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The pest complex *Cryptoblabes gnidiella* (Millière) (Lepidoptera: *Pyralidae*) and *Planococcus citri* (Risso) (Homoptera: *Pseudococcidae*) on sweet orange groves (*Citrus sinensis* (L.) Osbeck) in Portugal: Interspecific association

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La polilla del naranjo (PN), *Cryptoblabes gnidiella* (Millière) (Lepidoptera: Pyralidae), es una plaga polífaga de numerosos cultivos, siendo considerada una plaga secundaria de los cítricos, normalmente asociada a ataques de otras espécies, como es el caso de las cochinillas Pseudococcidea y de su melada.

Se han estudiado quatro parcelas de naranjo dulce (*Citrus sinensis* [L.]) Osbeck), cv. "Navel", localizadas en la región Sur de Portugal Continental (i.e., Algarve), para caracterizar la dinámica de las poblaciones de la PN, la importancia económica de los daños que PN causa y la asociación específica entre PN y le cotonete (CO), *Planococcus citri* (Risso) (Homoptera: Pseudococcidae).

El porcentaje del número total de machos capturados de PN, en cada parcela, presentó un padrón semejante y el mayor porcentage fue capturado durante el periodo Junio - Septiembre (excepto en el parcela "Fazenda Grande"). Fue posible identificar tres a quatro picos populacionales distintos. Los resultados sugieren también una asociación positiva significativa ($P \leq 0.05$) entre PN y CA, apoyando la hipotesis de varios autores de que es necesaria la presencia de infestaciones de CA para ocurrir el ataque de PN, en el caso de los cítricos. También, mismo en el caso de infestaciones bajas de orugas de PN, estas puden originar prejuicios debido ala caída prematura de frutos y, como consequencia, una reducción elevada de la producción de naranja dulce, principalmente en el caso de la cv. «Navel». Este tipo de prejuicio originado por la PN puede intensificar los prejuicios qué CO causa, ya identificados en trabajos anteriores.

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Palabras-clave: Asociación inter - específica, cotonete, *Cryptoblabes gnidiella*, dinámica de las poblaciones, naranjo dulce, prejuicios, polilla del naranjo, *Planococcus citri*, Portugal.

INTRODUCTION

The presence of some lepidoptera species that feed on citrus fruit, namely the honeydew moth (HM) *Cryptoblabes gnidiella* (Millière) and the carob moth (EC), *Ectomyelois ceratoniae* (Zeller) (Lepidoptera: Pyralidae), are associated with the presence of honeydew excreted by aphids or mealybugs in citrus (BODENHEIMER, 1951, PANIS, 1969, GARRIDO & BUSTO, 1987, SERGHIOU, 1983, VACANTE, 1988, WYSOKI, 1989, TREMBLAY, 1990).

The HM is found in the Mediterranean Basin, namely in France (PANIS, 1969), Egypt (WYSOKI *et al.*, 1975, SWAILEM & ISMAIL, 1872), Israel (BODENHEIMER, 1951, AVIDOV & GOTHILF, 1960), Italy (ORTU, 1982, VACANTE, 1988), Spain (GARRIDO & BUSTO, 1987, COSCOLLÁ, 1988), Portugal Mainland and Madeira (CARVALHO, 1995, CARVALHO & RAMOS, 1994, CARVALHO *et al.*, 1996), and New Zealand (BODENHEIMER, 1951, TREMBLAY, 1990), and also south-east Asia and Africa (i.e., Congo) (TREMBLAY, 1990). It is recorded as a polyphagous pest of numerous crops, such as apple (*Malus domestica* Borkhausen), avocado (*Persea americana* Miller), cotton (*Gossypium* spp.), custard apple (*Annona* spp.), feijoa (*Feijoa sellowiana* Berg.), fig (*Ceratoniae siliqua* L.), grape (*Vitis vinifera* L.), grapefruit (*Citrus paradisi* Macfadyen), kiwi (*Actinidia deliciosa* (Chevalier), lemon (*Citrus limon* [L.] Burman), lime (*Citrus aurantifolia* [Christ] Swingle), loquat (*Eriobotrya* spp.), maize (*Zea mays* L.), orange (*Citrus sinensis* [L.] Osbeck), peach (*Prunus persica* Batsch), pear (*Pyrus communis* L.), pomegranate (*Punica granatum* L.), quince (*Cydonia oblonga* Miller), rice (*Oryza sativa* L.), sorghum (*Sorghum* spp.) and wheat (*Triticum aestivum* L.) (BODENHEIMER, 1951, LIOTTA & MINEO, 1964, AVIDOV & HARPAZ, 1969, PANIS, 1969, WYSOKI *et al.*, 1975, BJOSTAD *et al.*, 1981, ORTU, 1982, GARRIDO & BUSTO, 1987, COSCOLLÁ, 1988, VACANTE, 1988, TREMBLAY, 1990, YEHUDA *et al.*, 1991\92, CARVALHO & RAMOS, 1994, CARVALHO *et al.*, 1996), and of weeds such as *Daphne gnidium* L., *Nerium oleander* L., *Paspalum dilatatum* Poiret and *Ricinus communis* L. (HEINRICH, 1956, COSCOLLá, 1988, YEHUDA *et al.*, 1991\92).

