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SEASONAL DISTRIBUTION AND SEX RATIO OF ELEVEN NOCTUID SPECIES (INSECTA, LEPIDOPTERA) CAPTURED IN BLACKLIGHT TRAPS ON TERCEIRA ISLAND (AZORES)

By V. VIEIRA ¹, M.G. GOMES DE ARAÚJO ² & J. TAVARES ¹

With 11 figures and 1 table

ABSTRACT. The adult flight periods of *Agrotis segetum* (DENNIS & SCHIFFERMÜLLER), *Noctua pronuba* (LINNAEUS), *Noctua atlantica* (WARREN), *Peridroma saucia* (HÜBNER), *Xestia c-nigrum* (LINNAEUS), *Mythimna loreyi* (DUPONCHEL), *Phlogophora meticulosa* (LINNAEUS), *Phlogophora interrupta* (WARREN), *Mesapamea storai* (REBEL), *Autographa gamma* (LINNAEUS), and *Trichoplusia orichalcea* (FABRICIUS) (Lepidoptera: Noctuidae) were studied between November 1992 and November 1993, at Terra Chã (110 m), Granja (310 m), Fajãs (310 m) and Santa Bárbara (525 m) on the island of Terceira, Azores archipelago, using Pennsylvania blacklight traps. While there was evidence of considerable fluctuations in abundance, *A. segetum*, *P. saucia*, *X. c-nigrum*, *M. loreyi* and *P. meticulosa* were present continuously at Santa Bárbara. In contrast *N. pronuba*, *N. atlantica*, *M. storai*, *P. interrupta*, *A. gamma*, and *T. orichalcea* were generally captured from Spring to beginning of Autumn. For any given species both sexes were captured simultaneously. Males of *X. c-nigrum*, *P. meticulosa* (Santa Bárbara), *A. segetum* and *M. storai* (Fajãs) were more frequent than females, while in the other species females were more abundant. However, in no case does the sex ratio deviates entirely from 1:1. Under an integrated pest management perspective, blacklight trap is an important technique for agricultural warning services, allowing to forecast the outbreaks of agricultural pests.

¹ Universidade dos Açores, Departamento de Biologia, PT - 9500 PONTA DELGADA (Açores).

² Quinta da Piedade, Lote 45, 3º FRT, PT - 2625 Póvoa de Santa Iria.

INTRODUCTION

Terceira island, Archipelago of the Açores, located in the Atlantic ocean between 38°38'10" and 38°47'40"N and between 27°03'00" and 27°24'00"W, presents climatic conditions favorable for the development of many Lepidoptera (about 106, VIEIRA, 1997), including some species of Noctuidae that are considered as agricultural pests (TAVARES, 1989). The adults of this family present great mobility, and the larvae of many species are polyphagous. The migratory movements of certain noxious species stresses the need for a warning system that allows to forecast their outbreaks. For what, among other techniques, light traps are used (VIEIRA *et al.*, 1994).

In Terceira island the following noctuids were frequently captured by this sampling method: *Agrotis segetum* (DENNIS & SCHIFFERMÜLLER), *Noctua pronuba* (LINNAEUS), *Noctua atlantica* (WARREN), *Peridroma saucia* (HÜBNER), *Xestia c-nigrum* (LINNAEUS), *Mythimna loreyi* (DUPONCHEL), *Phlogophora meticulosa* (LINNAEUS), *Phlogophora interrupta* (WARREN), *Mesapamea storai* (REBEL), *Autographa gamma* (LINNAEUS), and *Trichoplusia orichalcea* (FABRICIUS) (Lepidoptera, Noctuidae).

A. segetum, *N. pronuba*, *N. atlantica*, *P. saucia*, and *X. c-nigrum* belong to subfamily Noctuinae. With the exception of *N. atlantica* which is endemic (WARREN, 1905; MEYER, 1991; VIEIRA & PINTUREAU, 1993), they are considered as agricultural pests, with a cosmopolitan distribution (BALACHOWSKY, 1972; TAVARES, 1989). They are reported for all the Azorean Arquipelago, except *A. segetum* which has not been recorded for Pico and Faial, *N. atlantica* for Santa Maria and *N. pronuba* not found in Graciosa (VIEIRA & PINTUREAU, 1993; VIEIRA & TAVARES, 1995; VIEIRA, 1997).

M. loreyi (subfamily Hadeninae), with a tropical-subtropical origin, is only recorded for Graciosa, Santa Maria and São Miguel islands (VIEIRA & PINTUREAU, 1993; VIEIRA, 1997).

A. gamma and *T. orichalcea* (subfamily Plusiinae) may present several generations per year and both are widely polyphagic species, with a palearctic and tropical-subtropical distribution, respectively (BALACHOWSKY, 1972; CALLE, 1982). They are reported for all the Azorean Arquipelago (VIEIRA & PINTUREAU, 1993; VIEIRA & TAVARES, 1995; VIEIRA, 1997).

M. storai, *P. interrupta* and *P. meticulosa* belong to subfamily Ipimorphinae. *P. meticulosa* can present several generations per year and is a widely polyphagic species, with an asiatic-mediterranean distribution (BALACHOWSKY, 1972; CALLE, 1982). The three species are reported for all the islands of the Azorean Arquipelago, except *M. storai* which is not recorded for Santa Maria and Graciosa, and *P. interrupta* an endemic species (MEYER, 1991; VIEIRA & PINTUREAU, 1993) not found in Graciosa and Corvo (VIEIRA & PINTUREAU, 1993; VIEIRA & TAVARES, 1995; VIEIRA, 1997).

In this paper, seasonal distribution and sex ratio was studied for the above mentioned noctuid species. The potential impact of these species on the regional agroecosystem is also discussed.

