THE UNIVERSITY OF MANITOBA

# FACTORS AFFECTING THE NUMBERS OF APHIDS ON GRAIN CROPS IN MANITOBA WITH OBSERVATIONS ON APHID PREDATORS AND PARASITES

by

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# ABSTRACT

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Various biotic and abiotic factors prevented aphids on grain crops from reaching their potential on fields under observation in Manitoba in 1968 and 1969. These included wind, rain, predators, parasites and fungus disease. In some cases wind or rain or a combination of wind and rain with other factors caused population decline before plants ripened.

Laboratory studies on the effectiveness of the common lady beetle species found preying on aphids on grain crops in Manitoba revealed that *Hippodamia tredecimpunctata tibialis* and *H. convergens* were effective aphid predators. They had a high voracity and fecundity and they developed on all the five main aphid species studied. In field collections, the former made up 52% in 1968 and 62.4% in 1969 of all lady beetle species found, and the latter constituted 43.8% and 14.6%.

Surveys of aphid predators and parasites in the field

revealed that Coccinellids were the most abundant aphid predators followed by Syrphids and Chrysopids. The most commonly found primary parasites of aphids on grain crops were *Aphelinus mali*, *Aphidius avenaphis* and *Lysiphlebus testaceipes*. The effectiveness of primary parasites was reduced by the hyperparasites *Asaphes fletcheri*, *Pachyneuron siphonophorae*, *Charips* sp., *Lygocerus* sp., and *Alloxysta* sp.

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## CHAPTER I

## INTRODUCTION

"Aphids or plant lice are among the smallest most defenseless, and most preyed upon of all insects; yet because of their immense vitality and extraordinary fecundity, due to shortness of their life cycle and ability to reproduce parthenogenetically they cover the earth with an enormous assemblage of species and tons of individuals affecting nearly every kind of green plant." (Metcalf *et al*, 1962).

Aphids feed on the sap of plants attacking either leaves, twigs, fruits, or roots causing damage to plants as well as transmitting diseases from one plant to another. They would be a great deal more destructive to vegetation were it not for their numerous parasites, predators and pathogens. Detrimental effects of chemical applications to control insect pests have made it necessary to develop the integrated control concept to combat insect pests.

Integrated control is a program of pest regulation which makes the most efficient use of weather, natural predators, parasites, or pathogens and integrates them with artificial control methods if economic injury levels are threatened.

## The Problem

The purpose of the study was threefold: (1) to determine to what extent abiotic factors prevented aphid populations from causing injury to wheat, oats and barley at Winnipeg, Manitoba, in 1968 and 1969; (2) to investigate which predators are most effective in controlling the important aphid species on grain crops, ornamentals and weeds in Manitoba; (3) to determine which species of parasites are found parasitizing aphid populations on grain crops, ornamentals and weeds in Manitoba.

## Importance of the Study

Although knowledge of the continuity of the population dynamics of aphids and their complex of parasites, predators, and pathogens from area to area and year to year would be ideal, Smith (1966a) stated that, "knowledge of the short term population dynamics of one population cycle restricted to a single portion of an agricultural field is critical to the development of integrated control procedures to combat insect pests."

Proper utilization of the integrated control concept requires some conceptual models which can predict when aphid populations will reach economic thresholds. Conceptual models require a knowledge of the type of numerical changes occurring and the factors which determine these changes in numbers (Clarke et al, 1967).

It is important to have a knowledge of all the potential parasites and predators of aphids on grain crops, as well as their sources of alternate prey and host aphids, on other plants (Imperti, 1966d). A study of aphid parasites and predators in Winnipeg on grain crops, ornamentals, and weeds was attempted in 1968 and 1969.

Since the main predators of aphids on grain crops were a few species of coccinellids, a laboratory study was conducted to determine the relative effectiveness of the coccinellids in the laboratory, and how abundance of predators was related to numbers of aphids, and type of grain crop.

## Organization of Thesis

The literature is reviewed in Chapter II. It covers: aphid population dynamics; relationships between aphids and their parasites in the field; relationships between aphids and their predators in the field, and aphid pathogens.

Chapter III explains the materials and methods used. Chapter IV includes the data and discussion on the population trends exhibited by aphids of economic importance on wheat, oats and barley in Manitoba. Chapter V includes data and discussion on the laboratory studies to determine the effectiveness (voracity, fecundity, and development rate) of the most important predators of grain aphids in Manitoba.

The results of studies on the important aphid-parasite and aphid-predator relationships on agricultural crops, ornamentals, and weeds in Manitoba are given in Chapter VI. Chapter VII contains the summary and conclusions.

CHAPTER II

# REVIEW OF LITERATURE

Robinson and Hsu (1963) reported 11 species of aphids in Manitoba on grain crops: Schizaphis graminum (Rondani) (greenbug); Macrosiphum avenae (Fabricius) (English grain aphid); Rhopalosiphum padi (Linnaeus) (bird cherry oat aphid); Rhopalosiphum maidis (Fitch) (corn leaf aphid); Metopolophium dirhodum (Walker) (rose grass aphid); Rhopalosiphum fitchii (Sanderson) (apple grain aphid); Sipha kurdjumovi (Mordvilko) (quackgrass aphid); Hyalopterus pruni (Geoffroy) (mealy plum aphid); Hysteroneura setariae (Thomas)(rusty plum aphid); Brachycolus tritici Gillette (western wheat aphid); and Forda olivacea Rohwer (a root aphid on Graminae).

Oswald and Houston (1951) mentioned the first five of the above species as being associated with transmission of virus to grain crops in the United States. These five species were the important aphids found on wheat, oats, and barley at Winnipeg, Manitoba, in 1968 and 1969.

Medler (1962) stated that S. graminum, M. avenae, and R. maidis overwinter in the southern United States (Oklahoma, Kansas, Texas, Missouri) and migrate northward in the spring. Populations build up in the northern United States (and, it is assumed, Manitoba) from the migrants which settle and reproduce. Species such as R. padi migrate from overwintering areas in the south, and also overwinter locally (Medler, 1962). M. dirhodum overwinters locally on Rosa species, and it has not been reported as migrating from the south.

Johnson (1969) stated that: "Little is published about duration of single flights, the duration of the flying period of individual greenbugs, and the quantitative aspects of discharge at sources, and delivery at terminus. Nor are the conditions known that lead to prolonged flight as distinct from a succession of short flights involving a succession of generations which extend further and further northwards as the season advances". Taylor (1965) described the possible mechanics involved in aphid migrations in the central United States. He thought that S. graminum could endure prolonged flight if it fell from cold upper air into warm lower air such as a low level jet stream.

Hosts of the English grain aphid, M. avenae, included the exposed leaves and heads of oats, wheat and barley, and various grasses (Bruehl, 1961; Forbes, 1962; Adams and Drew, 1964a, 1964b; Wood, 1965; Apablaza, 1967). Apablaza (1967) found that the English grain aphid was the most destructive aphid on older plants, in the laboratory. Robinson and Hsu (1963) stated that some insecticides were applied in Manitoba in 1962 to prevent the English grain aphid from damaging wheat. The greenbug, S. graminum, was reported on 62 species of Graminae by Patch (1938). Peairs (1941), Bruehl (1961), Metcalf *et al* (1962) and Little (1963) reported that it was the most destructive aphid attacking grains in the United States. Apablaza (1967) found it to be the most harmful to young seedlings in the laboratory. He also found it reproduced equally well on wheat, oats and barley. Robinson and Hsu (1963) stated that chemical application to reduce high greenbug populations was required in Manitoba in 1962.

Normal amounts of rain fell in July and August, but the monthly meteorological summary for Winnipeg, June, 1962, shows that precipitation occurred on only six days and was 1.08 inches below the normal of 3.19 inches. No large amounts of precipitation occurred on any particular day. June 1962 also had the lowest mean monthly windspeed on record to that date, with no gale force winds. Aphid colonies probably developed rapidly in the early summer and persisted throughout the season.