Concerning the economic importance of HM, this species is usually refereed as a secondary pest, associated with attacks of others organisms, such birds (BODENHEIMER, 1951, SWAILEM & ISMAIL, 1972), bacteria and fungi (SWAILEM & ISMAIL, 1972), and insects such aphids (WYSOKI, 1989, TREMBLAY, 1990), mealybugs (BODENHEIMER, 1951, SWAILEM & ISMAIL, 1972, WYSOKI *et al.*, 1975, WYSOKI, 1989, TREMBLAY, 1990, FRANCO & CARVALHO, 1991, CARVALHO & RAMOS, 1994) and the lepidoptera *Lobesia botrana* Den. y Shiff. (Lepidoptera: Tortricidae) (BODENHEIMER, 1951, COSCOLLá, 1988). Relatively to the mealybugs, it was recorded the species of pseudococcidae family, such as citrus mealybug (CM), *Planococcus citri* (Risso) (Homoptera: Pseudococcidae), in citrus (ORTU, 1982, GARRIDO & BUSTO, 1987, VACANTE, 1988, FRANCO & CARVALHO, 1991, CARVALHO & RAMOS, 1994), specially in sweet orange cultivars "Navel" (TREMBLAY, 1990), and *Pseudococcus longispinus* (Targioni-Tozzetti) (Homoptera: Pseudococcidae) in avocado (WYSOKI *et al.*, 1975). The HM has been recorded also as a primary pest of avocado (WYSOKI *et al.*, 1975, YEHUDA *et al.*, 1991\92), grape and loquat (SCHWEIG, 1950).

The importance of HM (i.e., secondary or primary pest) may result of the anatomy of the attacked organs, specially fruits, and of the resistance to penetration by the larvae. In fact, in the case of citrus, it is usually refereed that the early larval instars feed mainly on the honeydew secreted by aphids or mealybugs and only the later larval instars are able to pierce the fruit exocarp and sometimes the fruit endocarp (BODENHEIMER, 1951, SERGHIOU, 1983, WYSOKI, 1989), or on areas infested by another organisms, as refereed before.

The damage caused by HM results from the fruit piercing and, as a corollary to this, the fruits become yellow prematurely and after occurs the premature drop, in the case of citrus (BODENHEIMER, 1951, PANIS, 1969, LUPINO, 1979, TREMBLAY, 1990). ORTU (1982) observed that from 6.9% of lost citrus production, 66.7% are caused by HM attack (i.e., HM caused the lost of 4.6% of total production). Concerning the grape, the presence of high population densities of HM can contribute to the increase of grape grey mould (COSCOLLÁ, 1988).

The present study has been intended to contribute to the knowledge of the HM population dynamics on sweet orange groves (mainly in "Navel" cultivares), the importance of damage caused by HM, and the interspecific association between HM and citrus mealybug species, particularly CM.