MATERIAL AND METHODS

The adult flight periods of *A. segetum*, *N. pronuba*, *N. atlantica*, *P. saucia*, *X. c-nigrum*, *M. loreyi*, *P. meticulosa*, *P. interrupta*, *M. storai*, *A. gamma*, and *T. orichalcea* were studied using pennsylvania light traps placed at four locations in Terceira island: Terra Chã (110 m), Granja (310 m), Santa Bárbara (525 m) (from November 1992 to November 1993; 53 weeks), and Fajãs (310 m) (between March and November 1993; 36 weeks). For a given species, stations where the number of adults was very low (< 3 adults) are not discussed here.

Following SILVA *et al.* (1995a), each light trap, equipped with a TLD 18W lightbulb, was placed lifted at the hedge of a permanent gramineae pasture, one meter above the ground. The captured specimens would fall into a container with a formalin solution (5%). Adults were collected from trap-containers once a week. The biological material was washed, and sorted by species and sex. Records were made of species name, sex and date of capture for each specimen. The number of captured adults per week for each species and location was determined.

In order to evaluate differences between male and female catches at the same place, and between places, data were arcsine transformed prior to applying two factor analysis of variance. Differences in total catches between sites were analysed using a $\log(x+1)$ transformation followed by a one-way analysis of variance and Scheffe test when appropriate.

RESULTS AND DISCUSSION

Agrotis segetum (DENNIS & SCHIFFERMÜLLER)

The total catches of *A. segetum* were 239 adults at Santa Bárbara, 34 at Granja and 74 at Fajãs (Fig. 1, Table 1). This species was more abundant in Spring and Summer; it appeared sporadically in March and November-December at the highest location (Santa Bárbara). The captures reached a maximum of 88 adults at Santa Bárbara in Summer 1993.

The sex ratio was favourable to the females at Santa Bárbara (54.81%) and Granja (58.82%), while at Fajãs it was so for the males (44.59%) (Table 1).

Since *A. segetum* is considered a sedentary species (POITOUT & BUES, 1976), this sex ratio variation might be related to the higher number of insects captured at higher altitude, which probably results from favourable climatic conditions for insect development (SILVA *et al.*, 1995a).

No significant differences were found between places ($F=0.2$, $p=0.854$) or between the sexes ($F=1.0$, $p=0.323$). Also, the interaction between both factors is not significant ($F=0.5$, $p=0.584$).

According to SILVA *et al.* (1995a), *A. segetum* is markedly polyphagous, attacking many of the crop plants and weeds in the region, except for flowers and garden plants.

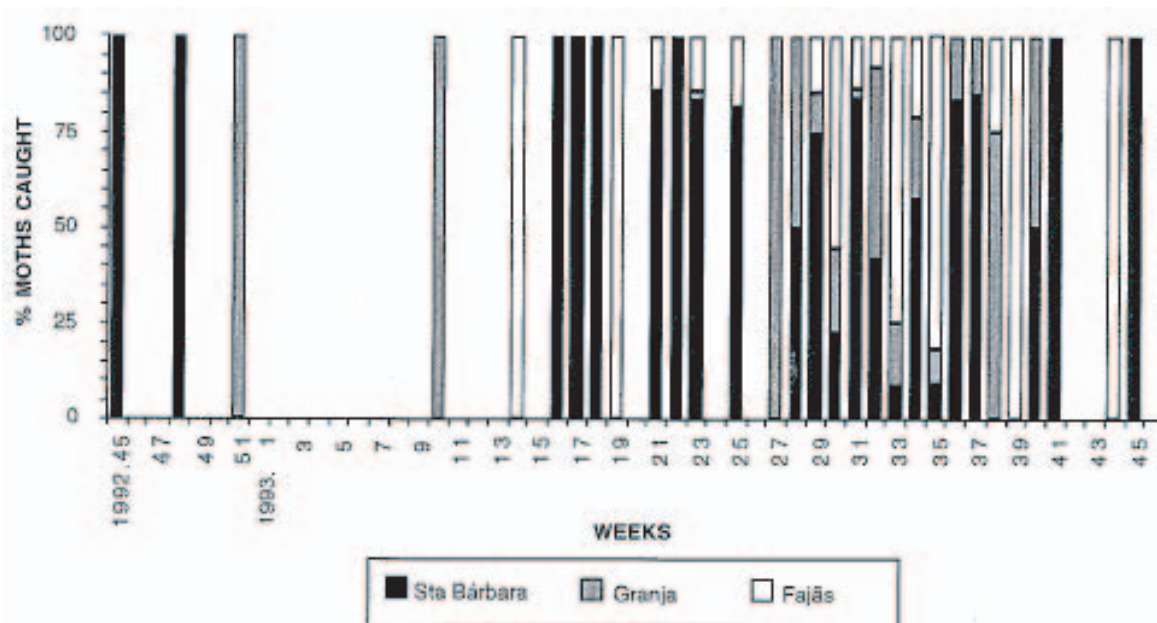


Fig. 1 - Proportion of *A. segetum* adults captured weekly at three sites in Terceira island: Granja, Santa Bárbara (from November 1992 to November 1993; 53 weeks), and Fajãs (between March and November 1993; 36 weeks).

Noctua pronuba (LINNAEUS)

The total catches of *N. pronuba* were 30 at Santa Bárbara and 13 at Fajãs and Granja (Fig. 2, Table 1). This species was observed mainly in the second semester of 1993, with a maximum of captures between July and September, and at higher altitude.

