The Role of Predatory Insects in Regulating the Population of Wheat Aphids at Ambo

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Abstract

This study was conducted for three seasons (1993 to 1995) to determine the role of predatory insects in regulating the population of wheat aphid at Ambo. The change in the number of aphids in uncaged, open-sided and closed cage plots was determined and related to changes in the density of predators. In 1993, nonsignificant differences in aphid population development was observed between all the treatments; significant differences were observed in 1994 and 1995. Aphid populations in closed cage plots increased at a higher rate and reached a peak in October (106 and 48 aphids/ shoot in 1994 and 1995, respectively). Nonsignificant differences are detected between open sided caged and uncaged plots in mean number of aphids recorded per plant. The aphid populations in open sided and uncaged plots increased at slower rate and ranged from 5 to 37 aphids/shoot in open sided cages and 5 to 26 aphids/shoots in uncaged plots. In 1994 four to five, while in 1995 eight to twelve fold differences are observed in aphid numbers in closed cages and the other two treatments. Four phases of aphid population development were observed. In both seasons the divergence phase of the aphid population in open-sided cages coincided with an increase in the number of predators and a negative association between predator numbers and aphid abundance was apparent. Aphid predators *Sphaerophoria ruppelli* (Wiedman) (Diptera: Syrphidae:) and *Adonia variegata* (Goeze) spp. *tredecinsignata Muls* and *Cheilomenes lunata* (F) (Coleoptera: Coccinellidae), comprised the dominant species recorded at Ambo and has a significant role in reducing the population of wheat aphids at Ambo condition. In both seasons a substantial number of aphids were also found parasitized by *Aphidius hortensis* (Marshal) and *Aphidius setiger* (Mackauer) (Braconidae).

Introduction

Wheat, *Triticum aestivum* L., is attacked by different aphid species worldwide. The most economically important species include the greenbug, *Schizaphis graminium* (Rondani); the Russian wheat aphid, *Diuraphis noxia* (Mordvilko); the bird cherry-oat aphid, *Rhopalosiphum padi* (L.); the English grain aphid, *Macrosiphium avenae* (F.); and the corn leaf aphid *Rhopalosiphum maidis* (Fetch) (Burton et al 1991). Among these, the greenbug and the Russian wheat aphid are considered to be the major aphid species attacking wheat in Ethiopia (Schmutterer 1971; Adugna Haile and Kemal Ali 1985; Bijlmakers 1990). These two species are generally considered more important pests in highland areas, under moisture stress conditions and on young plants as compared to mature plants (DZARC 1984). Feeding damage by these aphids is sometimes severe and reduce both yield and grain quality (Burton et al 1991). In addition to direct feeding damage, many of the wheat aphids serve as vectors of serious virus diseases, such as Barley yellow dwarf (BYD), which further amplifies the importance of the pests (Burton et al 1991; Muthangya et al 1992).

In Ethiopia, studies so far conducted have focused on the development of various control measures against the various aphid species, particularly, the Russian wheat aphid (*Diuraphis noxia*) on barley and wheat. Some of the studies include: manipulation of planting time and insecticide application (DZARC 1984), host plant resistance and host preference studies (Adugna unpublished report; DZARC 1984). Some aspects on the biology of this pest has also been studied on barley (Adugna 1984). Current methods for controlling these pests in other countries rely heavily on insecticides (Burton et al 1991; Zuniga 1991). Environmental studies have revealed that the use of synthetic organic insecticides in crop pest control programs around the world has resulted in the disturbance of the environment, pest resurgence, pest resistance to insecticides, and lethal effects on non-target organisms. Furthermore, pesticides are inaccessible to small-scale farmers particularly in developing countries (Morallo-Rejesus 1987). These, together with the mounting concern over chemical residue in food stuffs, dictate a reappraisal of insect pest management program in which biological control has an increasingly important role (Hall and Papierok 1982; Charnely 1991). To find permanent and effective solutions, an integrated pest management (IPM) program must be based on a flexible and biologically orientated approach (Zuniga 1991). In this regard it has been suggested that the classical biological control may be the most successful approach against pests of different crops (Huffaker 1985; Zuniga 1991). Using this approach, countries such as Argentina, Brazil and Chile achieved successful results in controlling *Metopolophium dirhodum* (Walker) and *Sitobion avenae* (F.) by using natural predators and parasitoids (Zuniga 1991). The past achievements in biological control of insect pests in Ethiopia has been reviewed by Tsedeke (1985). Very recently an attempt was also made to collect the naturally occurring predators and parasitoids of the various insect pests in Ethiopia (Tsedeke 1991; SPL 1980, 1986). However, the efficiency of these predators and parasitoids to control their respective hosts has not been adequately studied. In view of starting a wheat aphid pest management program that has a biological control component, a preliminary study was launched in 1993 with the objective of evaluating the efficiency of naturally occurring predators and parasitoids in regulating the population of wheat aphids and determining their species composition under Ambo conditions. This paper covers the results achieved in three years' study.