The corn leaf aphid, *R. maidis*, prefers to feed on the whorls of barley (Bruehl, 1961; Adams and Drew, 1964b; Wells and MacDonald, 1961; Robinson and Hsu, 1963) while wheat and oats are less attractive (Wildermuth and Walter, 1932; Adams and Drew, 1964b; Apablaza, 1967). Apablaza (1967) found that the corn leaf aphid was the least harmful of the three species which he tested in the laboratory. Robinson and Hsu (1963) stated that many thousands of acres of barley were destroyed in western Canada in 1955 by the corn leaf aphid. *R. padi* is found on barley (Adams and Drew, 1964b; Green, 1966; Harper and Blakely, 1968), wheat (Adams and Drew, 1964b; Wood, 1965; Kieckhefer and Gustin, 1967) and oats (Forbes, 1962; Adams and Drew, 1964a).

The rose grass aphid, *M. dirhodum*, is found on orchard grass, oats and various grasses (Forbes, 1962; Green, 1966; Robinson and Bradley, 1968). It does not occur in the heads but prefers the exposed blades (Forbes, 1962; Green, 1966). The following chart shows the status of five species of aphids on three cereal crops in Manitoba, based on observations by Professor A. G. Robinson of the University of Manitoba, over the past 20 years.

STATUS OF FIVE SPECIES OF APHIDS
ON THREE CEREAL CROPS IN MANITOBA

| | Wheat | Oats | Barley |
|---|---|---|---|
| Greenbug | xxx(1950)<br>xx | xx | xx |
| English grain aphid | xx | xx | xx |
| Corn leaf aphid | x | x | xxx<br>xx(1955) |
| Rose grass aphid | x | x | xx |
| Birdcherry oat aphid | xx | xx | xx |

x Occasional or unsatisfactory development of aphid on plant
xx Normal development of aphid on plant
xxx Economic injury level and year in which it occurred.

Aphid Population Dynamics

Population dynamics is the study of the interrelated processes that govern change of numbers or age distribution of a species over a period of time. Clarke et al (1967) stated that the understanding of the population dynamics of a species required "knowledge of the kinds of numerical changes that occur in a population, analysis of the factors causing these changes, and the construction of a conceptual model that interrelates changes of abundance with their causes." Construction of conceptual models has been hampered by complexities of population sampling (Hafez, 1961; Van Emden et al, 1969), unknown numerical relationships between populations occurring on a sequence of host plants (Van Emden et al, 1969), polymorphism (Van Emden et al, 1969), long distance migrations (Hafez, 1961; Van Emden et al, 1969), overlapping generations (Hafez, 1961), confusion between aphids sucked dry by predators and exuviae of immature stages (Van Emden, 1969).

Population changes involve interspecific factors, as well as intraspecific factors due to the aphids themselves. Interspecific factors include fungus (Shands and Simpson, 1959; Hafez, 1961; Hughes, 1963; De Fluiter, 1966; and Van Emden et al, 1969), predators (Pimentel, 1961; Hafez, 1961; Forbes, 1962; De Fluiter, 1966; Hughes, 1963; Sluss, 1967; Way, 1967; and many other authors), parasites (Shands and Simpson, 1959; Hafez, 1961; Pimentel, 1961; Hughes, 1963;

De Fluiter, 1966; Van Emden *et al*, 1969 and many other authors), temperature affecting reproduction, development and survival (Hafez, 1961; Sun, 1965; Hagen and Sluss, 1966; Sluss, 1967; Harper and Blakely, 1968), temperature affecting flight (Freeman, 1945; Taylor, 1965), precipitation destroying aphids mechanically (Way and Banks, 1967), precipitation associated with fungus epizootic (Hafez, 1961), precipitation preventing flight (Hafez, 1961; Taylor, 1965), wind preventing aphid flight (Taylor, 1965), leaf conditioning (Sluss and Hagen, 1966; Sluss, 1967), ripening and maturing of host plants (Ito, 1960; Forbes, 1962; Green, 1966), and chemical and cultural control (De Fluiter, 1966). Intraspecific factors causing population changes include decrease in reproduction rate due to low plant metabolism (Mittler, 1958; Hughes, 1963; Way and Banks, 1967), emigration following maturation of fall migrants (Shands and Simpson, 1959), emigration due to drying of plants (Ito, 1960; Forbes, 1962; Hughes, 1963; Wyatt, 1965; Way and Banks, 1967; Van Emden *et al*, 1969), crawling away of third and fourth instar nymphs, and flying away of alate aphids (Apablaza, 1967; Way and Banks, 1967), redistribution on all plants in the field followed by emigration of alates from the field (Ito, 1960; Wyatt, 1965), and decreased survival when population reaches a certain density (Way, 1967; Way and Banks, 1968). This could be due to the above factors alone or by modification of their action by weather, host plant, and aphid populations.

Upon first arrival of aphids into the field and until the end of infestation the host plant influences all phases of the population dynamics (Kennedy and Stroyan, 1959; Auclair, 1963; Apablaza, 1967; Van Emden *et al*, 1969). De Fluiter (1966) stated that populations of aphids depend on host plant nutrition, attraction and suitability. It has been found by many authors that the period of increase of aphids occurs during tillering of cereal plants and reaches a peak at or before boot stage. After this, populations begin to decline as the plant matures (Forbes, 1962; Adams and Drew, 1964a, Green, 1966). Drying of plants finally forces all aphids to leave the plant.

Smith (1966) divided short term population dynamics into initiation, increase, crash and survival during unfavourable periods. Van Emden *et al* (1969) divided the population ecology of *Myzus persicae* (Sulzer) into initial aphid attack, development of infestation and decline of infestation.

Smith (1966) defined initiation as "the period of establishment of the aphid population in the area together with its predators, parasites, pathogens, and competitors. In unstable environments this may require a new colonization of an area by part of the complex. In permanent situations the population is the result of differential attrition during the previous unfavourable period."

Adams and Drew (1964a) in New Brunswick showed that initial numbers of M. avenae and R. maidis from 1959 and 1963 were not found until the middle of June when the oat crops were six inches high. Forbes (1962) found that populations of M. avenae and M. dirhodum first appeared on oats in British Columbia in the mid to late tillering stage. Green (1966) concluded that M. avenae and M. dirhodum population buildup on barley in Oregon were influenced by planting date. Smith (1966) stated that synchronization, sources of aphids and distance travelled by immigrants, and weather are the main factors to be considered in development of initial populations. Shands and Simpson (1959) found that numbers of aphids on potatoes at this point vary considerably because of weather. They found initial populations were influenced by time of spring migration, emergence of plants and size of initial infestation. Movement occurs from plant to plant in the field until all plants in the field support one or more aphids, after which populations build up on individual plants (Shands and Simpson, 1959; Ito, 1960; Wyatt, 1965). Hughes (1963) found initial populations had high reproductive rates, suffered no starvation, and showed little emigration, parasitism, or fungus disease.

Smith (1966) defined increase as "the period when conditions are most favourable to the aphids and without the intervention of outside factors the aphid numbers would increase almost geometrically." In the laboratory it was shown by Apablaza (1967) that one aphid could destroy a plant in 20 to 60 days, depending on aphid species, cereal species, and stage of growth of the plant when the aphid was placed on it. Development of peak populations is usually related to host plant condition and type, soluble nitrogen and carbohydrate content, osmotic pressure of sap, and pH levels (Van Emden *et al*, 1969). Assessment of the actual part the host plant plays in aphid population dynamics is limited by the complex interaction of plant physiological factors (Van Emden *et al*, 1969). The important factors to be considered during the period of increase are the balance between voracity of aphidophagous species and reproduction rate of the aphids (Imperti, 1966a; Van Emden, 1966), weather (Hodek, 1966b), type of plant and its maturation (Bombosch, 1966; Van Emden *et al*, 1969), original pattern of infestation (Way, 1966), leaf conditioning (Sluss and Hagen, 1966; Way, 1966), rate and pattern of growth of host plant (Way, 1966), and selectivity and maximum consumption of aphids by predators (Yakhontov, 1966). Adams and Drew (1964a) found that peak numbers of *M. avenae* on oats were 674, 7, and 39 per 100 plants in 1959, 1962, and 1963 respectively, before panicles emerged from the sheaths. Wells and McDonald (1961) found some damage due to peak numbers of *R. maidis* on early stages of barley. Green (1966) found a peak population of *M. avenae* in mid July in Oregon. Large populations of *M. dirhodum* occurred in later stages of barley development and fluctuated between peak levels for a month. Shands and Simpson (1959) observed "explosive" population buildup on individual plants after all plants in the field were infested with at least one aphid each.