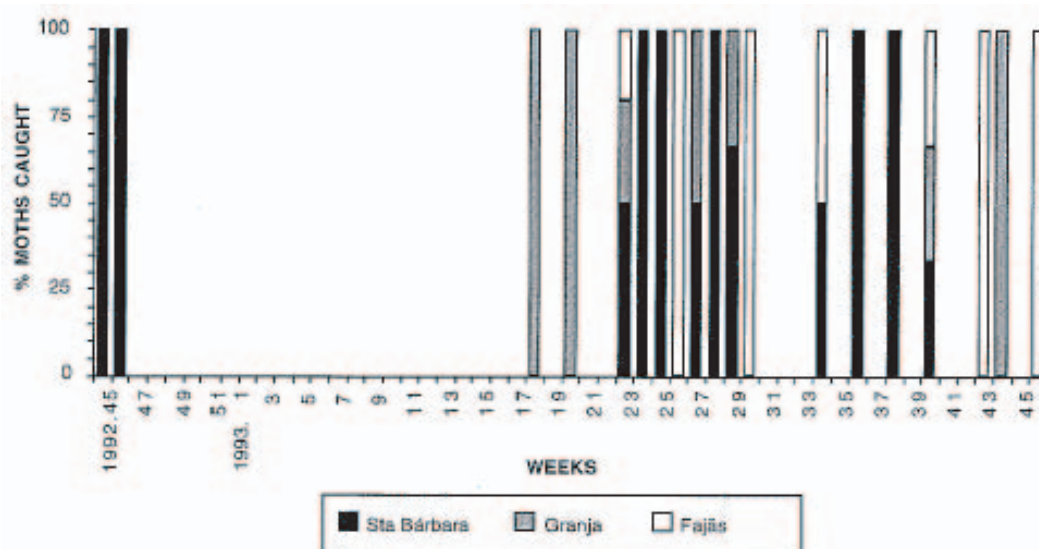


Fig. 2 - Proportion of *N. pronuba* adults captured weekly at three sites in Terceira island: Granja, Santa Bárbara (from November 1992 to November 1993; 53 weeks), and Fajãs (between March and November 1993; 36 weeks).

The sex ratio was favourable to the females at Fajãs (53.85%) and Granja (76.92%), while for Santa Bárbara it was 50% (Table 1).

No significant differences were found between places ($F=1.6$, $p=0.212$) or between the sexes ($F=0.4$, $p=0.504$). Also, the interaction between both factors is not significant ($F=0.4$, $p=0.688$).

N. pronuba attacks many plants, mainly horticultural crops and weeds (SILVA *et al.*, 1995a).

Noctua atlantica (WARREN)

The presence of *N. atlantica*, an endemic species of the Azores, was nearly constant in the three locations (Fig. 3, Table 1), except during the Winter, with a total of 27 at Santa Bárbara, 18 at Fajãs and 11 at Granja. The highest catch was 16 adults, in August 1993 at Santa Bárbara.

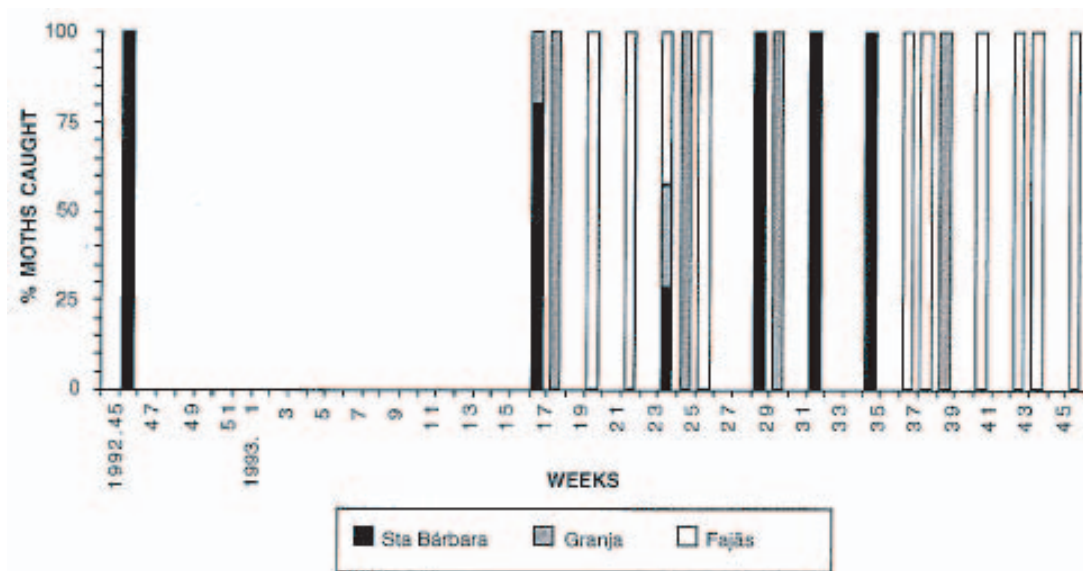


Fig. 3 - Proportion of *N. atlantica* adults captured weekly at three sites in Terceira island: Granja, Santa Bárbara (from November 1992 to November 1993; 53 weeks), and Fajãs (between March and November 1993; 36 weeks).

The sex ratio was favourable to females in all the studied locations: Santa Bárbara and Fajãs 66.67%, Granja 63.64% (Table 1).

No significant differences were found between places ($F=1.7$, $p=0.182$) or between the sexes ($F=0.4$, $p=0.554$). Also, the interaction between both factors is not significant ($F=0.4$, $p=0.641$).

Peridroma saucia (HÜBNER)

The presence of *P. saucia* was nearly constant in the four locations (Fig. 4, Table 1), with a total of 127 adults captured at Santa Bárbara, 52 at Fajãs, 27 at Granja and 14 at Terra

Chã. The highest catch was 44 adults, in August 1993 at Santa Bárbara, but was much lower at the other sites.

