Boll. Zool. agr. Bachic.
Ser. II, 28 (2), 1996: 185-194

V. CALECA, G. LO VERDE, S. RAGUSA-DI CHIARA
A. SINACORI, H. TSOLAKIS (*)

Observations on Insects Visiting Flowers of Cherimoya and Atemoya in Sicily (Italy) (**)

Abstract - As an inadequate pollination is one of the factors limiting the commercial production of *Annona* spp. in many countries, observations on insects visiting flowers of Cherimoya (*Annona cherimola* Mill.) and Atemoya (*A. cherimola* x *A. squamosa* L.) were carried out in Campobello di Mazara (Trapani) and Sciacca (Agrigento) (Sicily), in 1995. All the insects which visited flowers were surveyed and most of them identified. 44,6% and 20,5% of flowers were visited by insects in Campobello di Mazara and Sciacca respectively. Nine species of insects were collected in the first orchard: among them the staphylinid *Paraphloeostiba gayndahensis* (McLeay), the nitidulid beetle *Carpophilus tersus* Wollaston, and the thrip *Frankliniella occidentalis* (Pergande) represented 87.4% of all the insects found inside flowers; the most abundant species in Sciacca was the anthocorid *Orius laevigatus* (Fieber) (70.3%). In 1996 branches of some custard-apples (*A. cherimola* cv Fino de Jete) were covered with sleeves inside which specimens of *O. laevigatus* were released. The species had a positive influence on the pollination of *Annona* as the percentage of fruit set was similar to that obtained in the uncovered control. The percentage of well formed fruits was however lower than the one obtained in the uncovered control.

Riassunto - *Osservazioni sugli insetti che visitano i fiori di* Annona *spp. in Sicilia.*

È stato realizzato uno studio sull'artropodofauna floricola dell'anona (*Annona* spp.), coltura tropicale i cui fiori dicogamici e proteroginici presentano problemi di impollinazione e conseguentemente di produttività. Nel corso del 1995 sono stati esaminati 2.970 fiori di *Annona* spp. in due campi sperimentali siti a Sciacca e Campobello di Mazara, registrando il numero di in-

---

(*) Authors are in alphabetical order and have equally contributed to this research.

(**) Work carried out in the context of the program "Tropical and subtropical fruit trees and citrus trees at unusual time of ripeness" supported by Assessorato Agricoltura e Foreste - Regione Siciliana.

setti presenti e raccogliendone gli esemplari per l'identificazione. La percentuale di fiori visitati da artropodi è stata del 44,6% a Campobello e del 20,5% a Sciacca. Nel primo sito sono state catturate nove specie, tre delle quali *Paraphloeostiba gayndahensis* (McLeay), *Carpophilus tersus* Wollaston e *Frankliniella occidentalis* (Pergande), hanno rappresentato insieme l'87,4% di tutti gli insetti osservati nei fiori; nel secondo sito la specie più abbondante è stata l'antocoride *Orius laevigatus* (Fieber), che da solo ha costituito il 70,3% degli insetti raccolti. La comunità di artropodi di Campobello è risultata più ricca e con una migliore equiripartizione di specie, probabilmente per la maggiore diversificazione ambientale delle aree immediatamente a ridosso della coltura. Le comunità dei due siti sono risultate statisticamente differenti. Nel secondo anno sono state condotte prove di insacchettamento di rami di anona (*A. cherimola* cv Fino de Jete) con introduzione di *O. laevigatus* nei sacchetti. L'antocoride si è confermato impollinatore della coltura, avendo fatto registrare percentuali di frutti simili a quelle del testimone non insacchettato. Tuttavia la percentuale di frutti ben formati è risultata nettamente inferiore rispetto a quest'ultimo.

Key words: *Annona* spp., insects, flowers, Sicily, pollination.

INTRODUCTION

Annona cherimola Mill. was imported from South America to Europe in the 15th century and cultivated since the second half of the 19th century. The plant was introduced to Italy at the end of the 18th century for the first time into the Botanical Garden of Palermo for scientific study and then into Calabria (Costantino, 1963).