MATERIAL AND METHODS

Location. The experimental study was conducted in four sweet orange groves (table 1), located at different places of the most important citrus production region in Portu-

Table 1. - **Study groves characterisation.**

Grove	Localisation	Cultivar	Rootstock	Area (m²)	Age
Bela Salema	Faro	Newhall	Citranger Troyer	11 376	21
Patacão	Faro	Newhall	Citranger Troyer	6 120	12
Murtais	Moncarapacho	Navelina	Citranger Troyer	924	6
Fazenda Grande	Tavira	Navelina	Sour orange	11 784	25

Table 2. - **Pesticide treatments**

Bela Salema		Patacão		Murtais		Fazenda Grande	
Date	**Pesticide**	**Date**	**Pesticide**	**Date**	**Pesticide**	**Date**	**Pesticide**
8 June	methomyl*	13 October	dimethoate	9 July	mineral oil butocarboxim	10 October	dimethoate
19 June	diflubenzuron*			2 August	mineral oil butocarboxim		
11 July	diflubenzuron* aldicarb*			12 September	mineral oil dimethoate		
28 July	aldicarb*			26 September	mineral oil dimethoate		
15 August	aldicarb*			21 October	mineral oil dimethoate		
14 October	dimethoate						

* Treatments performed only in small trees, not considered in this study.

gal (i.e., Algarve). The pesticide treatments are presented in table 2.

Monitoring of HM by pheromone traps. The HM male populations were monitored by placing «Funnel» traps containing the pheromone dispensers (Agrisense-BCS Limited) and insecticide plate (0,0-dimethyl-0-2,2-dichlorovinylphosphate). It was placed one trap per grove and the number of captured males were registered weekly, from 2nd March to 14th December 1995. The pheromones dispensers were replaced every 4 weeks and the insecticide plates weekly.

Field observations. From fruit set to harvest (8th July to 15th October, respectively), 1000 randomised fruits (20 fruits per tree, 50 trees) in groves the Bela Salema, Patacão and Fazenda Grande, and 500 randomised fruits (20 fruits per tree, 25 trees), in the grove Murtais, were examined at fortnight intervals, for the presence of HM larvae and CM colony, separately and/or together.

To evaluate the effect of HM on fruit drop, it was assumed that the total amount of fruit infested by HM, during the experimental period, represented the potential fruit drop caused by HM damage. It was also registered the different kind of damage caused by HM.

Laboratory observations. Some of the larvae were reared on the captured fruits, in plastic bottles (0.15 m long, 0.08 m diameter), under laboratory conditions (25 ± 0.5°C), to maturity and identified. Some exemplars of captured males on traps (total of 20 per grove), and females and males developed in laboratory, were identified based on the examination of morphological characters and genitalia, according to HEINRICH (1956) and BRADLEY (1987).

Statistical analysis. The interspecific association between HM and CM (i.e., presence of both species in the same fruit), during the experimental study, as tested using 2 × 2 contigency table as principal analytical tool. The χ^2 test (P $\leq$ 0,05) is used to determine whether the null hypothesis of independence should be accepted or rejected association and for the calculation of the degree of association it was used the Ochiai, Dice and Jaccard indices. All statistical analysis were performed with the programme presented by LUDWIG & REYNOLDS (1988).

RESULTS AND DISCUSSION

Monitoring of HM by pheromone traps. The number of HM male captures are presented in Figure 1a-d. In all groves, the first captures were recorded during March and continued until late May, indicating the emergence of the overwintering generation. The captures increased again from early June until