Regarding the species as a migrant (POITOUT & BUES, 1976), this peak can be related to the capture of adults arriving from other locations, eventually of lower altitudes, and normally with higher temperature (SILVA *et al.*, 1995a).

The sex ratio was favourable to females in all the studied locations (Santa Bárbara 60.63%, Fajãs 53.85%, Granja 55.56% and Terra Chã 78.57%) (Table 1).

Significant differences between places ($F=6.3$, $p=0.0004$) were found between Santa Bárbara and Terra Chã, and between Fajãs and those of Terra Chã and Granja ($p<0.05$), but no significant differences were found between sexes ($F=1.1$, $p=0.058$). The interaction between factors was also not significant ($F = 0.3$, $p = 0.843$).

P. saucia can damage different crops, except flower crops, and garden and forestry species (SILVA *et al.*, 1995a).

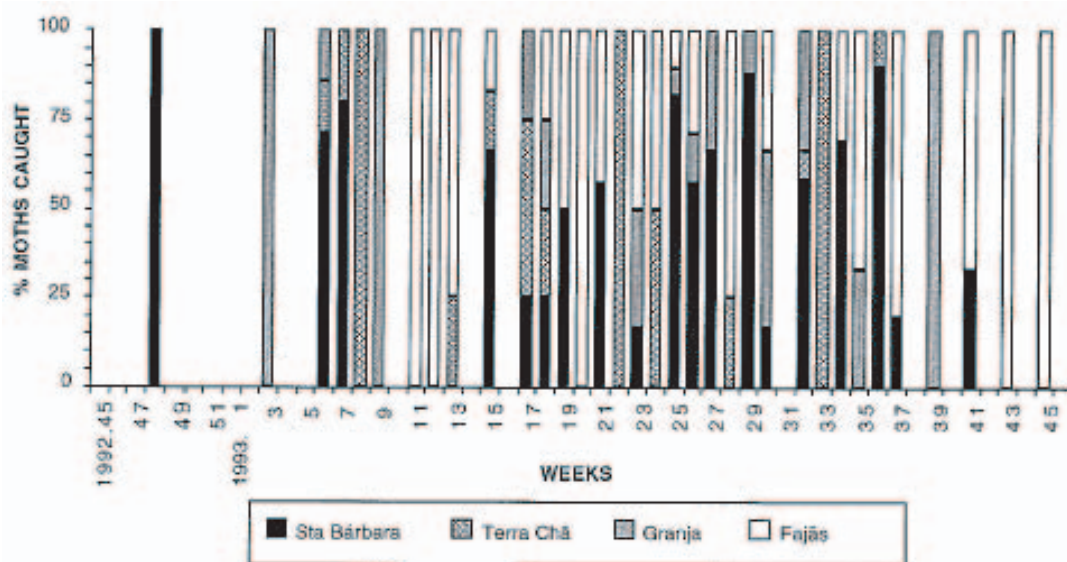


Fig. 4 - Proportion of *P. saucia* adults captured weekly at four sites in Terceira island: Terra Chã, Granja, Santa Bárbara (from November 1992 to November 1993; 53 weeks), and Fajãs (between March and November 1993; 36 weeks).

Xestia c-nigrum (LINNAEUS)

The total catches of *X. c-nigrum* were 1022 at Santa Bárbara, 316 at Fajãs, 124 at Granja and 171 at Terra Chã (Fig. 5, Table 1). The species was nearly always present at the four locations, with the maxima of 147 and 127 adults at Santa Bárbara, during the Summer months.

The sex ratio was not favourable to females at Santa Bárbara (47.75%), Granja (37.9%) and Terra Chã (39.18%), while at Fajãs it was so for the males (47.78%) (Table 1).

Significant differences in captures ($F=12.46$, $p<0.0001$) were found between Santa

Bárbara and those of Terra Chã and Granja, and between Fajãs and those of Terra Chã and Granja ($p < 0.05$), but no significant differences were found between sexes ($F = 0.3$, $p = 0.563$). The interaction between factors was also not significant ($F = 0.1$, $p = 0.969$).

In the Azores, *X. c-nigrum* feeds on a great variety of cultivated plants, except for those used in forestry (SILVA *et al.*, 1995a).