Some experimental orchards have been recently planted in Sicily with Cherimoya (*A. cherimola)* and Atemoya (*A. cherimola* x *A. squamosa* L.) by the Istituto di Coltivazioni arboree of Palermo University, to get a better understanding of the biological aspects of the plant as well as of its pollination in our region.

As an inadequate pollination is one of the factors limiting the commercial production of *Annona* spp. in many countries, observations were carried out in two different locations in Sicily, Sciacca (Agrigento) and Campobello di Mazara (Trapani), on insects which visited flowers, to verify their action on pollination.

MATERIALS AND METHODS

The orchard in Sciacca was located in a mosaic of agricultural landscape, mainly characterized by the presence of vineyards, olive groves and horticultural

crops, while Campobello orchard was located in a nursery, where different fruit-trees were also present.

In both orchards different cultivars of Atemoya and Cherimoya were present.

Observations were done in the daylight (8 a.m.-1 p.m. and 4-8 p.m.) twice a week during the whole flowering period (June-July) in 1995; all the insects which visited the flowers were collected and most of them identified; the sexual stage of flowers was also noted. The frequency of each species on the checked flowers, and with regards to the total number of collected insects, was taken into account.

Shannon diversity and Sörensen quantitative similarity indexes have been used to compare the arthropodofauna present in the two sites. χ^2 has also been calculated to verify if the differences found in Sciacca and in Campobello were statistically significant.

Moreover trials were carried out in Sciacca in 1996 using the anthochorid *Orius laevigatus* (Fieber), (the most common species in 1995) as possible pollinator.

Branches of custard-apples (*A. cherimola* cv Fino de Jete) were isolated using sleeves of antiaphid nets. Some branches were covered when they began blooming and were uncovered after 8 weeks (thesis 1) or after one week (thesis 2), in absence of insects. Some branches were covered and uncovered as above (theses 3 and 4), but 80 specimens of *O. laevigatus* per week were put. Branches were marked and left uncovered for the whole period of their blooming in the control.

Open flowers were eliminated from all the branches before putting the sleeves, while the closed ones were counted. In theses 2 and 4 all the closed flowers were marked and their status at the moment of uncovering was noted.

In the theses 1, 3 and in the control the mean number of flowers per branch per week was estimated taking into account the branch length and the number of flowers present at the moment of covering.

An average of 12 branches per thesis was taken into account.

RESULTS AND DISCUSSION

1995 observations

As the self and wind pollination of *Annona* is very poor (George et al., 1989), hand pollination is very expensive and results are not always satisfactory (Farré Massip, 1993; Schroeder, 1971), a great attention was paid to entomophilous pollination.

Table 1 shows the arthropods that visited flowers in both orchards and their frequencies. The flowers visited by arthropods, mostly insects, were 20.5% in Sciacca, where 6 species and 4 unidentified arthropods were collected, and

Table 1 - Different arthropods collected inside annona flowers and their frequencies in Sciacca (Agrigento) and Campobello di Mazara (Trapani).

