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POPULATION DYNAMICS AND SEASONAL OCCURRENCE OF ADULTS OF CHRYSOPERLA EXTERNA (HAGEN, 1861) (NEUROPTERA: CHRYSOPIDAE) IN A CITRUS ORCHARD IN SOUTHERN BRAZIL

SOUZA, B. and C. F. CARVALHO

Depto de Entomologia, Universidade Federal de Lavras
C.P. 37, 37200–000 Lavras MG, Brasil
E-mail: brgsouza@ufla.br; cfc@ufla.br

Studies of the population dynamics of *Chrysoperla externa* (HAGEN, 1861) adults were carried out in in Lavras, Minas Gerais, Brazil, in a citrus orchard, with the influence of precipitation, relative humidity and maximum, minimum and average temperatures on its population density being evaluated. Sampling was made weekly with an entomological net on 20 citrus trees in an area of ca. 2 ha, between 13:00 and 17:00 h, from May 1992 to April 1996. Annual sampling records for adults collected were 853, 629, 575 and 313, respectively, with a decreasing population trend during the period, mainly in the fourth year of study. An increase in the number of adults collected was observed from May to September, with peaks of 687 (80.5%), 344 (54.7%), 328 (57.0%) and 107 (34.2%) in September of 1992, 1993, 1994 and 1995, respectively. A remarkable decrease in the number of insects collected was observed in the months after September, with no insects or only few ones collected from November to March, December to February being the most critical period. There was an increase in the number of adults with the decrease in precipitation, relative humidity and temperature, with minimum and average temperature influencing the most.

Key words: *Chrysoperla*, Chrysopidae, Neuroptera, citrus, weather factors, seasonal occurrence

INTRODUCTION

The Chrysopidae stands out in citrus agro ecosystems for their occurrence in orchards in several countries; however, their presence is conditioned to many biotic and abiotic factors, with weather greatly affecting their seasonal abundance (ADAMS & PENNY 1985).

Most research on Chrysopidae carried out in Brazil is limited to the observations on their occurrence as organisms preying upon arthropod pests in several crops, in addition to some basic studies related to their biology. There is little information on the efficiency of these insects as agents regulating populations of plant-feeding arthropods, as well as their contribution in the maintenance of equilibrium in ecosystems. Thus, their population dynamics and the weather factors, which favor or delay their development and their population increase, have been poorly studied under natural conditions. In this work, *Chrysoperla externa* (HA-

GEN, 1861) adults were investigated in a citrus orchard as to the influence of weather factors upon their population dynamics.

MATERIAL AND METHODS

The work was carried out in a citrus orchard of ca. 2 ha in the Universidade Federal de Lavras (UFLA), Minas Gerais, Brazil. The influence of precipitation, relative humidity and maximum, minimum and average temperatures upon populations of *Ch. externa* was evaluated by periodical collections of adults in orange (*Citrus sinensis* OSBECK) trees of Natal, Valencia and Baía cultivars and on mandarin (*Citrus reticulata* BLANCO) trees.

The adults were collected weekly between 13:00 and 17:00 h, over the period from May 1992 to April 1996. Twigs and foliage of all quadrants of the trees were lightly shaken in a way that all surface of the plant canopy was sampled in order to displace the insects, which were then captured using a 30 cm diameter entomological net.

The influence of weather factors on the population density and seasonal occurrence of *Ch. externa* adults were analyzed by a simple correlation analysis (SOKAL & ROHLF 1995) among weather data of the collecting day and the number of adults captured weekly. In order to investigate the simultaneous influence of the climatic factors studied, a multiple linear regression analysis was accomplished; taking into account the total number of adults captured weekly over the four years' evaluation, in terms of precipitation, relative humidity and average temperature.

RESULTS AND DISCUSSION

Population dynamics

The number of adults of *Ch. externa* collected varied during the year, with a seasonal influence and a difference in the number of insects caught in each year being observed. The annual total number of insects collected in 1992, 1993, 1994, 1995 and 1996 decreased year after year (853, 629, 575 and 313 specimens, respectively), with a great reduction in the fourth year of evaluation (45.6% as compared to the third year) (Table 1). In Praha-Ruzyně, Czech Republic, HONĚK (1977) also recorded variations in the relative abundance and composition of the complex of aphid-feeding insects in evaluations accomplished in four consecutive years.