Smith (1966) defined crash or decline of aphid infestation as "the checking of the rapid rise of aphid population so that numbers are depressed to low levels or exterminated locally." The combination of these factors varies from place to place, and year to year (Shands and Simpson, 1959; Sluss and Hagen, 1966). Adams and Drew (1964a) found that M. avenae and R. maidis left the plant by emigration, as soon as the oat panicles emerged from the sheaths. They did not reproduce before emigrating. Forbes (1962) found increasing numbers of emigrating alates of M. avenae and M. dirhodum as the oats ripened. All aphids left when the plants matured. Factors associated with population decline were coccinellid, syrphid, and chrysopid predators, and parasites. A peak population of $47 \times 10^6$ aphids per acre was calculated during one season, but it did not reach an economic injury level. This was due to aphid densities not being maintained for a long period because of predators, parasites, and drying of host plant soon after peak. Two weeks after the peak population occurred the oats dried, and aphids were forced to leave the plants.

## Aphid Parasite Relationships

The ichneumonoid families Aphidiidae and Aphelinidae contain the most important aphid parasites. Hagen and Van Den Bosch (1968) divided hymenopterous parasites into two groups, primary parasites and hyperparasites. Hagen and Van Den Bosch (1968) divided the hyperparasites into 3 superfamilies; Chalcidoidea, Proctotrupoidea, and Cynipoidea. Parasites also occur on the main aphid predators, and one family of aphid parasites, Cecidomyiidae belongs in the order Diptera.

If the first or second instar of an aphid is parasitized it dies before maturing. If later instars are parasitized some nymphs are produced before the death of the adult, but fecundity is reduced.

Detection of the aphid host may occur by antennal contact (Wheeler, 1923; Spencer, 1926; Vevai, 1942; Way *et al*, 1954; Schlinger and Hall, 1959; Sekhar, 1960) or odour from aphids or their honeydew (Schlinger and Hall, 1961). All aphid stages are attacked, but intermediate stages are preferred (Hagen and Van Den Bosch, 1968). Griffiths (1960) stated that the oviposition behaviour depends on the parasites' age, nutrition, temperature, light, humidity, presence of suitable odour, and hosts of the right shape and activity. Webster (1909) described the act of oviposition, and stated that the preferred oviposition site is the area between the aphids' cornicles.

Schlinger and Hall (1960) found three larval stages for the parasite *Praon palitans* Muesebeck. The aphid appears normal up to the third day after oviposition by the adult parasite. On the fourth day the larva becomes active and begins to consume the entire contents of the aphid. The aphid becomes inactive and grips the leaf. Before the aphid dies the parasite larva chews a slit in the ventral surface of the aphid, spins a cocoon, and pupates. The silk from the cocoon adheres to the plant substrate through the slit and fastens the aphid to its host plant. The parasitized aphid is now called a "mummy" (Spencer, 1926). After pupation the adult parasite chews its way out of the aphid with its mandibles if the humidity is favourable (Schlinger and Hall, 1960). Adults feed on honeydew (Hagen and Van Den Bosch, 1968).

Spencer (1926), Schlinger (1960), and Stary (1962, 1966) thought that parasites of dioecious (two host plants) aphids diapause primarily on the primary host plants so that synchronization of aphid, plant host, and parasite is more efficient.

Hille Ris Lambers (1950) stated that the evolution of aphids and their host plants is so closely associated that plant hosts of aphids could be utilized in aphid classification. Similarly aphids and their parasites are so closely associated that Mackauer (1965) stated that "parallel evolution" has occurred between aphids and their parasites. Stary (1964) believes that habitat is the most important feature in the host specificity of aphidiid and aphelinid parasites. He listed many of the habitat associations of many aphids and their aphidiid parasites (Stary, 1964, 1966). Sekhar (1960) discovered that host plant and aphid species may influence aphid acceptance by the parasite. Doutt (1959) described the chain of events which determined host specificity. These were finding host habitat, finding the aphid host in its habitat, accepting host, and host suitability. Salt (1938) defined a suitable host as one in which the parasitoid can produce fertile offspring. Flanders (1953) suggested that conditions inside the aphid's body determine which aphid is a suitable host for the parasite, resulting in adequate or inadequate parasitism. He defined an inadequate aphid host-parasite relationship as "occasional, physiologically incomplete or ecologically incomplete." Salt (1938) listed the known causes of host unsuitability. Griffiths (1960) found that encapsulation of aphidiid eggs occurred in some aphid species. Schlinger and Hall (1960) and Sekhar (1960) observed many cases of parasites failing to emerge from parasitized aphids.

Various aphid parasites have been found associated with aphids on grain crops: *Lysiphlebus testaciepes* parasitizing *S. graminum* in Kansas (Hunter, 1909), *Aphelinus asychis* parasitizing *S. graminum* in Canada (Richardson and Westdal, 1965). Hagen and Van Den Bosch (1968) stated that *Aphelinus* sp. parasitized aphids in low vegetation which belong to the genera *Acyrthosiphon*, *Aphis*, *Lipaphis*, *Macrosiphum*, *Myzus*, *Rhopalosiphum*, *Schizaphis* and others. Forbes (1962) observed the primary parasites *Aphidius pisivorus* Smith, *Aphidius avenaphis* (Fitch) and the hyperparasites *Pachyneuron siphonophorae* (Ashmead) and *Asaphes californicus* Girault on the grain aphids *R. padi*, *M. dirhodum*, and *M. avenae*.

## Aphid Predator Relationships

The aphid predators include species of the insect families Coccinellidae, Syrphidae, Chrysopidae, Cecidomyiidae, Melyridae, Chamaemyiidae, Reduviidae, Lygaeidae, Miridae, Microphysidae as well as arachnids, birds, and small vertebrates.

Coccinellids are considered to be the most important predators on aphids (Hafez, 1961; Pimentel, 1961; Forbes, 1962; Hodek, 1967; Sluss, 1967; and Way, 1967). Hodek (1967) summarized the advantages coccinellids have as aphid predators. "They have a high searching rate, occupy all habitats, they survive well, both adults and the four larval stages consume aphids, they can easily be cultured, and in general have no host preference." Smith (1966) stated that rate of development and adult weight of coccinellids vary according to food abundance. The rate of development and generation time is below that of their prey, however (Smith, 1966; Van Emden, 1966).

Predator exclusion studies showed that aphids sheltered from predators increased many times more than populations not protected by cages (Atwal and Sethi, 1963; Bombosh and Tokamokoglu, 1966; Sailer, 1966 and Skuhravy and Novak, 1966). Simpson and Burkhardt (1960) evaluated predator effectiveness in the field by multiplying average daily consumption determined in the laboratory times the population of predators estimated in the fields.

The key factor in control of aphids by coccinellids, according to Hodek (1967), is the relationship between the number of aphids necessary to attract and keep the predator on the crop and the number of aphids which constitute the economic threshold and economic injury levels. Skuhravy and Novak (1966) found that Coccinella septempunctata could control aphids provided the ratio of predators to aphids was one to 90-200.

Van Emden (1966) stated that the important factors to take into account in determining predator effectiveness are voracity, synchronization of predator and aphid populations, and multiplication rate of the aphid. The number of aphids eaten (voracity) depends on predator appetite, activity, and searching behaviour.