			Sciacca				Campobello di Mazara			
			N. of flowers	N. of insects	% of flowers	% of insects	N. of flowers	N. of insects	% of flowers	% of insects
		Total	***1186***	***293***			***1784***	***1578***		
		Empty flowers	943		79.5		988		55.4	
		Visited flowers	243		20.5		796		44.6	
Thysanoptera	Thripidae	*Frankliniella occidentalis* (Pergande)	47	55	4.0	18.8	273	355	15.3	22.5
Rhynchota	Anthocoridae	*Orius laevigatus* (Fieber)	171	206	14.4	70.3	129	138	7.2	8.7
	Miridae	*Campylomma verbasci* (Meyer)	16	16	1.3	5.4	0	0	0.0	0.0
Coleoptera	Staphylinidae	*Paraphloeostiba gayndahensis* (McLeay)	6	7	0.5	2.4	214	542	12.0	34.4
	Nitidulidae	*Carpophilus tersus* Wollaston	3	4	0.3	1.4	222	481	12.4	30.5
		Carpophilus mutilatus Erichson	0	0	0.0	0.0	12	12	0.7	0.8
		Carpophilus hemipterus (L.)	1	1	0.1	0.3	2	2	0.1	0.1
		Epuraea luteola Erichson	0	0	0.0	0.0	2	2	0.1	0.1
		Urophorus humeralis (Fabricius)	0	0	0.0	0.0	6	7	0.3	0.4
		Urophorus rubripennis (Heer)	0	0	0.0	0.0	2	2	0.1	0.1
	Undetermined		0	0	0.0	0.0	8	8	0.4	0.6
Other Arthropods (no insects)			4	4	0.3	1.4	28	29	1.6	1.8
		Shannon diversity index				**0.89**				**1.35**

44.6% in Campobello di Mazara, where 10 species and 37 unidentified arthropods were collected.

One to three different species were frequently found inside each flower and the average number of specimens per flower was 1.2 in Sciacca and 2.0 in Campobello di Mazara. The maximum number of specimens per flower was found in Campobello where 21 insects, among which 12 specimens of the nitidulid *Carpophilus tersus* Wollaston and 9 of the staphylinid *Paraphloeostiba gayndahensis* (McLeay), were found.

Campobello showed a higher diversity of arthropodofauna and this was also confirmed by the Shannon diversity index, whose values were 1.35 in Campobello and 0.89 in Sciacca. Sörensen quantitative index was 0.22, showing a low similarity between the two sites. Moreover the differences found between Campobello and Sciacca resulted statistically significant ($p = 0.001$).

Fig. 1 shows the percentages of the most frequent species found inside the custard apple flowers in Sciacca and Campobello di Mazara, calculated taking into account the total number of observed flowers (fig. 1a) and the total number of collected insects (fig. 1b). The dominant species recorded in Sciacca was *O. laevigatus*, found in 14.4% of flowers (fig.1a) and representing 70.3% of total insects (fig. 1b), followed by *Frankliniella occidentalis* (Pergande) (4.1% of visited flowers and 18.8% of caught specimens). 2.5% of flowers was visited by the remaining species, which represented 10.7% of the caught specimens.

O. laevigatus was already mentioned on the 3-5% of *A. cherimola* flowers in Calabria (Continella et al., 1994) and its pollinating activity on *Lantana camara* L. has been recently demonstrated (Sinacori & Mineo, 1996).

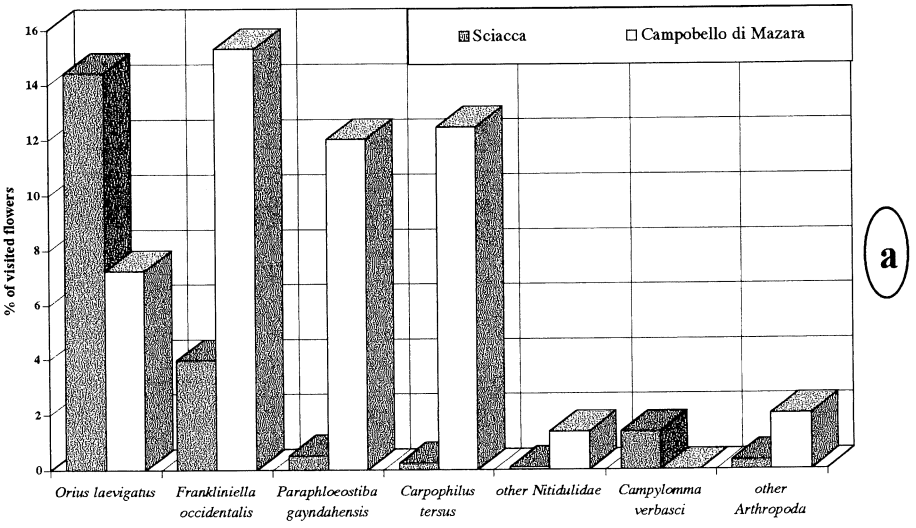
The action of thrips on pollination was already shown (Hagerup, 1950). As a matter of fact, Haslerud (1974) in Norway concluded that thrips were not very effective for pollination. According to Bournier (1983) their pollinating action was important in some biotopes and for some plants. As far as we know no information is available on the role of *F. occidentalis* on pollination. The thrip *Frankliniella bispinosa* (Morgan) was found on 9.7% of flowers in Florida (Nagel et al., 1989), but the Authors did not take into account if it had any influence on the pollination.