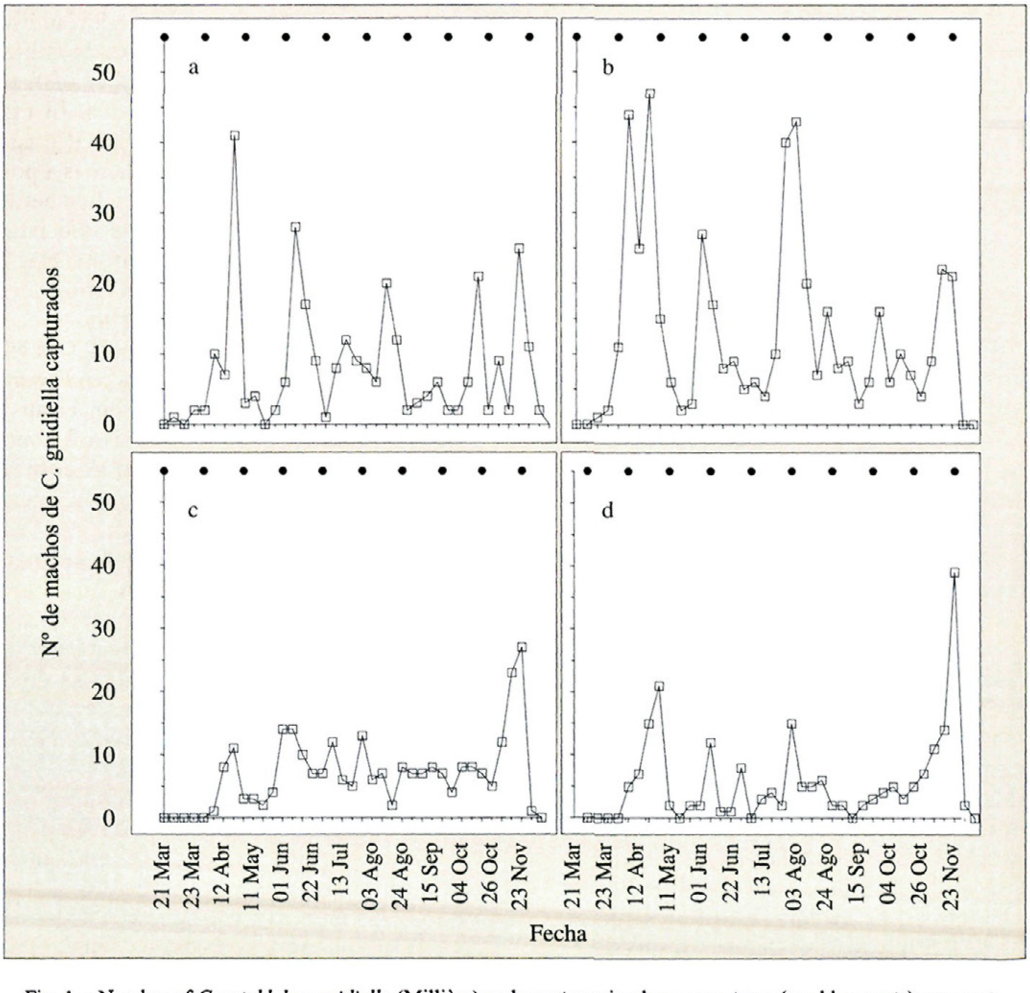

Fig. 1. - Number of *Cryptoblabes gnidiella* (Millière) male captures in pheromone traps (weekly counts) on sweet orange groves (*Citrus sinensis* [L.] Osbeck) (a - Bela Salema, b - Patacão, c - Murtais, d - Fazenda Grande) (• - dates of pheromone dispenser change) in Portugal.

late August, indicating the appearance of the males of the first generation. The peaking of this generation is difficult to establish because the captures did not exhibit a continuous pattern. After that period, the captures were low until early or mid November when increased again and a peak were recorded. The captures finished after late November or early December. In the case of the groves Bela Salema (Figure 1a) and Patacão (Figure 1b), were registered an increasing of captures in early October. The tendency described are more obvious in the case of the groves with higher number of HM male captures (Bela Salema - Figure 1a, Patacão - Figure 1b).

The percentage of the HM males captured, in each grove, in respect to the total captured, according to the periods March-May (Bela Salema –23.6%, Patacão –31.9%, Murtais –12.0%, Fazenda Grande –25.1%), June-September (Bela Salema –50.8%, Patacão –51.9%, Murtais –53.9%, Fazenda Grande –34.9%) and October-December (Bela Salema –25.6%, Patacão –16.2%, Murtais –34.1%, Fazenda Grande –0.0%), showed a similar pattern and the greater percentage of males was trapped during June-September period (except for the grove Fazenda Grande). It was possible to identify three or four distinct peaks of HM males (i.e., one in the March-May period, one or two in the June-September period and one in the October-December period).