In the surveys carried out in the first year, adults of *Ch. externa* were present in 46% of the samples, followed by 56%, 62% and 60% in the following years. Their presence was found in 112 samples, out of the 200 accomplished during the four years.

The number of Chrysopidae specimens collected was 1682, 905, 722 and 569 consecutively in the years of study, with 853 (50.7%), 629 (69.5%), 575 (79.6%) and 313 (55%) being *Ch. externa*, hence the most common species present in that orchard.

Table 1. Total number of adults of *Chrysoperla externa* collected over the period from May/1992 to April/1996 on citrus trees. Lavras, MG, Brazil

Months	Total/month				Period 1992/96		
	1992/93	1993/94	1994/95	1995/96	Total/month	Mean/month	Mean/collection
May	3	5	33	14	55	13.8	3.6
Jun	3	25	38	27	93	23.3	5.3
Jul	13	75	10	55	153	38.3	10.0
Aug	125	153	150	68	496	124.0	29.1
Sep	687	344	328	107	1466	366.5	77.4
Oct	19	13	5	24	61	15.3	3.9
Nov	1	0	6	7	14	3.5	0.9
Dec	0	0	1	0	1	0.3	0.1
Jan	0	2	0	0	2	0.5	0.1
Feb	0	0	1	0	1	0.3	0.1
Mar	0	7	1	1	9	2.3	0.5
Apr	2	5	2	10	19	4.8	1.2
Total	853	629	575	313	2370		

In general, there was an increase in the number of adults captured from May on, with the peak in September, with totals of 687 (80.5%), 344 (54.7%), 328 (57.0%) and 107 (34.2%) insects, in the years of 1992, 1993, 1994 and 1995, respectively (the values between parenthesis correspond to the percent over the total number of insects captured in each year). Subsequently, there was a marked reduction in the number of insects with a low occurrence or even their absence in the orchard from November to March, the most critical period being that from December to February. Sampling carried out during the 4-year study period demonstrated that adults were present in all months of the year, although only four specimens were collected during summer months (two in January 1994, one in December 1994, and one in February 1995) (Table 1). Similar results were obtained by LARA *et al.* (1977) who observed, for *Chrysopa* sp.*, a peak in August of 1974, when 192 individuals were collected, corresponding to 59.1% of the total captured throughout the year with a marked reduction in insect number taking place in September, with only 38 individuals (11.7% of the total).

* This species must belong to another genus of Chrysopidae, such as *Chrysopodes* NAVÁS, 1913; *Chrysoperla* STEINMANN, 1964; *Ceraeochrysa* ADAMS, 1982; or *Plesiochrysa* (ADAMS, 1982), since ADAMS and PENNY (1986) and BROOKS and BARNARD (1990) mentioned that the genus *Chrysopa* LEACH, 1815 "*sensu stricto*" doesn't occur in the South-American fauna.

Influence of weather factors

The populations of *Ch. externa* showed great sensibility to weather variations occurring over the period studied, with a significant negative correlation (P≤0.05) being verified between each weather factor and the catches. There was an increase in the number of insects, associated with a decrease in the precipitation, relative humidity and temperature. Within the years evaluated and of the ranges of variation occurring for those weather factors, the driest (low precipitation and relative humidity) and coldest (low temperatures) periods caused the increase of their population density.

Precipitation. This factor negatively affected the population of adults, being a factor of importance in the occurrence of these insects among the years (Fig. 1). The correlation coefficient (r = -0.35) obtained by the analysis between this factor and the number of *Ch. externa*, confirmed that the increase in precipitation caused a significant decrease in the number of adults caught. The results showed the importance of seasonality of precipitation for the populations of *Ch. externa* similar to those obtained by HONĚK and KRAUS (1981), who demonstrated a negative effect of precipitation upon the number of adults of *Chrysoperla carnea* (STEPHENS, 1836) caught in light traps in Praha-Ruzyně, Czech Republic. However, in a study from Itaguaí, RJ, GOUVEA *et al*. (1996*a*) observed that precipitation did not interfere in the population dynamics of *Chrysoperla* sp., with no significant correlation among these factors. In the same way, LARA *et al.* (1977) did not find a significant