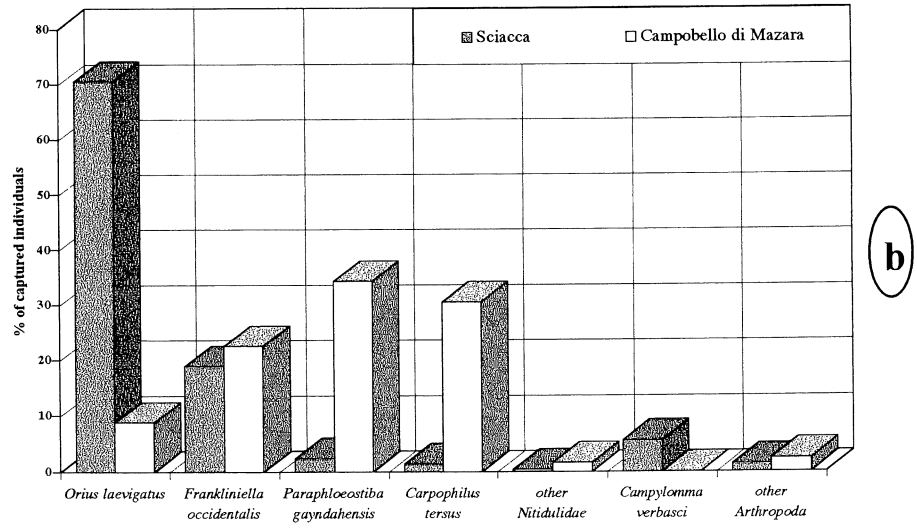
A different situation was noted in Campobello di Mazara, where the most abundant species were *F. occidentalis, C. tersus* and *P. gayndahensis*, visiting 15.3%, 12.4% and 12% of flowers respectively (fig. 1), and representing 22.5%, 30.5% and 34.4% of total insects (fig. 2). The last two species are reported for the first time on flowers of *Annona*, but further studies have to be carried out to check if they have an influence on its pollination.

O. laevigatus was found in 7.2% of flowers, being 8.7% of total specimens found. The remaining nitidulid beetles (*Carpophilus mutilatus* Erichson, *C. hemipterus* (L.), *Epuraea luteola* Erichson, *Urophorus humeralis* (Fabricius), and

U. rubripennis (Heer)) visited 1.3% of flowers while the remaining arthropods visited 2%.

96% of insects collected inside the flowers (at female stage) in Israel were nitidulid beetles. Among them the most important species was *U. humeralis* (47.6%), followed by *C. hemipterus* (27.6%), *E. luteola* (16.1%) and *C. mutilatus* (8.7%) (Gazit et al., 1982); *C. mutilatus* was found in Florida as the most relevant species, followed by *E. luteola* and *Carpophilus fumatus* Boheman (Nadel & Peña,