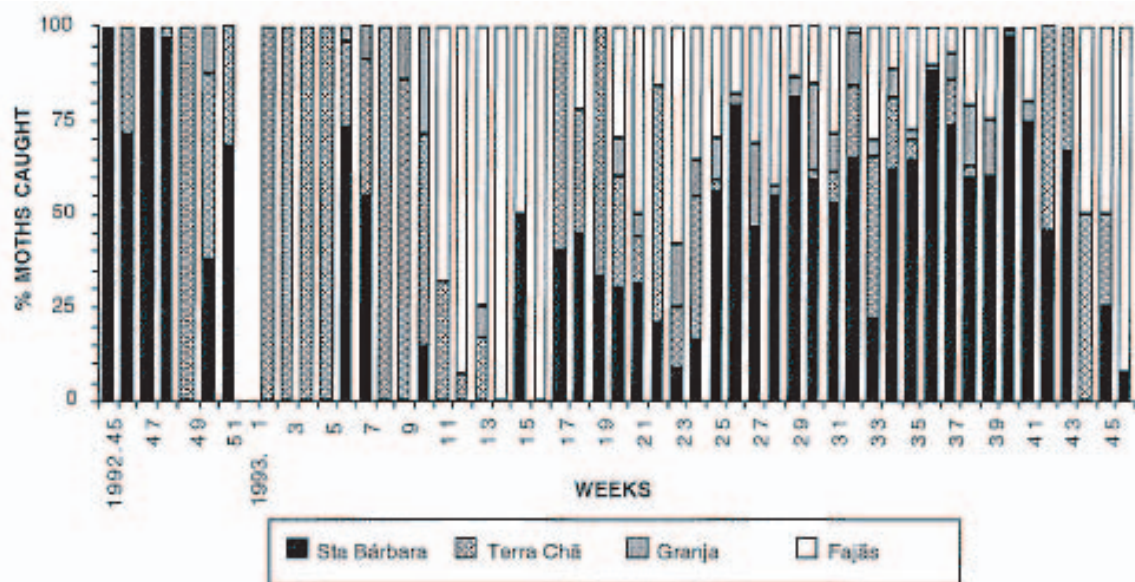


Fig. 5 - Proportion of *X. c-nigrum* adults captured weekly at four sites in Terceira island: Terra Chã, Granja, Santa Bárbara (from November 1992 to November 1993; 53 weeks), and Fajãs (between March and November 1993; 36 weeks).

Mythimna loreyi (DUPONCHEL)

The total numbers of *M. loreyi* adults captured in the light traps (Fig. 6, Table 1) were 2687 at Santa Bárbara, 121 at Fajãs, 36 at Granja and 3 at Terra Chã. The species was nearly always present in the Summer and Autumn months at the three locations, with the maximum catches of 762, 428, 368 and 237 adults at Santa Bárbara (higher altitude), during the Summer months.

The sex-ratio was favourable to females at Santa Bárbara (55.53%) and Granja (55.56%), while it was so for the males at Fajãs (50.41%) and Terra Chã (100%) (Table 1).

Significant differences were found between places ($F = 11.57$, $p < 0.0001$), mainly between Santa Bárbara and Terra Chã or Granja, and between Fajãs and Terra Chã ($p < 0.05$), but no differences were found between sexes ($F = 0.2$, $p = 0.670$). Also, the interaction between factors was not significant ($F = 0.2$, $p = 0.922$).

The larvae is polyphagous and feeds on a great variety of cultivated plants, namely Poaceae.

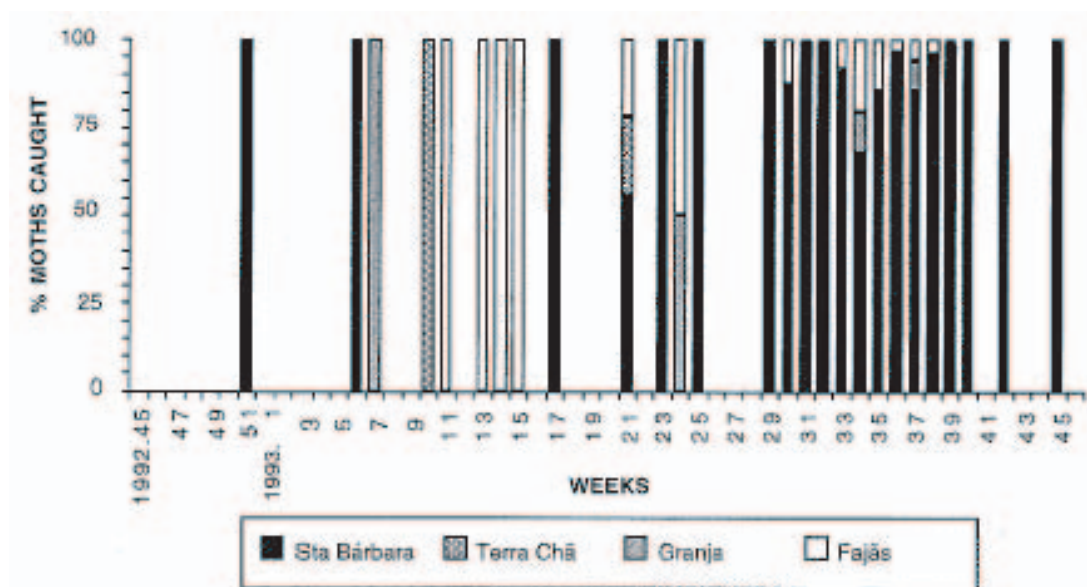


Fig. 6 - Proportion of *M. loreyi* adults captured weekly at four sites in Terceira island: Terra Chã, Granja, Santa Bárbara (from November 1992 to November 1993; 53 weeks) and Fajãs (between March and November 1993; 36 weeks).

Phlogophora meticulosa (LINNAEUS)

The total numbers of *P. meticulosa* adults captured in the light traps (Fig. 7, Table 1) were relatively low, i.e. 161 adults at Santa Bárbara and 46 at Fajãs. This species was present during the whole year at Santa Bárbara, the higher numbers being recorded during Summer months. A maximum of 24 adults appeared at Santa Bárbara. At Fajãs the captures revealed numbers lower than 10 insects.

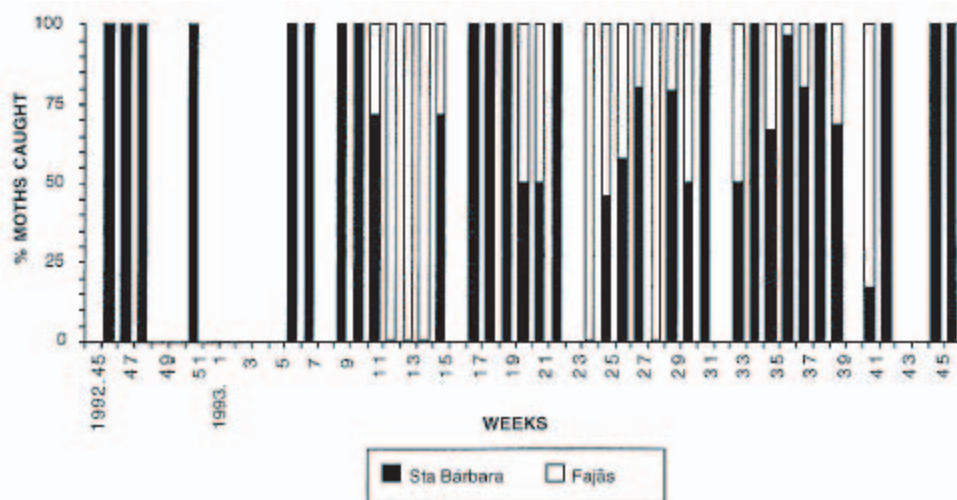


Fig. 7 - Proportion of *P. meticulosa* adults captured weekly at two sites in Terceira island: Santa Bárbara (from November 1992 to November 1993; 53 weeks) and Fajãs (between March and November 1993; 36 weeks).