Field observations. It was registered a very low infestation rate of HM larvae in the case of the groves Bela Salema (Figure 2a) and Murtais (Figure 2c), and in most dates the HM larvae were absence. However, in the date where both species were presented, it is observed a significative ($P \leq 0.05$) interspecific association between HM and CM (Tables 3, 5) and the association was positive, except in the case of grove the Murtais on the 1st September (Table 5).

In the case of the groves Patacão and Fazenda Grande, eventhough the low infestation rates of HM larvae (Figures 2b and 2d, respectively), the greater number of fruits with HM had also CM colonies. In fact, according to the results of interspecific association tests (Tables 4 and 6), there is a positive significant ($P \leq 0.05$) association between HM and CM in all dates. The association indices used showed a medium association degree, because the CM infestation level were higher than the HM infestation level.

It seems that this results of a positive significant association ($P \leq 0.05$) between HM and CM support, for the first time from a statistical point of view, the hypothesis of several authors (BODENHEIMER, 1951, AVIDOV &

Table 3. - **Interspecific association indices and statistic test between *Planococcus citri* (Risso) and *Cryptoblabes gnidiella* (Millière) in the grove Bela Salema (Faro, Portugal).**

Date	Index association	Association type[a]	χ^2	Indices: Ochiai	Indices: Dice	Indices: Jaccard
8 Jul	1.16	+	33.58 *	0.25	0.17	0.09
21 Jul	–	–	–	–	–	–
3 Aug	–	–	–	–	–	–
16 Aug	1.04	+	19.42*	0.14	0.04	0.02
31 Aug	–	–	–	–	–	–
17 Sep	–	–	–	–	–	–
29 Sep	–	–	–	–	–	–
14 Oct	–	–	–	–	–	–

[a] Sign indicates direction of the species associations.
* Significant value ($P \leq 0.05$).
– One of the species are absent in all dates.

GOTHILF, 1960, PANIS, 1969, ORTU, 1982, GARRIDO & BUSTO, 1987, CARVALHO, 1988) that the CM infestation is necessary for the attack by HM in the case of citrus fruits. Some of the factors that can induce this association were already identify, namely the honeydew excreted by CM which attracts the oviposition of HM females and the first larvar instar initially feed on the honeydew (BODENHEIMER, 1951, SERGHIOU, 1983). In the case of EC that attacks carob (*Ceratoniae siliqua* L.) fruits with *Phomopsis* spp. fungi, the oviposition stimulants were identified as short-chain alcohol's (GOTHILF *et al.*, 1976).

There was no apparent correlation between HM male captures (Figure 1) and larvae infestations (Figure 2), in all groves analysed. In fact, in the case of the grove Bela Salema, despite the high number of HM males captured (Figure 1a), the infestation rate of HM larvae (Figure 2a) was reduced. Also, in other studies of population dynamics, performed on avocado in Israel (YEHUDA et al., 1991/92), it was not possible to establish a correlation between HM males captures and larval infestations.

Concerning the importance of damage caused by HM, it was registered a percentage of fruit drop of 0.4%, 21.0%, 2.2% and 13.3%,