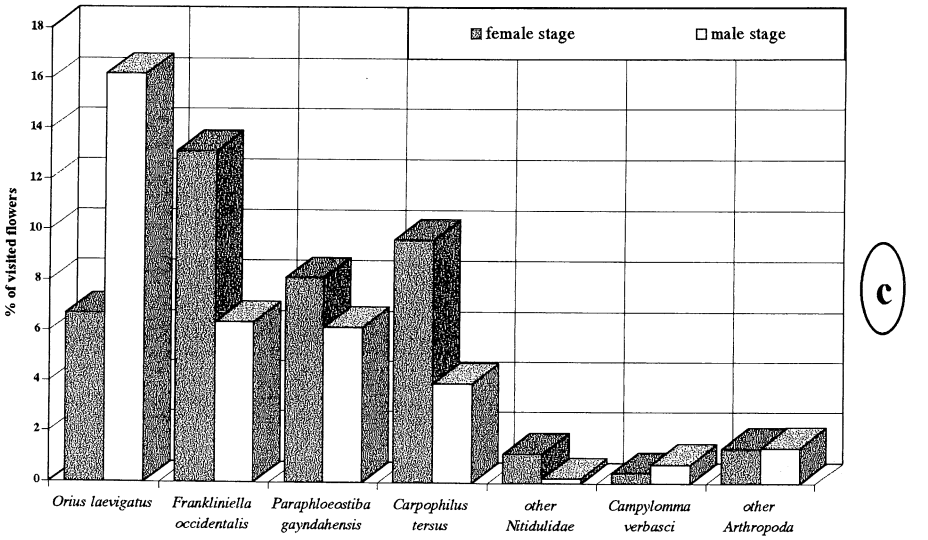


Fig. 1 - Percentage of *Annona* spp. flowers visited by different species of arthropods in Sciacca (Agrigento) and Campobello di Mazara (Trapani) (a) - Percentage of different species of arthropods captured in *Annona* spp. flowers (b) - Percentage of *Annona* spp. flowers visited by different species of arthropods during the two different sexual stages (c).

1994), while the most frequent one in Australia was *C. hemipterus* (George et al., 1989).

In fig. 1c the percentages of flowers during the two different sexual stages visited by different arthropods are reported. Flowers in the female stage were visited by most species. The percentages of flowers at the female stage visited by *F. occidentalis, C. tersus, P. gayndahensis* and other Nitidulidae were 13.1%, 9.6%, 8.1% and 1.2%, respectively, while the male ones were 6.4%, 3.9%, 6.2% and 0.2%. On the other hand *O. laevigatus* preferred 16.2% of flowers in the male stage and only 6.7% in the female one. The mirid *Campylomma verbasci* (Meyer) and other arthropods did not show a clear preference for any sexual stage of flowers. Moreover, from our observations in Sciacca 16.3% of flowers in the female stage and 27.3% of those in the male stage were visited, while these percentages in Campobello di Mazara were 48.9% and 36.6% respectively.

In fig. 2 the trends of the percentages of flowers visited by different species are shown. The percentage of flowers visited by *O. laevigatus* was under 20% in Sciacca up to June and reached a peak (47.8%) during the first ten days of July (fig. 2a); afterwards it sharply decreased, reaching the minimum value (2%) at the end of July. All the remaining species were at very low levels.

O. laevigatus reached a peak of 7% of visited flowers in Campobello di Ma-

zara during the second ten days of June, decreased afterwards and was under 5% throughout July (fig. 2b). *F. occidentalis* started visiting 31.4% of flowers and then decreased, while *P. gayndahensis* visited a low percentage of flowers until the end of June and then showed a sharp increase reaching the maximum level (51.9%) at the end of July. *C. tersus* visited a percentage of flowers varying from