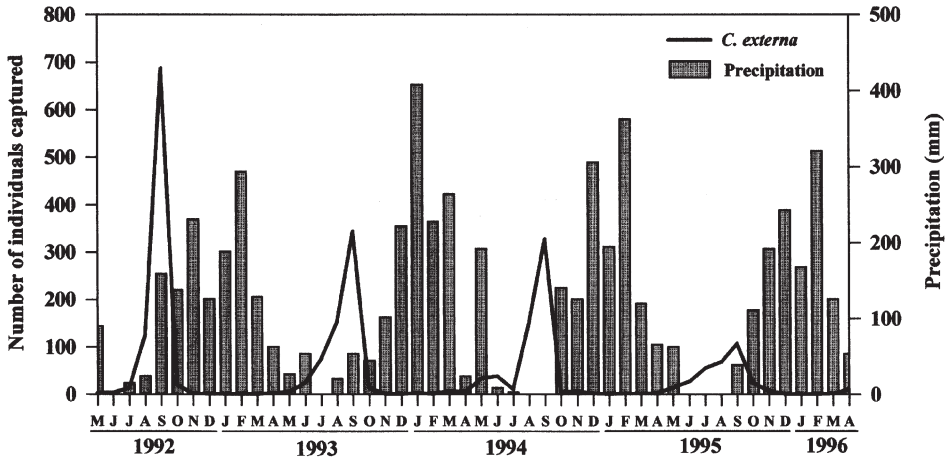

Fig. 1. Population dynamics of *Chrysoperla externa* adults over the period of May/1992 to April/1996 on citrus in relation to precipitation. Lavras – MG, Brazil

correlation between precipitation and population density of adults of *Chrysopa* sp., in Jaboticabal, São Paulo, Brazil.

Relative humidity. There was a negative correlation between the number of insects collected and relative humidity (r = -0.35). The driest conditions significantly increased the population density of *Ch. externa* in the area, enabling the catch of a greater number of specimens (Fig. 2). Likewise, LARA *et al.* (1977) verified a negative correlation between relative air humidity and the populations of *Chrysopa* sp. in citrus orchards in Jaboticabal, São Paulo, showing it to be the weather factor of greatest importance upon the population fluctuation of that chrysopid. TAUBER and TAUBER (1983) also stressed the effects of that factor upon the development, geographic distribution and the relative abundance of *Ch. carnea* and *Chrysopa rufilabris* (BURMEISTER, 1839) (= *Chrysoperla rufilabris*).

Temperature. In general, this was the climatic factor which influenced population dynamics of *Ch. externa* adults the most, the observation being that lower temperatures caused an increase in the number of insects caught.

Temperature may affect the geographic and seasonal distribution of several species of insects (TAUBER & TAUBER 1983). According to CAMMEL and KNIGHT (1992), this factor may have great influence upon the total number of eggs produced as well as affect the oviposition behavior of each individual. Firstly, through its effect on the development of the immature stages of a species by affecting the size and weight of adults and, in females, often there is a close relationship between the size of the body, number of ovarioles and eggs produced. Secondly, it

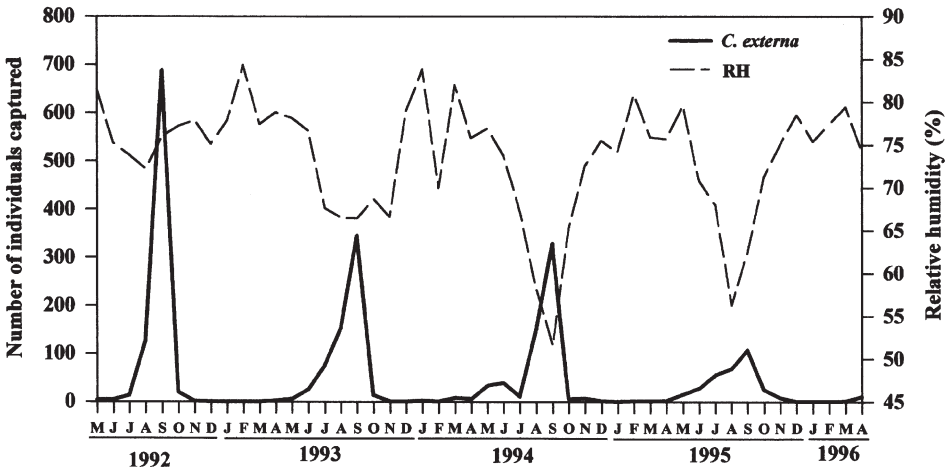

Fig. 2. Population dynamics of *Chrysoperla externa* adults over the period of May/1992 to April/1996 on citrus in relation to relative humidity. Lavras – MG, Brazil