The various factors which affect the ability of coccinellid predators to check infestations are: the particular aphid species (Way, 1967; Imperti, 1966a), high survival of prey the previous year (Skuhravy and Novak, 1966; Hodek, 1967), adjacent habitat (Banks, 1955; Galecka, 1966; Van Emden, 1966; Hodek, 1967), synchronization of prey populations with most effective stage of predator (Behrendt, 1966; Van Emden, 1966), alternative sources of food (Banks, 1955; Hodek, 1967), cannibalism due to lack of food (Banks, 1955), numbers of aphids (Banks, 1955; Van Emden, 1966; Hagen, 1966), shelter for predator (Banks, 1955; Imperti, 1966e), chemical applications (Meier, 1966; De Fluiter, 1966; Savoiskaya, 1966), topographical conditions of the site (Galecka, 1966), host plant (Banks, 1957; Dixon, 1959; De Fluiter, 1966), diapause (Hagen, 1962; Smith and Hagen, 1966; Hodek, 1966b; Hodek, 1967; McMullen, 1967; Hagen and Van Den Bosch, 1968), parasites and predators of coccinellids (De Fluiter, 1966; Hodek, 1967), weather (Hodek, 1966b; Hodek _et al_, 1966; De Fluiter, 1966; Imperti, 1966a; Bombosch and Tokamokoglu, 1966), cultural measures (De Fluiter, 1966), and predator voracity (Imperti, 1966a; Van Emden, 1966).

Coccinellids accept a wide range of foods (Hagen, 1962; Hodek, 1967). Specificity for particular aphid prey has been observed by Putman (1957), George (1957), Dixon (1958), Hodek (1966a), Blackman (1965, 1966), Hariri (1966), Imperti (1966c) and Hukusima and Watanabe (1966).

According to Hodek (1967) the best criterion for determining whether an aphid species is a suitable food is experimental proof that a predator will develop on a particular prey. However, he stated that in the field the predator usually lives in the habitat of several aphid species any one of which may serve as prey. Development of larvae and ripening of ovaries is possible only on "essential" prey. Such variations are revealed by studies on developmental rate, mortality and fecundity of the predator (Blackman, 1965, 1966, 1967; Hariri, 1966; Hukusima and Watanabe, 1966). Blackman (1967), Hodek (1967), and Van Emden (1966) found that coccinellids frequently accept alternative sources of food which serve as a source of energy, but do not allow for development. Some aphid species have proved to be toxic to particular coccinellids. Hodek (1966) thought that mortality of Coccinella septempunctata when fed Aphis sambuci was due to the glycosid sambunigrin which is present in the plant host which is transferred to the aphid body and split into cyanic acid and other compounds by enzymes. Dixon (1958) also stated that coccinellid mortality is due to toxic properties derived from the host plant that the aphid feeds upon. Okamoto (1966), and Hagen (1962) stated that some aphids are nutritionally deficient for the predator. Blackman (1965, 1967) stated that unsuitability of Aphis fabae for Adalia bipunctata may be due to difficulty in ingesting food, as some essential nutrient may be present in the part undigested. Hagen (1962) stated that each species "can be sensitive to a different set of "ecological triggers" permitting reproduction."

Total consumption of aphids by coccinellids is greater for ovipositing females than for males (Hodek, 1967). Neilson and Currie (1960) found that field collected lady beetles required less food than lady beetles reared on aphids in the laboratory. Hagen and Sluss (1966) found that first and second generations were more voracious than third and overwintering generations. Smith (1965a) discovered that food intake for the larva was greatest at the middle of the instar. Neilson and Currie (1960) found that daily consumption of spotted alfalfa aphids by the convergent lady beetle per instar was, "in direct arithmetical proportion to larval instar." Yakhontov (1966) stated that size and species of the aphid determine the quantity of food devoured by different lady beetle species. Total food consumption is influenced by alternating temperatures (Gawande, 1966). Duration of light, and relative humidity, except for extreme highs or lows, do not influence development rate or cause mortality in coccinellids (Hodek, 1958; Hagen, 1962).

Various authors have studied the five main lady beetle species occurring on grain crops in Manitoba. The life histories of both Hippodamia parenthesis and Coccinella transversoguttata were described by Palmer (1914). Adalia bipunctata occurs mainly in orchards and parks, and not in fields (Smith, 1958; Putman, 1964; Niemczyk, 1966; Imperti, 1966c; Hodek, 1967). Numbers of eggs produced by this species were recorded by Palmer (1914), Fluke (1929), and

Hariri (1966). *Hippodamia tredecimpunctata* prefers the upper regions of plants such as the ear or tassel of corn or whorl of barley (Ewert and Chiang, 1966). They found that it prefers corn leaf aphids over pollen, and occurs in meadows and agricultural crops. Its life history was described by Palmer (1914), Cutright (1924), and Neilson and Currie (1960). Ewert and Chiang (1966) found *Hippodamia convergens* on upper parts of plants such as the ear or tassel of corn, and whorls of barley. They found that it had no preference when offered a diet of pollen or corn leaf aphids.

Syrphid larvae are generally considered the second most effective among families of aphid predators, but according to Hamrum (1966) the life cycles and prey consumption are known for the common species only. Banks (1962) found that they are able to reach aphids hiding in whorls of leaves and in crevices between leaves. Schneider (1969) stated that the larvae are not host specific in general, but feed on a wide variety of aphids. The adults produce a large number of eggs, and can fly to a wide variety of favourable sites in search of high aphid populations (Sunby, 1966).

The key factor in determining the effectiveness of syrphids is the relationship between the numbers of aphids representing economic threshold and economic injury levels, and the number of aphids required to induce oviposition (Hagen and Van Den Bosch, 1968). Other factors which determine the degree of control on aphids achieved by syrphids are: abundance of syrphids in the last larval instar (which is the most effective stage); relation between consumption of prey and rate of prey multiplication; and number of contacts between prey and predator (Schneider, 1969); weather (Banks, 1959; Barlow, 1961; Schneider, 1969); physiological factors related to oviposition (Schneider, 1969), diapause (Dusek and Laska, 1966; Schneider, 1969), syrphid parasites and predators (Schneider, 1969), presence of nectar and honeydew as food for adults (Banks, 1959), chemical control (Barlow, 1961; Schneider, 1969), and host plants (Banks, 1959; Dusek and Laska, 1966; Chandler, 1966, 1968; Schneider, 1969).

The selection of habitat, host plant, aphid colony, and oviposition site must be considered in that order when determining how syrphids are orientated to oviposit on a particular site (Chandler, 1966). He presented some of the possible components of the stimulus pattern for syrphid oviposition. Optical responses are involved in habitat selection and form recognition of aphids (Chandler, 1966). Banks (1959) recorded maximum syrphid catches in habitats with varied vegetation. Banks (1962) and Dusek and Laska (1966) found that adult flies searched for hiding places such as curled up leaves. They found that the most important factors were the habitat and vertical position of the colony. More eggs are laid in large aphid colonies than in small ones, and negative phototaxis was the main factor orientating gravid female syrphids to oviposition sites (Chandler, 1968; Hagen and Van Den Bosch, 1968). In addition to detecting olfactory stimuli the ovipositor is used as a tactile organ on the ovipositional substrate (Bombosch and Volk, 1966). Eggs are usually deposited close to aphids (George, 1957). Tamaki *et al* (1967) found maximum oviposition occurred at a density of 30-40 green peach aphids per leaf at which time eggs were found on 50% of the leaves.

Hamrum (1966) found *Metasyrphus wiedermanni*, *Allograpta obliqua*, *Syrphus rectus*, *Sphaerophoria robusta*, and *Sphaerophoria cylindrica* common in Minnesota. *Sphaerophoria* species prefer aphids on herbs (Schneider, 1969) over those on trees and shrubs.

The families Chrysopidae and Hemerobiidae are common aphid predators (Burke and Martin, 1956; Toschi, 1965). The larvae and some adults which feed on aphids are very polyphagous (Hagen, 1950; Toschi, 1965). Fecundity in the species has been correlated to the amount of honeydew ingested (Hagen and Van Den Bosch, 1968). High populations are required to attract *Chrysopa carnea* and stimulate egg production, according to Hagen (1950). Dickson and Laird (1962) correlated abundance of *Chrysopa* spp. with height of sugar beet plants.