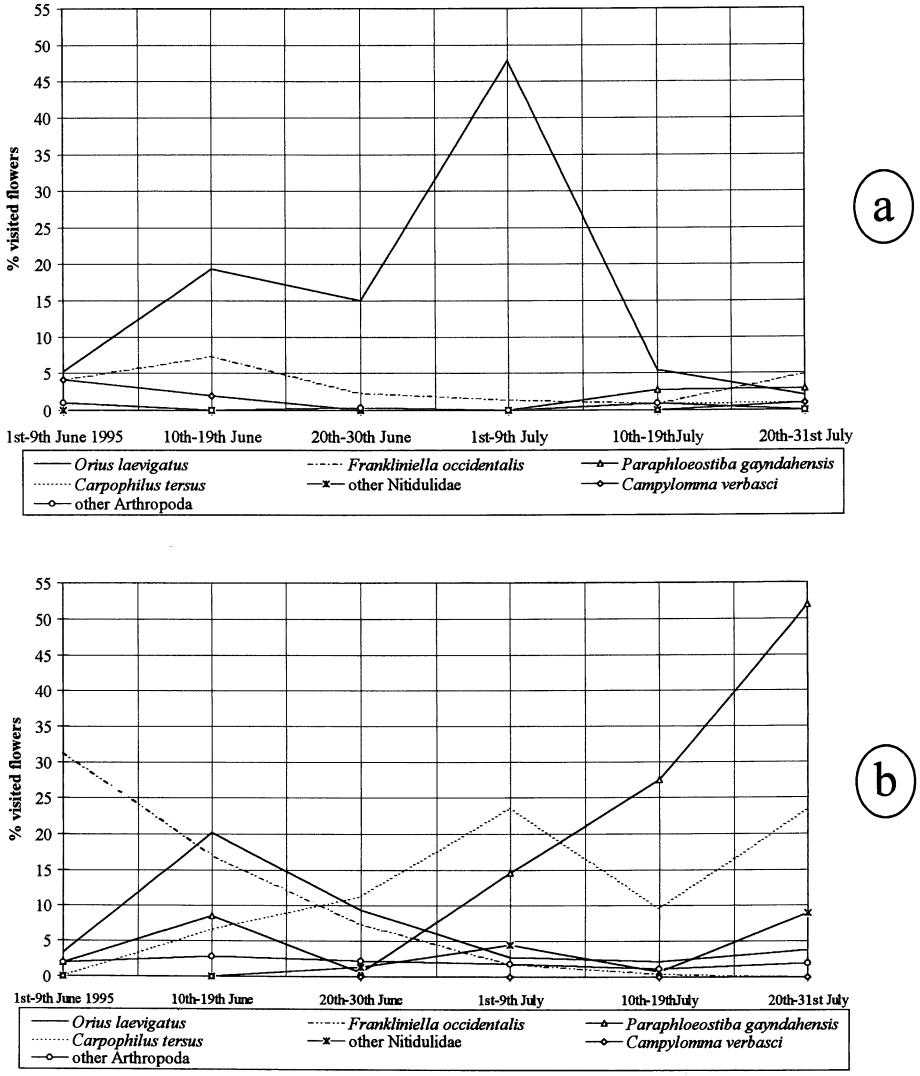


Fig. 2 - Trend of percentages of flowers visited by different species of arthropods in Sciacca (Agrigento) (a) and Campobello di Mazara (Trapani) (b).

6.6% to 12.4% in the initial twenty days of June, then slowly grew up reaching a peak of 23.6% in the first ten days of July, and another one at the end of the same month. From the above observations we see that among the most important species only *C. tersus* was more constantly present with values between 6.6% and 23.6% of visited flowers.

1996 trials

Results on the trials carried out in Sciacca during 1996 are reported in table 2. As it was expected, no fruits were formed where flowers were kept covered in ab-

Table 2 - Influence of Orius laevigatus *(Fieber) on fruit production of* Annona cherimola *Mill. cv Fino de Jete.*

Theses	Covering period	Nr. *O. laevigatus* released	Nr. flowers per branch (mean)	Fruits after three months (%)	High quality symmetrical fruits (%)
1	8 weeks	none	91	0	0
2	1 week	none	12*	0	0
3	8 weeks	80 per week	66	3.3	42.8
4	1 week	80	13*	8.4	22.2
Control (uncovered)	–	–	88	5.7	64

* mean number of flowers marked at the time of covering

sence of insects (theses 1 and 2). In thesis 3 the percentage of fruits obtained after three months was low (3.3%), but among them the 42.8% was well formed due to a good pollination. In thesis 4 the percentage of fruits obtained was higher when compared to the other thesis (8.4%), but the percentage of well formed fruits was lower (22.2%).