The sex ratio was favourable to males at both sites (Santa Bárbara 63.98% and Fajãs 62.5%) (Table 1).

The number of adults of *P. meticulosa*, although being rather low, shows no differences between places at high and medium altitudes ($F=2.96$, $p=0.0892$). This species shows a wide polyphagy, damaging many vegetable, industrial, fruit, flower, and cereal crops, as well as oak (SILVA *et al.*, 1994). We can find a relationship between some crops, growing at high altitude localities, and the appearance of adults. Although larval nocivity is not important (BALACHOWSKY, 1972), the relative abundance in its flight curve, joined to the polyphagy, lead to concern about local damage (SILVA *et al.*, 1994).

Phlogophora interrupta (WARREN)

The total number of *P. interrupta* adults captured in the light traps at Santa Bárbara was 73 (Fig. 8, Table 1), where the species was nearly allways present, except in Winter, with a maximum of 18 adults by the end of July 1993.

The sex ratio was favourable to females (58.9%) (Table 1).

Its presence is more characteristic in the natural forest, specially of the central group of the Azorean Archipelago (MEYER, 1991). The number of adults of *P. interrupta* being very low at lower altitudes (ARAÚJO, 1994).

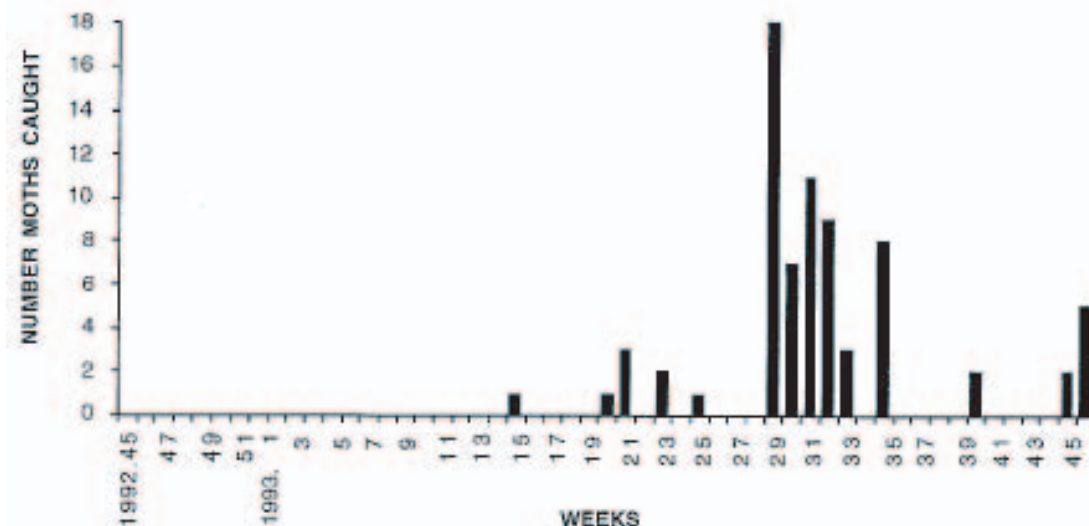


Fig. 8 - Number of *P. interrupta* adults captured weekly at Santa Bárbara, in Terceira island, from November 1992 to November 1993 (53 weeks).

Mesapamea storai (REBEL)

During the studied period, *M. storai* only appeared at Santa Bárbara and Fajãs (Fig. 9, Table 1), with a maximum of 18 captured adults by the end of September 1993.

The sex ratio was favourable to males at Fajãs (67.44%) and at Santa Bárbara it was

50% (Table 1).

The number of adults of *M. storai*, although being rather low, shows no differences between places at high and medium altitudes ($F=1.66$, $p=0.2011$). Its presence is more characteristic in the natural forest, specially in the central group of the Azorean Archipelago (MEYER, 1991). Moreover, it shows a preference for Poaceae, and probably its small variety of preferred host plants is the reason for such a low frequency, as well as an indicator of little economic importance (SILVA *et al.*, 1994).