Materials and Methods

The study was conducted at Ambo Plant Protection Research Centre. The centre is located in West Shoa Administrative Zone, 130km west of Addis Ababa at 08°57'N and 038°51'E at an altitude of 2225 m above sea level. The area is characterized by black soil (vertisol). The total average monthly rainfall for the area is 1115mm. The mean minimum and maximum temperature for the area is 11.7°C and 25.4°C respectively,. The area grows almost all agriculturally important crops including cereals (wheat, barley, teff, maize, sorghum); pulses (haricot bean, faba bean, field pea, chick pea); horticultural crops (pepper, tomato, enset, banana, potato, cabbage); oil crops (noug, linseed) and others. The study was conducted for three years from 1993 to 1995. Mechanical exclusion techniques were used to exclude aphid specific predators from a plot of wheat (Luck et al 1988). In 1993, closed and open sided cages (two from each) were randomly placed in wheat field at about 2-3 leaf stage. The cages used were 1.2 x 0.7 x 0.9 m size consisting of rectangular wooden frame covered with wire mesh (1 mm^2). In 1994 and 1995, the cages used were 1.8 x 1.5 x 1.5m size consisting of rectangular metal frame covered with fine close mesh. Three blocks, each separated by 0.5m spacing were planted with wheat (variety Enkoy). A total of three closed, three open-sided and three uncaged plots were used for the study. In all cases, the open-sided cages were made to have circular or rectangular openings in two opposite sides to allow free access of the wheat aphids and their natural enemies. The cages were placed in the field when aphids appeared on the plants. In 1994 and 1995, plant stands were counted and each cage was placed on about 305 plants. Similarly, the number of aphids in each cage was counted and adjusted to be 0.33 aphids per plant using artificial infestation to supplement the natural infestation. In 1993, the population of wheat aphids was counted weekly for one month by taking 50 randomly selected shoots in each cage. In 1994 and 1995, counts were made weekly for four months by taking 15 to 20 randomly selected plants. The variation in sample plants were based on the population size of aphids at each observation time. Type and stage of predators and their population size were also recorded in each cage at weekly intervals. Monthly rainfall and daily maximum and minimum temperature were recorded throughout the experimental period. The change in number of wheat aphids in uncaged, open-sided and closed cage plots was determined and related to changes in the density of predators using *t- test* procedures in Mstatc statistical program (Michigan state University 1985). Correlation analysis were also made to see the effect of some climatic factors on aphid population build-up.

Results

In 1993, both the aphid and predator populations were very low. There was no significant difference among uncaged, open sided and closed caged plots in number of wheat aphids counted per shoot. Predator species from Syrphidae and Coccinellidae were also recorded in a very low density during the season. Parasitized wheat aphids by parasitoids were also observed to be low. The experimental period in 1993 covers only one month (August) which might be one of the reasons for low population buildup of the aphids and their natural enemies (Table 1).