Similar results were obtained in Israel by Gazit et al. (1982), who used four species of nitidulids (*U. humeralis, C. hemipterus, E. luteola* and *C. mutilatus*) obtaining 5-10.7% of Atemoya fruits while 3.5% of Cherimoya fruits was obtained using *C. hemipterus* and *U. humeralis*.

The percentage of fruits obtained in the uncovered control was 5.7%, but the percentage of perfect fruits was higher (64%). Such results suggest that the anthocorid action in our weather conditions has to be completed by the other arthropods, whose role varies according to the characteristics of the different sites. This is supported by the percentage of high quality symmetrical fruits obtained in the control.

ACKNOWLEDGMENTS

The Authors wish to thank Prof. P. Audisio, Dr. G. Sabella, Prof. A. Carapezza and Dr. R. Marullo who identified Nitidulidae, Staphylinidae, Heteroptera and Thripidae, respectively. We are also grateful to Mr. G. Bono and Mr. C. Ferro who allowed us to use their *Annona* orchards and to Mrs E. Chiavetta-Ragusa who checked the English text.

REFERENCES

BOURNIER A., 1983 - Les Thrips. Biologie, Importance agronomique. - INRA, Paris: 1-128.

CONTINELLA G., LONGO S., ZAPPIA R., PALMERI V., 1994 - Flower and fruit biological behaviour of some Cherimoya (*Annona cherimola* Mill.) clones. - XXIVth Int. Hortic. Congr., Kyoto, Japan, 1994: 47.

COSTANTINO F., 1963 - Una coltura subtropicale di grande interesse per il Mezzogiorno: l'*Annona cherimola*. - Frutticoltura 3: 243-247.

FARRÉ MASSIP J.M., 1993 - I fruttiferi tropicali e subtropicali nella Spagna mediterranea. - Inf.tore agrario 1: 23-28.

GAZIT S., GALON I., PODOLER H., 1982 - The role of Nitidulid beetles in natural pollination of *Annona* in Israel. - J. Amer. Soc. Hort. Sci. 107 (5): 849-852.

GEORGE A. P., NISSEN R. J., IRONSIDE D. A., ANDERSON P. 1989 - Effects of Nitidulid Beetles on Pollination and Fruit Set of *Annona* spp. Hybrids. - Scientia Hortic. 39: 289-299.

HAGERUP O., 1950 - Thrips pollination in *Calluna*. - Kungl. Danske Videnskab. Selskab. Biolog. Medels 18: 1-16.

HASLERUD H.D., 1974 - Pollination of some Ericaceae in Norway. - Norw. H. Bot. 21: 211-216.

NADEL H., PEÑA J.E., 1994 - Identity, Behavior, and Efficacy of Nitidulid Beetles (Coleoptera: Nitidulidae) Pollinating Commercial *Annona* Species in Florida. - Environ. Entomol. 23 (4): 878-886.

NAGEL J., PEÑA J.E., HABECK D. 1989 - Insect Pollination of Atemoya in Florida. - Florida Entomologist 72 (1): 207-211.

SCHROEDER C.A., 1971 - Pollination of Cherimoya. - Calif. Avocado Soc. Yearbook 54: 119-122.

SINACORI A., MINEO G., 1996 - Prime osservazioni sull'azione impollinatrice di *Orius laevigatus* (Fieber) 1860 (Hemiptera: Anthocoridae). - Phytophaga 6 (1995): 73-83.

DR. VIRGILIO CALECA, DR. GABRIELLA LO VERDE, PROF. SALVATORE RAGUSA-DI CHIARA, DR. ANGELA SINACORI, DR. HARALABOS TSOLAKIS - Istituto di Entomologia agraria, Università degli Studi, viale delle Scienze 13, I-90128 Palermo (Italy).

Ricevuto il 10 dicembre 1996; pubblicato il 30 dicembre 1996.