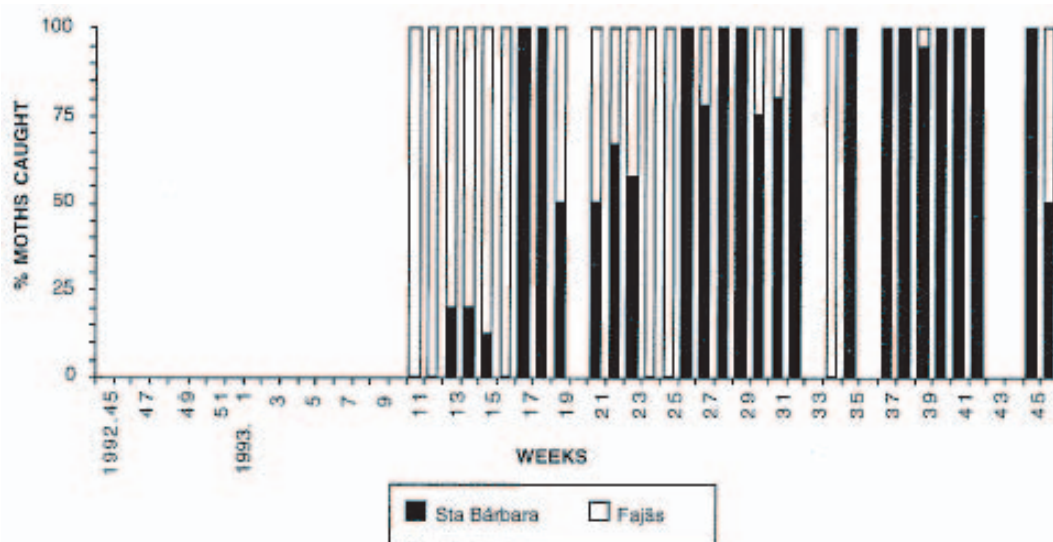


Fig. 9 - Proportion of *M. storai* adults captured weekly at two sites in Terceira island: Santa Bárbara (from November 1992 to November 1993; 53 weeks) and Fajãs (between March and November 1993; 36 weeks).

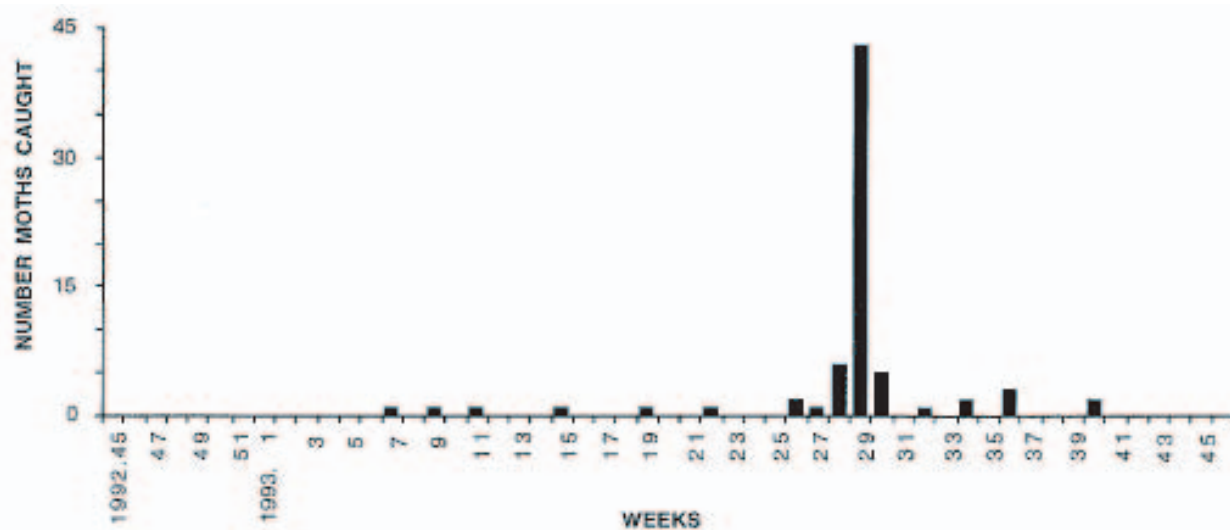


Fig. 10 - Number of *A. gamma* adults captured weekly at Santa Bárbara, in Terceira island, from November 1992 to November 1993 (53 weeks).

Autographa gamma (LINNAEUS)

The total number of *A. gamma* adults captured in the light traps (Fig. 10, Table 1) was relatively low, i.e. 71 adults at Santa Bárbara. Whatever the location, this species was present, except from November to January. The captures reached a maximum of 43 adults in July 1993.

The sex ratio was favourable to females in this location (63.38%) (Table 1).

A. gamma can find a large variety of plants available all over the year at this locality. This supports its life cycle and may justify its abundance throughout the year, although in rather low numbers (SILVA *et al.*, 1995b).

Trichoplusia orichalcea (FABRICIUS)

T. orichalcea was registered at the three places (Figure 11, Table 1), with a total of 167 adults captured at Santa Bárbara, 56 at Granja and 27 at Fajãs. This species was more abundant in Summer and Autumn months in all three locations, with a peak of 75 insects in August 1993 at Santa Bárbara.

For this species both sexes were captured simultaneously. The sex ratio was favourable to the females at Santa Bárbara (62.28%) and Fajãs (77.78%), and at Granja it was 50% (Table 1).

No significant differences were found between places ($F=0.5$, $p = 0.588$) or between the sexes ($F=0.04$, $p=0.825$). Also, the interaction between both factors was not significant ($F=0.5$, $p = 0.615$).

SILVA *et al.* (1995b) showed that *T. orichalcea* is polyphagous, attacking many vegetable crops planted in the Azorean islands.