In 1994 and 1995, artificial infestation was made in all plots to supplement the natural infestation and the experiment was conducted throughout the growth period of the crop. In both seasons relatively higher number of aphids and predators were recorded (Figure 1 & 2). In 1994, there was a significant difference ($t_{(0.01)}$ (7) = 3.4696) between closed and open sided cages in mean number of aphids recorded per plant. Aphid populations were also different between closed and uncaged plots ($t_{(0.01)}$ (7) = 3.6604). Similarly, in 1995 there was a significant difference ($t_{(0.05)}$ (8) = 3.2975) between closed and open-sided cages in mean number of aphids per plant. Significant difference ($t_{(0.05)}$ (8) = 3.0743) was also observed in aphid populations between closed and uncaged plots . On the other hand, a nonsignificant difference was observed between open sided cages and uncaged plots in mean number of aphids recorded per plant in both crop seasons. Four phases of aphid population development was observed in this experiment: an initial slow growth phase, rapid growth phase, a divergence phase, and a decline phase (Fig.1). During the growth phase, in 1994, the aphid population in closed cages increased at a higher rates and reached a peak at the end of October, while population in open-sided and uncaged plots increased at a slower rate and the maximum number of 37 and 26 aphids/shoot, respectively were recorded in mid October (Fig.1). In 1995, the aphid population in closed cages also increased at a higher rate and reached a peak around mid October, while population in open-sided and uncaged plots increased at slower rate and the maximum number of five aphids per plant was recorded in mid October in both cages (Fig. 2). The rate of decline of aphid populations in open-sided and uncaged plots were faster than that of the closed cage plots during both seasons (Fig.1&2). In 1994, a nonsignificant negative association between predator number and aphid abundance was observed at the peak time of aphid population. This might be due to the low population of predators recorded throughout the experimental period. In 1995, the association between the populations of aphid and their natural enemies in open-sided cages was positive and significant ($r= 0.823$, $p > 0.01$), indicating density-dependent nature of the predators and parasitoids. The population of predators and mummified aphids was high in mid October when aphid populations started to decline in all cages (Fig 1&2). This is in line with Adugna (1981), who found that the population of these natural enemies is low and builds up late, after the crop had already been damaged by the pests. From Syrphidae, *Sphaerophoria ruppelli* (Wiedman) and from Coccinellidae, *Adonia variegata* (Goeze) Spp. *tredecinsignata* Muls. and *Cheilomenes lunata* (F) were the dominant predator species recorded at Ambo. The parasitoids (Braconidae) that were also recorded throughout the experimental period were *Aphidius hortensis* (Marshal) and *Aphidius setiger* (Mackauer). However, these parasitoids were found in low number in wheat field than sorghum fields showing the prey preference of the parasitoids. A total of 8, 18 and 4 wheat aphids were found parasitized by Aphidis in uncaged, open sided cage and closed caged plots.

In 1994, a negative association was also noted between aphid population build up in closed caged plots and monthly rainfall and minimum temperature while, positive with daily maximum temperature (Table 2). In 1995, except daily maximum temperature, all the other climatic factors showed a negative association with aphid population buildup in closed cage (Table 3). The relation of aphid population and climatic factors for the other two treatments are also indicated (Table 2 and 3). In all cases, however, the association was not significant.

Dicussion

Sphaerophoria ruppelli (Wiedman) (Syrphidae) was found to be predacious in its larval stage while in coccinellidae: *Adonia vaiegata* (Goeze) Spp. *tredecinsignata* Muls and *Cheilomenes lunata* (F) both adults and the larvae were found feeding on the same type of prey. However, which stage is more predacious on aphids is not clear. The negative association between predator numbers and aphid abundance was observed at the time of aphid peak number in this experiment. However, it is suggested that artificially introducing these natural enemies will help to check the population of wheat aphids at lower level. These predators were also found to be effective in suppressing the population of wheat aphids in South Africa (N.J. Van Rensburg, 1995). Laboratory studies have shown that the Coccinellids in the genus *Cheilomenes* as promising for biological control of the cow pea aphid in Nigeria (Ofuya 1986; Ofuya and Akingbohungbe 1988; Ofuya 1990;1995).

The large-scale aphicide application may obviously temporally suppress the wheat aphid populations, but the effect will not be long lasting as there will be dispersal of aphids from other places. Aphicide applications also may have a negative or lethal effect on the available natural enemies. Therefore, the practice of using these predators as a component of biological control methods and developing an IPM system in the country needs more attention as these will reduce wheat production costs and environmental problems. A biological control approach has to be largely empirical until the role of predators is completely understood and to use predators for biological control of aphids either alone or in integrated control programmes. Thus, further studies should be made in order to understand the dynamics of wheat aphids and their efficient predator species along with their stage and per capita consumption rate under different environmental conditions.

Table 1. Average number of wheat aphids and predators recorded in uncaged open-sided and closed cage plots in 1993 (n = 2 cages and 50 shoots per cage).