*Anthocoris melanocerus* (Hemiptera: Anthocoridae) was able to suppress populations of *Myzus persicae* on sugar beets (Tamaki and Weeks, 1968). Both larvae and adults feed on aphids, according to Anderson (1962). He found that they occupy a wide range of herbaceous plants, trees, and shrubs, and that fecundity depends on the type and number of prey. Several species of the family Cecidomyiidae prey on aphids. The majority belong to the genus Phaenobremia (Barnes, 1929).

Many other predators of aphids, of less importance, have been described by various authors. They include species in the insect families: Nabidae, Pentatomidae, Reduviidae, Lygaeidae, Miridae, Microphysidae (Hagen and Van Den Bosch, 1968), Melyridae (Neilson and Henderson, 1959), Chloropidae (Parker, 1918).

## Aphid Pathogens

Aphid-attacking fungi are not host specific. The species attacking aphids belong mainly to the genus Empusa of the order Entomophthorales (Madelin, 1966). Rainfall and warm temperatures are prerequisites for epizootics to occur (Fluke, 1929; MacLeod, 1955; Hafez, 1961). Steinhaus (1945), Grobler *et al* (1962) and Hughes (1963) found that fungus epizootics among aphids are density dependent. Diseased aphids are readily distinguished by reddish brown color and their texture (MacLeod, 1955; Grobler *et al*, 1962). MacLeod (1956) discussed the distribution of Empusa cohn in Canada.

# CHAPTER III

## MATERIALS AND METHODS

Five species of aphids were used in the experiments. They were the greenbug, the corn leaf aphid, the English grain aphid, the birdcherry oat aphid, and the rose grass aphid. Studies were conducted either in the field or in the laboratory using summer viviparae. Field tests utilized Manitou wheat, Harmon oats, and Conquest barley as host plants. Field studies were carried out on grain crops in the area around Winnipeg, Manitoba, and Glenlea, Manitoba (latitude 50°, longitude 97°).

### Studies on the Changes in Numbers of Aphids on Grain Crops

A population study was carried out on the species of aphids found on cereal crops in 1968 and 1969. This study was made to determine the factors affecting the numbers of the common aphid species on wheat, oats and barley throughout the season in Manitoba. There are five major species, viz. the greenbug, the corn leaf aphid, the English grain aphid, the rose grass aphid, and the birdcherry oat aphid. During the two year study very few greenbugs and birdcherry oat aphids were found on cereal crops in Manitoba. It appears that except under unusual circumstances when there are high populations in the source regions in the United States, combined with southerly wind systems to allow immigration, the greenbug does not constitute an economic threat to Manitoba cereal crops. Similarly, in order for the summer viviparae of the birdcherry oat aphid to reach economic injury level there would have to be an unusually high overwintering egg population, high survival of overwintering eggs and suitable spring weather conditions to allow large populations to build up on the winter host, and produce progeny which would fly to the cereal crops. Studies were thus restricted to the English grain aphid, the rose grass aphid, and the corn leaf aphid.

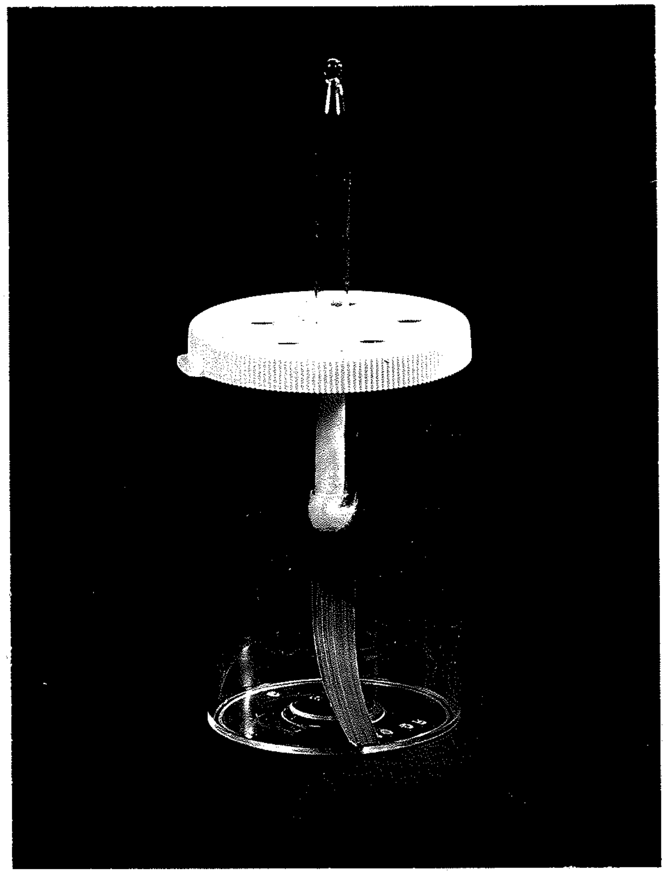
Fields selected were approximately five acres in size and individual plants bearing aphid colonies (one or more aphids on a plant) were selected at random in the field. Originally it was intended that a single colony on a plant would be observed repeatedly throughout the summer, recording the increase or decrease continuously through the season until the host plant matured, dried and all the aphids left the plant. It was found immediately that few of the colonies observed initially in the early part of the season continued throughout the season. The majority of aphid infested plants showed reduced aphid numbers between sampling dates, probably due to wind, rain, fungus disease, predators, or parasites which destroyed individual aphids or entire colonies. If no aphids were found on one of the sample plants, another plant in the field, with aphids, was chosen to replace it for future sampling observations.

Aphid population studies commenced during the tillering stage of the plants. Plants infested with aphids were selected at random from the field and a four foot bamboo stake was placed adjacent to it for identification. A pot label was also placed by the plant and assigned a number. One hundred plants with aphid colonies were selected in a field for each aphid species and grain species. For each aphid-infested plant the following information was recorded each sampling date: aphid species, host plant, date, present total, plant stage, plant site, number of parasitized aphids, number of aphids infected with fungus disease, and weather conditions. Total aphid numbers consisted of small nymphs, medium nymphs, apterous adults (wingless), alate adults (winged), or alatoid (nymphs with wing pads which develop into alate adults). Plant stages were designated as tillering, boot, and heading. Plant site was recorded as leaf 1, 2, 3 or 4 (taking the four uppermost leaves and counting from the lowest leaf) stem, and head. This showed where the aphid colony was located. Also it was established if aphids were in the whorl of the leaves or exposed on the leaf surfaces. Parasitized aphids, presence of predators, aphids with fungus disease, and weather conditions were also noted.

Experiments on Lady Beetle Effectiveness

Samples of each of the five species of lady beetles, Hippodamia convergens Guerin, Adalia bipunctata (Linnaeus), Hippodamia tredecimpunctata tibialis (Say), Coccinella transversoguttata Falderman and Hippodamia parenthesis (Say) were obtained from the field. They were first or second generation specimens. (Experiments were originally tried on third and overwintering generations but their effectiveness is much less than that of first and second generation lady beetles.) The lady beetles were kept in plastic cages constructed from pill vials, six centimeters in diameter and nine centimeters in length as described by Wilson (1969) (Figure 1). Holes were made in the lid to allow air exchange and the top was lined with cheesecloth to prevent escape of prey and predator. A Pasteur pipette was filled with water and a piece of absorbent cotton was used to plug the one open end. The water was absorbed by the cotton and utilized by the beetles. The lady beetles were confined to cages and were supplied with aphids so that at no time were they short of prey. Aphids fed on a portion of Conquest barley leaf enclosed in the cage. The cages containing predator and prey were kept in a growth chamber at 72-75° F, 55% RH, and 16 hours light, 8 hours dark. Studies on lady beetle effectiveness consisted of counting the number of aphids consumed by adult lady beetles and last three larval instars, and observing the fecundity of the adults when fed

FIGURE 1. The cage utilized in studies on lady beetle effectiveness constructed of a 40 dram plastic pill vial, containing a disposable Pasteur pipette and barley leaf for aphid feeding.



on a diet consisting of one aphid species exclusively. Adult studies on voracity and fecundity were carried out utilizing egg laying females only. Results of these studies were related to field populations of aphids and lady beetles to determine if there was any relation between species of grain, aphids and lady beetles present. Sampling in the field was conducted in 1968 and 1969. Numbers of lady beetles found on aphid infested plants were determined by counting the number of lady beetles found in a straight line transect through the field for approximately 100 feet. The dominant species of aphid and species of grain were noted.

