	1.08	1.29	1.45	0.999
P. erigens	0.19	0.31	0.48	0.69	0.99	1.47	0.998

TABLE 5
Mean length of one generation (T), net reproductive rate (R_o), intrinsic rate of increase (rm), and finite rate of increase (λ) for *Platynota rostrana*, *Phidotricha erigens*, and *Ecdytolopha aurantiana*, reared on artificial diet. Temp. 25 ± 2 °C, RH 70 ± 10%, 14 h photophase.

Species	T (days)	R_o	rm	λ
P. rostrana	42.97	64.44	0.0970	1.1019
P. erigens	35.55	6.59	0.0530	1.0545
*E. aurantiana**	44.30	17.32	0.0640	1.0665

* Values for *Ecdytolopha aurantiana* determined by Garcia (1998).

P. rostrana and 35.6 days for *P. erigens*, with a net reproductive rate (R_o) of 64.4 and 6.6 for *P. rostrana* and *P. erigens*, respectively. Therefore, *P. rostrana* – with a higher rate of increase per generation - has greater potential for causing damage. Finite rate of increase (λ) was also higher (Table 5) than that obtained by Garcia (1998) for *Ecdytolopha aurantiana* (Lima), a significant citrus pest, but close to those for *P. erigens* (Table 5). Thus, *P. rostrana* has high pest potential since, besides attacking shoots and developing fruit, it has great reproductive capacity generationally.

Since the parameters in Table 5 were obtained with insects reared under laboratory conditions and on an artificial diet, they would probably differ from those obtained in field research, which is affected by biotic (parasitoids, predators, pathogens) and abiotic factors (precipitation, temperature). However, the present results indicate that these insects are potentially major pests, as *E. aurantiana* has become in recent years in citriculture in São Paulo State (Parra *et al*., 2004).

Occurrence and damage

The tortricid *P. rostrana* (Fig. 2a), the appearance of which coincides with the period immediately following citrus flowering, has been recorded quite frequently in recent years in different regions of São Paulo State. This is particularly so in the case of the municipalities of Itapetininga and Casa Branca, in which pest control by pyrethroid fogging is causing biological disruptions that are resulting in increase of previously infrequent pests increase.

Caterpillars progressively damage unripe fruits (Fig. 3a) and citrus leaves (Fig. 3b) in areas of approximately 4.5 mm-to 40 mm. The process begins with first-instar caterpillars scraping leaves and fruits, usually those near the last leaves on the branches of

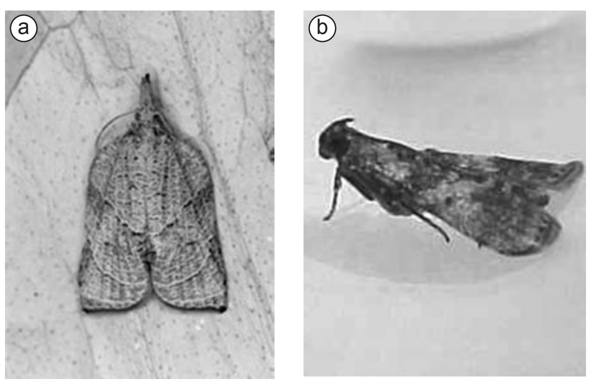

Fig. 2 — *Platynota rostrana* a) and *Phidotricha erigens* b) adults.

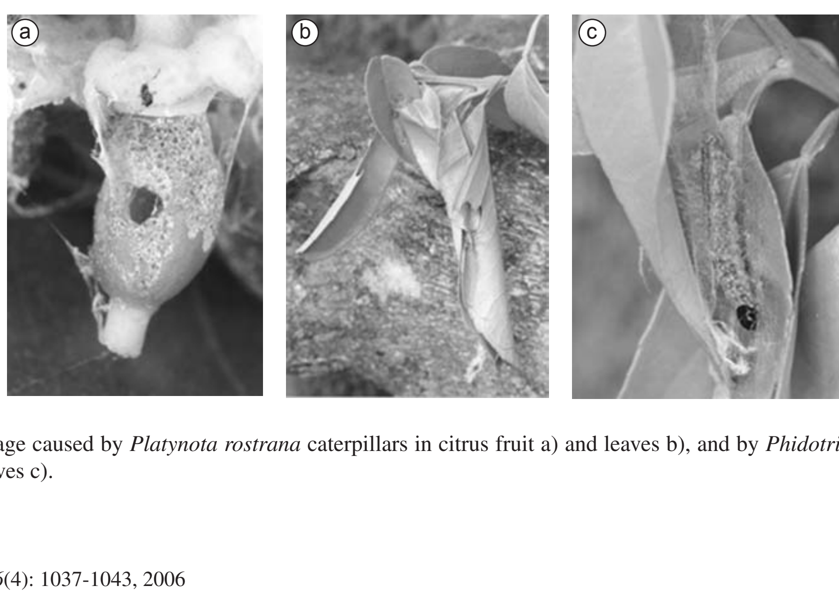

Fig. 3 — Damage caused by *Platynota rostrana* caterpillars in citrus fruit a) and leaves b), and by *Phidotricha erigens* caterpillars on leaves c).