may considerably affect the adults' fecundity during the reproductive phase. This, more than any other physiological function, is adversely affected by temperature threshold.

In contrast to the results obtained in this research on *Ch. externa*, was verified by BUSOLI (1992), a positive correlation between temperature and *Chrysopa* sp. populations in Monte Alto, São Paulo. His results also differ from those found by LARA *et al.* (1977) who found no significant effect of the maximum temperature on the populations of *Chrysopa* sp. present in a citrus orchard in Jaboticabal, SP. In research by PAIVA *et al*. (1994), it was also found that both adults and larvae of chrysopids present in the citrus orchards occurred in a distinctive pattern throughout the year, with the greatest number of adults over the period of summer (41%).

The minimum and average temperatures were the factors which had the greatest influence on the catches of *Ch. externa* adults. A correlation coefficient of –0.61 was found for the minimum temperature and of –0.52 for the average temperature (Fig. 3). The values of the coefficients showed that the fluctuations in the number of *Ch. externa* adults were due especially to the effects of the minimum and average temperatures, with the reduction in these factors producing a significant increase in the number of adults in the area studied.

Similar results were obtained by LARA *et al.* (1977) who determined a significant correlation between the minimum temperature and an increase in the number of adults of *Chrysopa* sp. caught under conditions of lowest minimum temperature

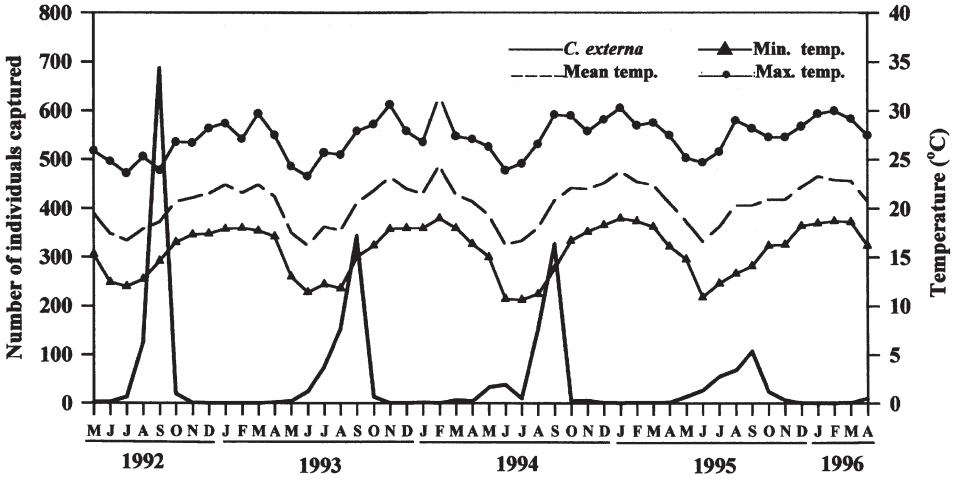

Fig. 3. Population dynamics of *Chrysoperla externa* adults over the period of May/1992 to April/1996 on citrus in relation to temperature. Lavras – MG, Brazil

(mean 13.3°C) which took place in the months from July to September 1974, in Jaboticabal, São Paulo.

The correlation coefficient obtained for precipitation, relative humidity and maximum temperature showed a similarity in the intensity of their effects upon the population densities of adults of *Ch. externa*. Conditions of low precipitation, low relative humidity and moderate maximum temperature, which are typical during winter in the region of Lavras, caused less effect on the population increase which occurred in the coldest and driest periods in contrast to the more dramatic effect caused by the minimum and average temperatures. Likewise, the reduction of their populations in the rainy and hottest seasons, typical of the summertime, was not due, primarily, to increased precipitation and increase of the relative humidity and maximum temperature, but rather to the increase of the minimum and average temperatures.