Dates	Mean No. of aphids/shoot^{NS}			No. of predators recorded/ cage^{NS}			
	Closed Cage	Open cage	Uncaged	Coccinellidae*		Syrphidae**	
				Open cage	Uncaged	Open cage	Uncaged
August 9	0.72	1.12	1.32	4.0	2.0	0.0	0.0
August 16	0.22	0.20	0.26	1.0	0.0	0.0	4.0
August 23	0.40	0.36	0.48	2.0	0.0	1.0	4.0
August 30	0.72	0.22	0.32	0.0	1.0	0.0	0.0

NS= Nonsignificant (p=0.05)
* *Adonia variegata (Goeze) spp. tredecinsignata Muls and Cheilomenes lunata;* ** *Syphaerophoria ruppelli (Wiedman)*

Table 2. The relationship between aphid population buildup in uncaged, open-sided and closed cage plots
and some climatic factors at Ambo (1994).

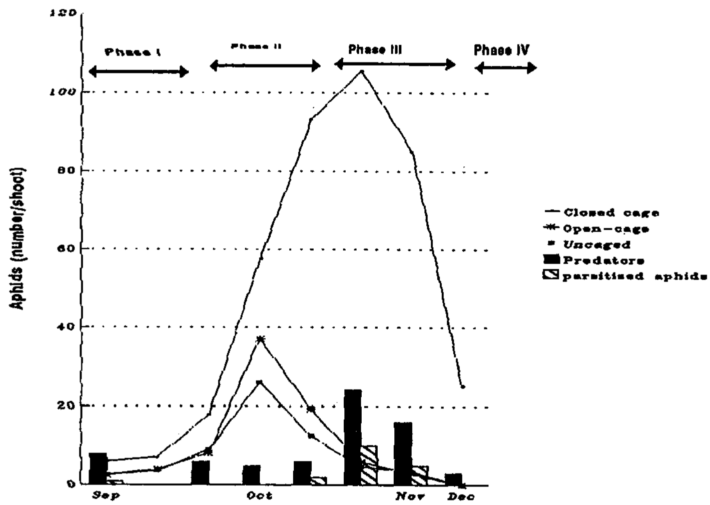
Factors	Correlation coefficient (r)^{NS} Closed cages	Open-sided cages	Uncaged plots
Aphid population Vs:			
Monthly rainfall	-0.43	-0.25	0.23
Daily MaximumTemperature	0.63	-0.10	0.55
Daily Minimum Temperature	-0.51	0.27	0.61

NS = Nonsignificant (p = 0.05)

Table 3. Relation between aphid population build up in uncaged, open-sided and closed cage plots and some climatical factors at Ambo, PPRC (1995)

Factors	Correlation coeffient (r)^{NS} Closed cages	Open sided cages	Uncaged plots
Aphid population vs			
Monthly rainfall	-0.243	-0.050	-0.055
Daily maximum Temperature	0.269	0.054	-0.550
Daily minimum temperature	-0.259	0.088	0.300
Daily relative humidity	-0.154	-0.372	-0.675

NS= Nonsignificant (p=0.05)



I) slow growth pehse, II) rapid growth phase, III) divergence phase and IV) a decline phase.

Fig. 1. Number of aphids on wheat in various cages, numbers of predators and parasitized aphids/open cages (1994).

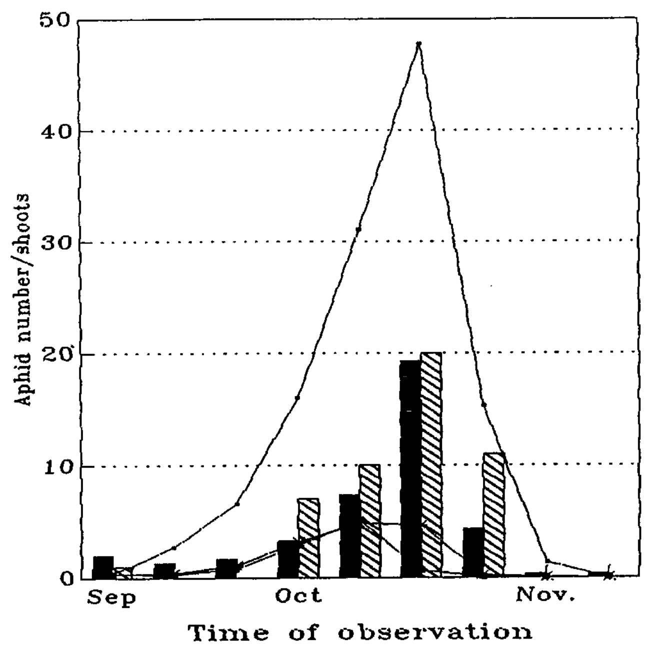


Fig. 2. Dynamics of wheat aphids and their natural enemies under Ambo condition (1995)

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