the main stem. There, they use plant debris, feces, and silk strands to build cocoons from which they emerge to feed (Fig. 3b) and in which they remain until pupation. They chew through fruit skin, or bore holes that result in lesions and fallen fruit.

While exhibiting the same behavior as *P. rostrana*, the pyralid *P. erigens* (Fig. 2b) is less destructive, since during collections the caterpillars were found feeding exclusively on shoots (Fig. 3c).

Our study shows that *P. rostrana* and *P. erigens* can be reared on an artificial diet and that both species can be maintained continuously in the laboratory. In addition, it provides data on their biological cycles and reproduction potential, which are essential to developing alternatives by which to control these citrus pests, if that should become necessary.

REFERENCES

BENTO, J. M., PARRA, J. R. P., VILELA, E. F., WALDER, J. M. & LEAL, W. S., 2001, Sexual behavior and diel activity of citrus fruit borer *Ecdytolopha aurantiana*. *J. Chem. Ecology, 27*: 2053-2065.

BUTT, B. A. & CANTU, E., 1962, Sex determination of lepidopterous pupae, ARS. USDA, Washington, pp. 33-75.

DYAR, H. G., 1890, The number of molts of lepidopterous larvae. *Psyche, 5*: 420-422.

FERREIRA, C. R. R. P. T., 2000, Defensivos agrícolas: situação do mercado. *Inf. Econ., 30*: 57-60.

GALLO, D., NAKANO, O., SILVEIRA NETO, S., CARVALHO, P. P. L., BAPTISTA, G. C. de, BERTI FILHO, E., PARRA, J. R. P., ZUCCHI, R. A., ALVES, S. B., VENDRAMIM, J. D., MARCHINI, L. C., LOPES, J. R. S. & OMOTO, C., 2002, *Entomologia Agrícola*. Piracicaba: FEALQ, 920p. (Biblioteca de Ciências Agrárias Luiz de Queiroz, 10).

GARCIA, M. S., Bioecologia e potencial de controle biológico de *Ecdytolopha aurantiana* (Lima, 1927) (Lepidoptera: Tortricidae), o bicho-furão-dos-citros, através de Trichogramma pretiosum Riley, 1879. Piracicaba, 1998, 118p. Tese (Doutorado) - Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo.

LEAL, W. S., BENTO, J. M., MURATA, Y., ONO, M., PARRA, J. R. P., & VILELA, E. F., 2001, Identification, synthesis and field evaluation of the sex pheromone of the citrus fruit borer *Ecdytolopha aurantiana*. *J. Chem. Ecology, 27*: 2041-2051.

PARRA, J. R. P. & HADDAD, M. L., 1989, *Determinação do número de ínstares de insetos*. Piracicaba: FEALQ, 49p.

PARRA, J. R. P., 2000, *Técnicas de criação de insetos para programas de controle biológico*. 4th. Ed. Piracicaba: FEALQ, 137p.

PARRA, J. R. P., BENTO, J. M. S., GARCIA, M. S., YAMAMOTO, P. T., VILELA, E. F. & LEAL, W. S., 2004, Development of a control alternative for the citrus fruit borer, *Ecdytolopha aurantiana*: from basic research to the grower. *Rev. Brasil. Entomol.*, *48*: 561-567.

SINGH, P., 1983, *A general purpose laboratory diet mixture for rearing insects*. Insect Science and its Application, Elmsford., *4:* 357-362.

SILVEIRA NETO, S., NAKANO, O., BARBIN, D., & VILLA NOVA, N. A., 1976, *Manual de ecologia dos insetos*. São Paulo: Agronômica Ceres, 419p.

SLANSKY, F., Jr. & SCRIBER, J. M., 1985, Food consumption and utilization, pp. 87-163. *In:* G. A. Kerkut & L. I. Gilbert (eds.), Comprehensive insect physiology, biochemistry, and pharmacology, v. 4. Pergamon Press, Oxford.