The greatest effect of temperature, especially of the minimum, on the *Ch. externa* populations, demonstrated their greater sensitivity to these conditions, within the thermal range found during the study period. Such conditions favored the population increase of adults, which occurred in greater number in the winter season. The pattern of population dynamics presented by this chrysopid differed from those found for most of the other groups of arthropods in tropical and temperate regions, which generally show population increases over the rainy and hot season (LEVINGS & WINDSOR 1990). This seasonal behavior of populations of *Ch. externa* adults may have occurred due to their best adaptation to the climatic variations to which normally they are submitted. These variations are characterized by well-defined summer and winter seasons, but not marked by such extreme and rigorous conditions as occurs in the temperate regions.

Adults of *Ch. externa*, when submitted to constant thermal conditions (15, 27 and 30°C) had their population density affected negatively (FIGUEIRA 1998, MAIA 1998). According to CAMMEL and KNIGHT (1992), the data related to insect biology, obtained at constant temperatures, may cause certain errors when extrapolated to a natural environment, where the thermal conditions are oscillatory. Under relatively low average temperatures, the developmental rate will be greater under oscillatory thermal conditions than under constant conditions, the effect of which on insect biology will be greater under larger variations of the diurnal temperature. Thus, the thermal oscillations occurring in field conditions, especially in the period of winter, may be of vital importance for the development of *Ch. externa*. These results may be compared to those obtained by GOUVEIA *et al.* (1996b), which showed the high sensitivity of chrysopids to temperature variations, suffering great changes in their population density when submitted to relatively small thermal variations.

In the northern hemisphere, the months from April to September, corresponding to the spring and summer seasons, are in general the most favorable to the development of insects of the order Neuroptera (JUBB & MASTELLER 1977, NEUENSCHWANDER & MICHELAKIS 1980, HONĚK & KRAUS 1981, CAMPOS 1989, MARÍN & MONSERRAT 1991). A significant increase in the chrysopid population in August and September was documented by ZELENÝ (1984) in the Czech Republic. Likewise, in Rumania, PAULIAN (1996) found a variation in the population of chrysopids captured in light traps in terms of the time of the year, recording a greater occurrence during summertime when over 90% of the total were captured.

In Praha-Ruzyně, Czech Republic, HONĚK and KRAUS (1981) documented significant correlation between adult *Ch. carnea* catches in light traps and temperature, wind velocity, precipitation and cloud amount. Precipitation showed a negative effect on the *Ch. carnea* captured, resembling, therefore, the results obtained for *Ch. externa* here reported. However, opposite to the results here reported, they found that an increase of temperature positively influenced the population density of that species.

The divergence between the results obtained for those chrysopids of the northern hemisphere and *Ch. externa* in relation to the effects of temperature, namely, the finding that higher temperatures have provided an increased number of insects captured in the north, may be due to thermal conditions during the winter which are characterized by extremely low temperatures unfavorable to their development. Increased temperatures during the summertime favored the catch, bringing about a negative correlation between those two factors, adversely to what was shown for *Ch. externa*.

The regression analysis of the total of *Ch. externa* adults captured weekly in the four years evaluated in terms of the weather factors (number of adults = β_0 + + $\beta_1 \times$ precipitation + $\beta_2 \times$ relative humidity + $\beta_3 \times$ temperature + ε) was significant ($P \leq 0.01$). The factor precipitation did not influence the number of adults ($P > 0.05$); but, the fit of the equation obtained was relatively low ($R^2 = 0.106$), indicating that the linear model used was not suitable to explain the joint effect of those factors on the changes in the size of the adult populations of this chrysopid. Thus, other models may be more adequate for furnishing the best fit.

Although, an increase in the number caught has been found in the coldest and driest period of each year, in general, its occurrence was observed though out the study period. Hence, there are times in which the weather conditions allow its survival, but they are unfavorable to its growth, development and reproduction. According to CAMMEL and KNIGHT (1992) insect species may response differently to

those conditions through physiological and behavioral changes capable of keeping them in their own habitat or to cause their spread to more favorable locals.

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