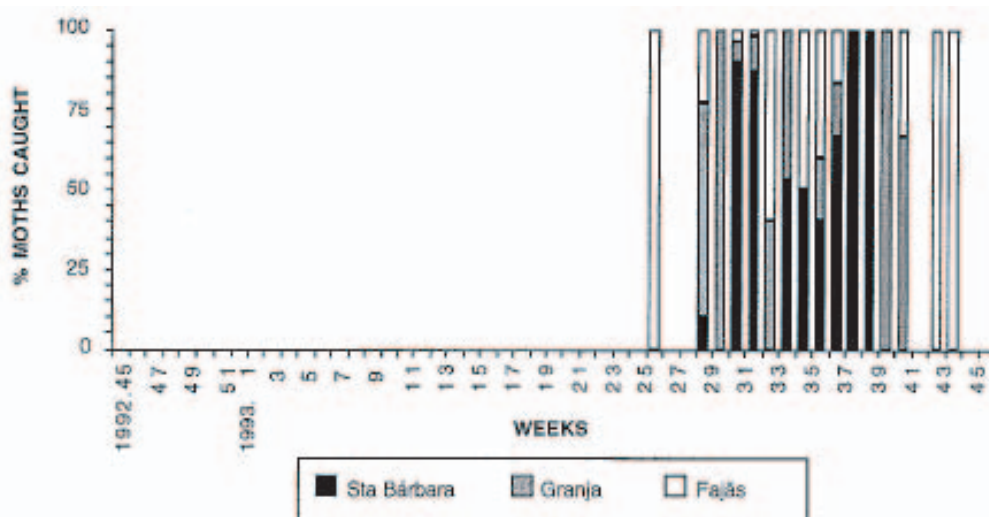


Fig. 11 - Proportion of *T. orichalcea* adults captured weekly at three sites in Terceira island: Granja, Santa Bárbara (from November 1992 to November 1993; 53 weeks), and Fajãs (between March and November 1993; 36 weeks).

TABLE 1 - The total numbers of moths and percentage of females of *A. segetum*, *N. pronuba*, *N. atlantica*, *P. saucia*, *X. c-nigrum*, *M. loreyi*, *P. meticulosa*, *P. interrupta*, *M. storai*, *A. gamma*, and *T. orichalcea* captured weekly in Terceira island at Terra Chã, Granja, Santa Bárbara (from November 1992 to November 1993; 53 weeks), and Fajãs (between March and November 1993; 36 weeks).

SPECIES	LOCALITY			
	Sta Bárbara (525 m)	Fajãs (310 m)	Granja (310 m)	Terra Chã (110 m)
<i>Agrotis segetum</i>				
Total	239	74	34	
Mean $\pm$ Std. error	4.51 $\pm$ 1.95	2.06 $\pm$ 0.68	0.64 $\pm$ 0.18	
% Females	54.81	44.59	58.82	
<i>Noctua pronuba</i>				
Total	30	13	13	
Mean $\pm$ Std. error	0.57 $\pm$ 0.18	0.36 $\pm$ 0.14	0.25 $\pm$ 0.10	
% Females	50	53.85	76.92	
<i>Noctua atlantica</i>				
Total	27	18	11	
Mean $\pm$ Std. error	0.51 $\pm$ 0.32	0.50 $\pm$ 0.16	0.21 $\pm$ 0.09	
% Females	66.67	66.67	63.64	
<i>Peridroma saucia</i>				
Total	127	52	27	14
Mean $\pm$ Std. error	2.4 $\pm$ 0.95	1.4 $\pm$ 0.27	0.5 $\pm$ 0.16	0.26 $\pm$ 0.07
% Females	60.63	53.85	55.56	78.57
<i>Xestia c-nigrum</i>				
Total	1022	316	124	171
Mean $\pm$ Std. error	19.3 $\pm$ 4.24	8.8 $\pm$ 1.40	2.3 $\pm$ 0.61	3.2 $\pm$ 0.45
% Females	47.75	52.22	37.9	39.18
<i>Mythimna loreyi</i>				
Total	2687	121	36	3
Mean $\pm$ Std. error	50.7 $\pm$ 18.4	3.4 $\pm$ 1.07	0.7 $\pm$ 0.30	0.06 $\pm$ 0.04
% Females	55.53	49.59	55.56	0
<i>Phlogophora meticulosa</i>				
Total	161	46		
Mean $\pm$ Std. error	3.02 $\pm$ 0.66	1.56 $\pm$ 0.37		
% Females	36.02	37.5		
<i>Phlogophora interrupta</i>				
Total	73			
Mean $\pm$ Std. error	1.38 $\pm$ 0.47			
% Females	58.9			
<i>Mesapamea storai</i>				
Total	110	43		
Mean $\pm$ Std. error	2.10 $\pm$ 0.55	1.19 $\pm$ 0.28		
% Females	50	32.56		
<i>Autographa gamma</i>				
Total	71			
Mean $\pm$ Std. error	1.34 $\pm$ 0.82			
% Females	63.38			
<i>Trichoplusia orichalcea</i>				
Total	167	27	56	
Mean $\pm$ Std. error	3.15 $\pm$ 1.66	0.75 $\pm$ 0.28	1.06 $\pm$ 0.53	
% Females	62.28	77.78	50	

CONCLUSIONS

Although climateric conditions at the four sites allow the development of these species (ARAÚJO, 1994), the preliminary results obtained do not allow a conclusion regarding the voltinism of each species.

While there was evidence of considerable fluctuations in abundance, *A. segetum*, *P. saucia*, *X. c-nigrum*, *M. loreyi* and *P. meticulosa* were present continuously at Santa Bárbara. In contrast *N. pronuba*, *N. atlantica*, *M. storai*, *P. interrupta*, *A. gamma*, and *T. orichalcea* were generally captured from Spring to beginning of Autumn. For any given species both sexes were captured simultaneously. Males of *X. c-nigrum*, *P. meticulosa* (Santa Bárbara), *A. segetum* and *M. storai* (Fajãs) were more frequent than females, while in the other species females were more abundant. However, in no case does the sex ratio deviates entirely from 1:1.

Under an integrated pest management perspective, blacklight trap is an important technique for agricultural warning services, allowing to forecast the outbreaks of agricultural pests.

The studies related with adult population dynamics should be continued, and if possible widened to other islands of the Archipelago. In parallel, there is a need for more research on larval population dynamics and diapause or hibernation, as well as on the phenomena of migration or sedentarism, in order to have a better knowledge about the biological cycle of those species.

All the cited species are polyphagous, attacking many crops from the region, but not reaching critical economic levels.

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