Parasite Predator Study

Aphid predators and aphid parasites were observed on grain crops and ornamentals in the Winnipeg area in 1968 and 1969. If some members of an aphid colony were being preyed upon or were parasitized, a few adults of this colony were collected in lactophenol and mounted as described by Richards (1964). The plant host of the aphid colony was also identified. Predators were collected when they were actually consuming aphids, killed in a cyanide killing bottle, mounted and identified. If the predator was in an unidentifiable stage (usually larva or pupa) it was brought into the laboratory and placed in a pint carton cage with an organdy covered lid. The predator was reared until it emerged into an identifiable (adult) stage. Parasitized aphids were collected on the plant host to which they were attached (Spencer, 1926) and put into cartons covered with organdy and kept there until they emerged. After emergence they were kept without food until they died, after which they were mounted and identified. Aphid predators and parasites were reared at 72° F, 55% RH, 16 hours light and 8 hours dark. The names of the host plants, aphid species, parasites and predators of aphids are presented in Tables XXXIX and XL.

## CHAPTER IV

## CHANGES IN APHID NUMBERS ON SELECTED PLANTS OF WHEAT, OATS AND BARLEY IN THE FIELD

English grain aphid on Manitou wheat, 1969

In 1968 heavy rains and muddy conditions in the field prevented continuous and adequate sampling of English grain aphid on wheat at the Glenlea Research Station. Data obtained in 1969 are presented in Tables I and II and trends shown in Figure 2. Table I associates changes in population numbers of English grain aphid with effects of wind or rain or predators, and Table II with effects of emigration or immigration or parasites or diseases.

On three sampling dates, July 15, 20 and 25, approximately 25 per cent of the plants showed a total loss of aphid colonies and the succeeding three sampling dates, July 30 and August 3 and 11 showed even higher numbers of plants with all aphids disappeared. Despite these large numbers of plants which had no aphids on them on the next sampling date, total numbers of live aphids on 100 plants, and total numbers of live aphids on the plants still infested at the next sampling date increased on July 15, 20 and 25. After July 25, total numbers of aphids on plants rapidly declined. Over the whole sampling period, range of

TABLE I

POPULATION CHANGES IN ENGLISH GRAIN APHID ON MANITOU WHEAT, 1969, ASSOCIATED WITH EFFECTS OF WIND OR RAIN OR PREDATORS

| Sampling date | No. of live aphids on 100 plants | No. of live aphids on the 100 plants observed on the previous sampling date | No. of the 100 infested plants remaining infested since last sampling date | Range of number of aphids per plant | Per cent net change in live aphids between sampling dates | | Per cent net loss associated with wind or rain or predators | Speed (mph) of maximum wind gust between sampling dates | Maximum rainfall (inches) in a 24 hr. period between sampling dates | No. of the 100 infested plants with predators and range per plant |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | loss | gain | | | | |
| July 8 | 678 | - | 100 | 1-19 | - | - | - | - | - | 0 |
| " 15 | 1130 | 724 | 73 | 1-26 | - | 6.7 | - | 29 | 0.10 | 4 (0-1) |
| " 20 | 1511 | 1081 | 77 | 1-30 | 4.3 | - | 4.3 | 24 | 0.30 | 11 (0-1) |
| " 25 | 1512 | 1267 | 76 | 1-30 | 16.1 | - | 11.8 | 37 | 0.04 | 12 (0-1) |
| " 30 | 573 | 371 | 48 | 1-14 | 75.4 | - | 65.9 | 27 | 1.92 | 19 (0-1) |
| Aug. 3 | 652 | 438 | 37 | 1-16 | 23.5 | - | 12.0 | 34 | 0.41 | 22 (0-2) |
| 11 | - | 49 | 17 | 1-3 | 92.4 | - | 83.9 | 51 | 0.35 | 16 (0-2) |

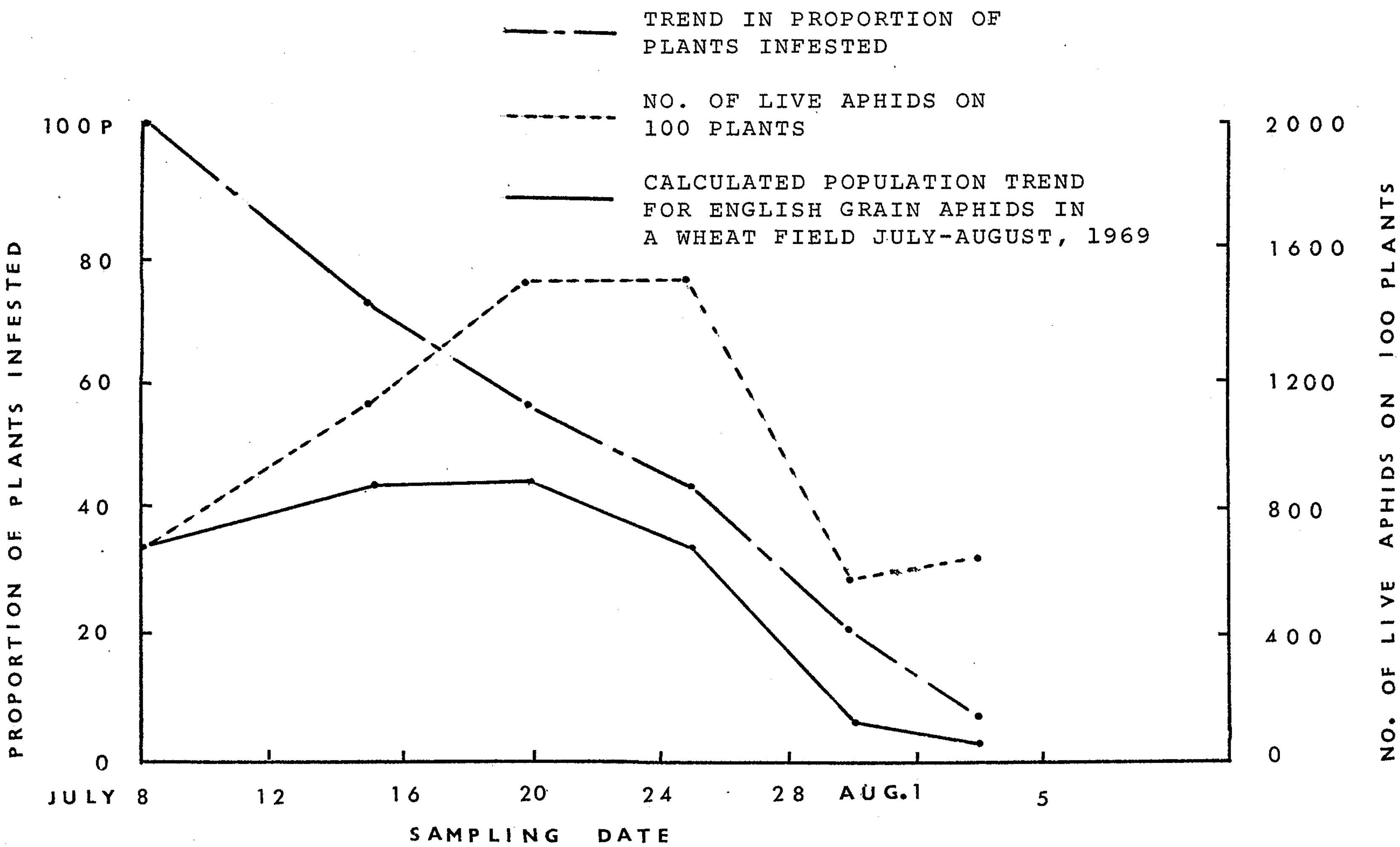
TABLE II

POPULATION CHANGES IN ENGLISH GRAIN APHID ON MANITOU WHEAT, 1969, ASSOCIATED WITH EMIGRATION OR IMMIGRATION OR PARASITES OR DISEASE