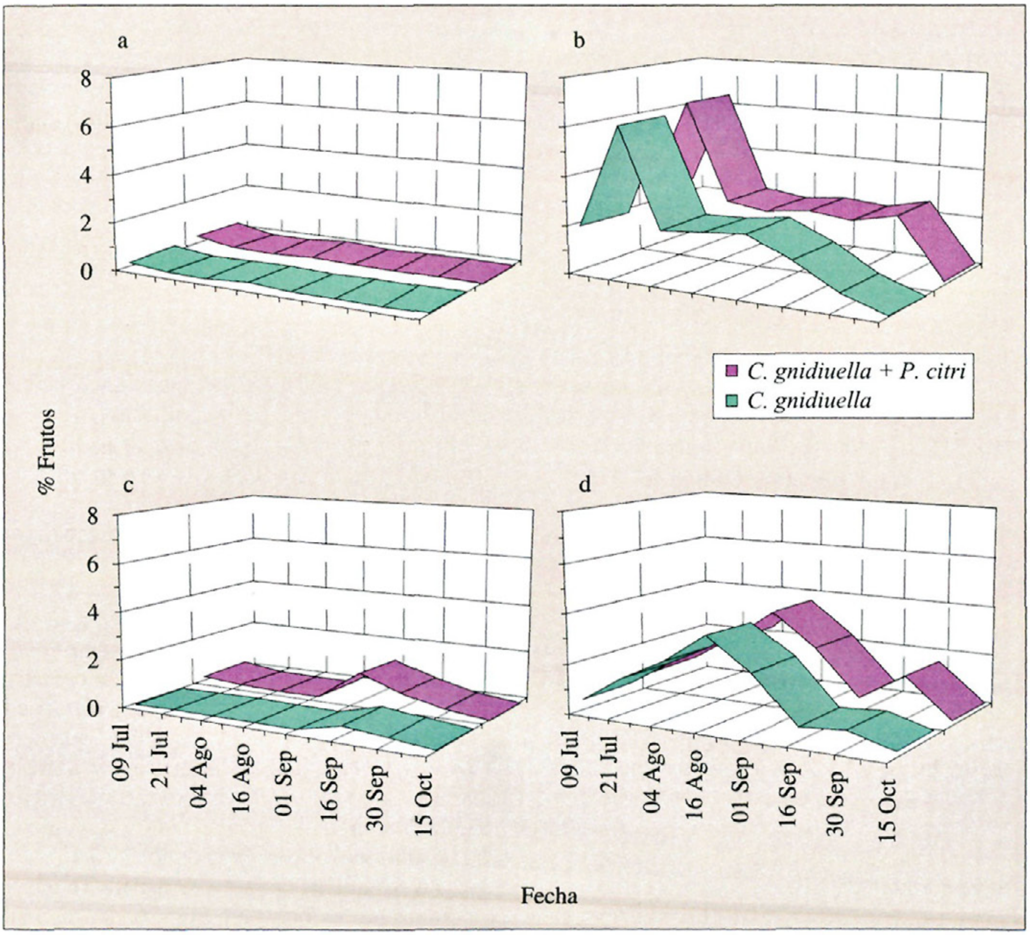

Fig. 2.-Infestation rates of *Cryptoblabes gnidiella* (Millière) larvae (HM) and of the complex *C. gnidiella* larvae and *Planococcus citri* (Risso) (HM+CM) colonies on sweet orange groves (*Citrus sinensis* [L.] Osbeck) (a - Bela Salema, b - Patacão, c - Murtais, d - Fazenda Grande) in Portugal.

Table 4. - **Interspecific association indices and statistic test between *Planococcus citri* (Risso) and *Cryptoblabes gnidiella* (Millière) in the grove Patacão (Faro, Portugal).**

Date	Index association	Association type[a]	χ^2	Indices		
				Ochiai	Dice	Jaccard
9 Jul	1.17	+	61.71*	0.29	0.18	0.10
20 Jul	1.23	+	81.62*	0.38	0.27	0.15
4 Aug	1.07	+	14.21*	0.19	0.08	0.04
16 Aug	1.17	+	68.06*	0.31	1.17	0.09
31 Aug	1.15	+	51.71*	0.27	0.16	0.09
17 Sep	1.67	+	52.78*	0.28	0.18	0.10
30 Sep	1.06	+	4.10*	0.12	0.10	0.05
15 Oct	1.05	+	13.16*	0.16	0.05	0.03

[a] Sign indicates direction of the species associations.
* Significant value (P ≤ 0.05).

Table 5. - **Interspecific association indices and statistic test between *Planococcus citri* (Risso) and *Cryptoblabes gnidiella* (Millière) in the grove Murtais (Moncarapacho, Portugal).**

Date	Index association	Association type[a]	χ^2	Indices		
				Ochiai	Dice	Jaccard
9 Jul	–	–	–	–	–	–
21 Jul	–	–	–	–	–	–
4 Aug	–	–	–	–	–	–
16 Aug	–	–	–	–	–	–
1 Sep	0.99	–	9.59*	0.0	0.0	0.0
16 Sep	1.57	+	92.06*	0.58	0.57	0.40
30 Sept	1.67	+	61.88*	0.71	0.67	0.50
15 Oct	–	–	–	–	–	–