| Sampling date | Stage of plant growth | Total no. of aphids counted | Total no. of dead aphids counted | Per cent parasitized | Per cent diseased | Per cent alatoid nymphs (Emigration)* | Per cent alate adults (Immigration)** |
|---|---|---|---|---|---|---|---|
| July 8 | Tillering | 678 | 0 | 0 | 0 | 0 | 5.0 |
| " 15 | " | 724 | 0 | 0 | 0 | 0 | 2.8 |
| " 20 | " | 1081 | 0 | 0 | 0 | 0 | 1.2 |
| " 25 | " | 1324 | 57 | 3.1 | 1.2 | 0 | 0 |
| " 30 | " | 410 | 39 | 7.8 | 1.7 | 0.7 | 0 |
| Aug. 3 | Boot | 491 | 53 | 8.1 | 2.7 | 2.7 | 0 |
| " 11 | " | 52 | 3 | 3.8 | 2.0 | 3.9 | 0 |

* Alatoid nymphs usually leave plants by next sampling date (Johnson and Taylor, 1957).
** Alate adults appeared in the field before field populations were producing alatoid nymphs.

FIGURE 2. Population trends for English grain aphids in a wheat field July - August, 1969.


TREND IN PROPORTION OF PLANTS INFESTED
NO. OF LIVE APHIDS ON 100 PLANTS
CALCULATED POPULATION TREND FOR ENGLISH GRAIN APHIDS IN A WHEAT FIELD JULY-AUGUST, 1969
PROPORTION OF PLANTS INFESTED
100 P
80
60
40
20
0
NO. OF LIVE APHIDS ON 100 PLANTS
2000
1600
1200
800
400
0
JULY 8
12
16
20
24
28
AUG.1
5
SAMPLING DATE

number of aphids per plant varied from 1 - 30 (Table I).

"Per cent net change" was calculated as the total loss or gain in numbers of live aphids between sampling dates, expressed as a per cent. A net increase in aphid numbers was recorded only between the first and second sampling dates. The next column in Table I shows per cent net loss associated with wind or rain or predators, i.e. not associated with parasites, diseases or emigration. Except for the large losses shown for July 30, there was a gradual increase in net losses until August 11. The large losses shown for July 30 are believed to be the result of heavy rains between sampling dates (1.92 inches). On August 11 only 17 plants still had aphid colonies which is reflected in the very high net losses for that date. This was attributed to the combined effects of predator pressure and a storm on the evening of August 3 which consisted of hail, rain and very strong winds. The majority of aphid losses were associated with combined effects of wind, rain, and predators since losses associated with parasites, fungus disease or emigration were low throughout the season (Table II). Sampling was terminated on August 11 as the aphid population in the field was very low and did not recover after this date.

The last column in Table I shows the number of aphid-infested plants on which one or more predators were counted at each sampling date. There were never more than one or two predators associated with a colony of aphids, but one lady beetle larva or adult may devour entirely a small colony of aphids. Therefore the number of predators found (varying from 4 - 22) could account for some of the unexplained aphid losses between sampling dates.

In Table II the stage of plant growth shown for each sampling date indicates that aphid numbers in this field began to decline while plants were still tillering. Total number of aphids counted (including dead ones) is shown. Total number of dead aphids counted was attributed to parasites or diseases. Parasitized or diseased dead aphids can be readily recognized within the aphid colony. Table II shows that losses due to parasitism varied from 3.1 to 8.1 per cent, first recorded on July 25. Losses due to fungus disease were lower, varying from 1.2 to 2.7 per cent, first noted on July 25.

Some immigration was noted on the first three sampling dates, resulting from alate adults flying into the field, perhaps carried into Manitoba by strong southerly winds. No alatoid nymphs were noted until July 30. Alate adults from these nymphs would not remain with the colony (Johnson and Taylor, 1957) so this is shown in Table II at the next sampling date as losses due to emigration.

Figure 2 shows calculated trends for per cent plants infested and population trends based on one hundred plants examined. "Trend in proportion of plants infested" was calculated for each sampling date as a per cent of the originally infested plants still infested at that sampling date (e.g. Table I July 20, 0.77 x 0.73; July 25, 0.76 x 0.77 x 0.73; July 30, 0.48 x 0.76 x 0.77 x 0.73). One hundred plants represented an unknown proportion of all the infested plants in the field (100P, Figure 2). "Trend in proportion of plants infested" is thought to be comparable to sampling the same 100 plants throughout the season in the field. "Number of live aphids on 100 plants" is obtained from the second column of Table I. "Calculated population trend for English grain aphids in a wheat field July - August 1969" was calculated as a product of the number of live aphids on 100 plants and the proportion of plants infested (e.g. Table I, July 20, 0.77 x 0.73 x 1511).

Figure 2 shows that although "trend in proportion of plants infested" decreased during the sampling period (July 8 - August 3) total numbers of aphids increased during the period July 8 to July 25 and then decreased. The increases are the natural result of rapid aphid reproduction on plants before environmental factors such as predators, parasites, emigration, diseases and weather began to exert an effect, as apparently happened after July 25.

English grain aphid on Harmon oats, 1968

In 1969 a severe rain and hailstorm destroyed the English grain aphid population being sampled on oats shortly after sampling began. Data obtained in 1968 at the Glenlea Research Station were taken at variable sampling time intervals because of muddy fields or bad weather. These data are shown in Tables III and IV and Figure 3.

Table III records changes in numbers of English grain aphids between sampling dates, and associates those aphid losses which could not be accounted for by parasites, fungus disease, or emigration (Table IV) with combined effects of wind, rain and predators. Table III shows a gradual increase in the number of plants with total loss of aphid colonies through the season except for July 18. A heavy rain (1.51 inches) and wind (56 miles per hour) occurred between July 15 and 18. Total numbers of live aphids on 100 plants and number of live aphids at the next sampling date increased between July 15 and August 1. After August 1 total numbers of aphids on plants rapidly declined associated with a heavy rain (3.45 inches) between August 1 and 9. Over the whole sampling period the range of number of English grain aphids per plant varied from 1 - 28 (Table III).

Per cent net change columns indicate that net increases were recorded on July 19 and 26, associated with calm weather. Net decreases of 26 per cent and 87.9 per cent occurred between July 15 and 18 and August 1 and 9 respectively. These two heavy losses are associated with heavy rain and high winds. Per cent net loss column shows that the majority of aphid losses were associated with the combined effects of wind and rain since predators were in low numbers in this field (last column, Table III), and losses associated with parasites, fungus disease and

TABLE III

POPULATION CHANGES IN ENGLISH GRAIN APHID ON HARMON OATS, 1968, ASSOCIATED WITH EFFECTS OF WIND OR RAIN OR PREDATORS

| Sampling date | No. of live aphids on 100 plants | No. of live aphids on the 100 plants observed on the previous sampling date | No. of the 100 infested plants remaining infested since last sampling date | Range of number of aphids per plant | Per cent net change in live aphids between sampling dates: loss | Per cent net change in live aphids between sampling dates: gain | Per cent net loss associated with wind or rain or predators | Speed (mph) of maximum wind gust between sampling dates | Maximum rainfall (inches) in a 24 hr. period between sampling dates | No. of the 100 infested plants with predators and range per plant |
|---|---|---|---|---|---|---|---|---|---|---|
| July 15 | 163 | - | 100 | 1-6 | - | - | - | - | - | 0 |
| " 18 | 266 | 120 | 61 | 1-9 | 26.3 | - | 26.3 | 56 | 1.51 | 0 |
| " 19 | 302 | 268 | 87 | 1-14 | - | 7.5 | - | 28 | 0 | 1 (0-1) |
| " 26 | 481 | 374 | 81 | 1-14 | - | 23.8 | - | 36 | 0.28 | 1 (0-1) |
| " 29 | 600 | 461 | 65 | 1-11 | 4.1 | - | 3.7 | 33 | 0 | 3 (0-1) |
| Aug. 1 | 945 | 541 | 44 | 1-28 | 9.8 | - | 5.0 | 44 | 0.46 | 2 (0-1) |
| " 9 | - | 114 | 27 | 1-8 | 87.9 | - | 53.3 | 30 | 3.45 | 2 (0-1) |