[a] Sign indicates direction of the species associations.
* Significant value (P ≤ 0.05).
– One of the species are absent in all dates.

respectively on the groves Bela Salema, Patacão, Murtais and Fazenda Grande. Although the restrict number of groves analysed and the fact that the fruit drop assessment may overcame reality, it can be conclude that even in the case of low HM larvae infestations and in absence of any specific pesticide treatment for HM (Table 2), such the case of the groves Patacão and Fazenda Grande, this species can cause serious damage on fruit drop and, consequently, high reduction of sweet orange production, mainly in the case of «Navel» cultivares. This damage caused by HM can intensify the damage caused by CM, already identified in previous studies (Silva, 1994, Silva & Mexia, 1997a, Silva & Mexia, 1997b), since, as was stressed already, the presence of HM on citrus required the existence of CM colonies.

Additional observation on the HM biology showed that HM larvae were usually found at contact points between fruits or leaves and fruits, and mostly inside the CM colonies. The injury caused by HM feeding consists of fruit piercing and gallery formation at fruit

Table 6. - **Interspecific association indices and statistic test between *Planococcus citri* (Risso) and *Cryptoblabes gnidiella* (Millière) in the grove Fazenda Grande (Tavira, Portugal).**

Date	Index association	Association type[a]	χ^2	Indices		
				Ochiai	Dice	Jaccard
9 Jul	1.08	+	13.80*	0.16	0.07	0.04
21 Jul	1.11	+	34.55*	0.23	0.12	0.06
4 Aug	1.20	+	84.57*	0.33	0.20	0.11
16 Aug	1.37	+	143.04*	0.42	0.31	0.18
1 Sep	1.36	+	199.96*	0.48	0.37	0.23
16 Sep	1.16	+	68.60*	0.30	0.16	0.09
30 Sep	1.16	+	35.91*	0.23	0.18	0.10
15 Oct	1.17	+	49.36*	0.30	0.17	0.09

[a] Sign indicates direction of the species associations.
* Significant value ($P \leq 0.05$).

exocarp and endocarp. As a result of this, the formation of gum-exudation occurs and the fruits became yellow and drop prematurely.

Concerning the other pyralid moth (EC), only one larvae was observed in 20th July at the grove Patacão and one larvae in 29th September at the grove Bela Salema.

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ABSTRACT

SILVA, E. B. & A. MEXIA: The pest complex *Cryptoblabes gnidiella* (Millière) (Lepidoptera: *Pyralidae*) and *Planococcus citri* (Risso) (Homoptera: *Pseudococcidae*) on sweet orange groves (*Citrus sinensis* (L.) Osbeck) in Portugal: Interspecific association. *Bol. San. Veg. Plagas,* **25** (1): 89-98.

The honeydew moth (HM), *Cryptoblabes gnidiella* (Millière) (Lepidoptera: Pyralidae), is a polyphagous pest of numerous crops and is recorded as a secondary pest in citrus groves, often associated with attacks of others species such mealybugs and their honeydew. A study of HM population dynamics on sweet orange groves (*Citrus sinensis* [L.] Osbeck), the importance of damage caused by HM and the interspecific association between HM and the citrus mealybug (CM), *Planococcus citri* (Risso) (Homoptera: Pseudococcidae), were realized in four groves at Southern region of Portugal (i.e., Algarve).

The percentage of the total HM males captured, in each grove, showed a similar pattern and the greater percentage of males were trapped during the June-September period (except for the grove Fazenda Grande). It was possible to identify three or four distinct peaks. The results suggest also a positive significant association ($P \leq 0.05$) between HM and CM, supporting the hypothesis of several authors that the CM infestation is necessary for the attack by HM, in the case of citrus. Even in the case of low HM larvae infestation, it can caused serious damage by fruit drop and, consequently, high reduction of sweet orange production, mainly in the case of "Navel" cultivares. This damage caused by HM can intensify the damage caused by CM, already identified in previously studies.

Key-words: Citrus mealybug, *Cryptoblabes gnidiella*, damage, honeydew moth, interspecific association, *Planococcus citri*, population dynamics, Portugal, sweet orange.

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