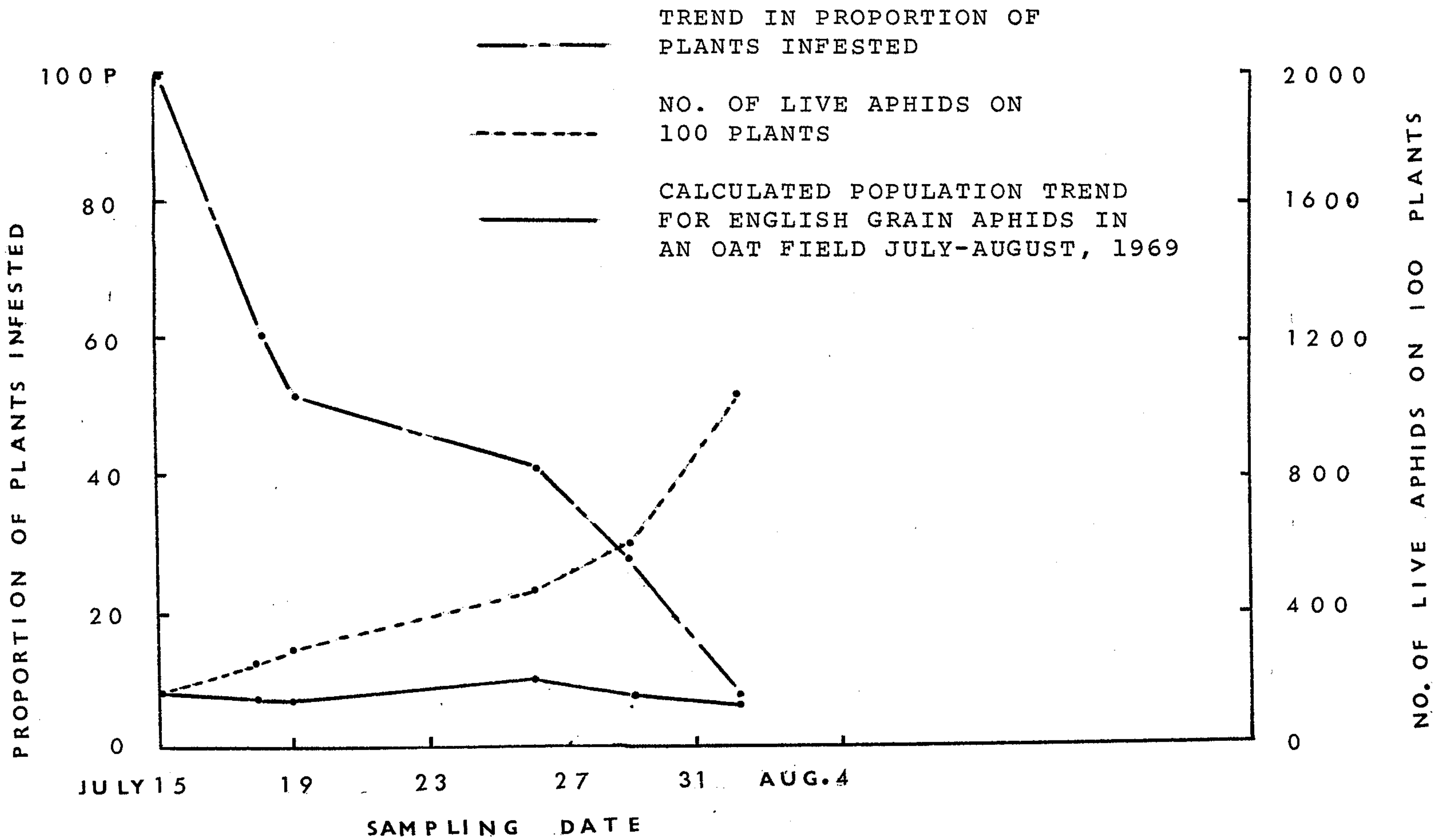
TABLE IV

POPULATION CHANGES IN ENGLISH GRAIN APHID ON HARMON OATS, 1968, ASSOCIATED WITH EMIGRATION OR IMMIGRATION OR PARASITES OR DISEASES

| Sampling date | Stage of plant growth | Total no. of aphids counted | Total no. of dead aphids counted | Per cent parasitized | Per cent diseased | Per cent alatoid nymphs (Emigration)* | Per cent alate adults (Immigration)** |
|---|---|---|---|---|---|---|---|
| July 15 | Tillering | 163 | 0 | 0 | 0 | 0 | 22.1 |
| " 18 | " | 120 | 0 | 0 | 0 | 0 | 24.2 |
| " 19 | " | 268 | 0 | 0 | 0 | 0 | 16.4 |
| " 26 | " | 374 | 0 | 0 | 0 | 0 | 0 |
| " 29 | " | 463 | 2 | 0.4 | 0 | 1.7 | 0 |
| Aug. 1 | " | 558 | 17 | 1.3 | 1.8 | 6.3 | 0 |
| " 9 | Heading | 159 | 45 | 15.7 | 12.6 | 3.5 | 0 |

* Alatoid nymphs usually leave plants by next sampling date (Johnson and Taylor, 1957).
** Alate adults appeared in the field before field populations were producing alatoid nymphs.

FIGURE 3. Population trend for English grain aphids in an oat field July - August, 1968.


TREND IN PROPORTION OF PLANTS INFESTED
NO. OF LIVE APHIDS ON 100 PLANTS
CALCULATED POPULATION TREND FOR ENGLISH GRAIN APHIDS IN AN OAT FIELD JULY-AUGUST, 1969
PROPORTION OF PLANTS INFESTED
100 P
80
60
40
20
0
NO. OF LIVE APHIDS ON 100 PLANTS
2000
1600
1200
800
400
0
JULY 15
19
23
27
31
AUG. 4
SAMPLING DATE

emigration were low, except at the last sampling date (Table IV).

Table IV shows that aphid populations declined in this field shortly before plants began to head. Losses due to parasitism varied from 0.4 to 15.7 per cent, first noted on July 29. Losses due to fungus disease varied from 1.8 to 12.6 per cent and were first recorded on August 1.

Immigration was recorded on the first three sampling dates, perhaps resulting from alate adults being carried into Manitoba by strong southerly winds. No alatoid nymphs were noted until July 29.

Figure 3 indicates that although "trend in proportion of plants infested" decreased through the sampling period July 15 - August 9, "number of live aphids on 100 plants" increased slowly until August 1, while "calculated population trend" remained almost constant.

English grain aphid on Conquest Barley, 1968

In 1969 a severe rain and hailstorm destroyed the English grain aphid population on the barley field being sampled shortly after sampling began. Data obtained in 1968 on a late seeded barley field are presented in Tables V and VI and trends are shown in Figure 4.

Table V shows a gradual increase in the number of plants having lost all their aphids as the season progressed except for records on August 26, which show more plants

TABLE V

POPULATION CHANGES IN ENGLISH GRAIN APHID ON CONQUEST BARLEY, 1968, ASSOCIATED WITH EFFECTS OF WIND OR RAIN OR PREDATORS

| Sampling date | No. of live aphids on 100 plants | No. of live aphids on the 100 plants observed on the previous sampling date | No. of the 100 infested plants remaining infested since last sampling date | Range of number of aphids per plant | Per cent net change in live aphids between sampling dates: loss | Per cent net change in live aphids between sampling dates: gain | Per cent net loss associated with wind or rain or predators | Speed (mph) of maximum wind gust between sampling dates | Maximum rainfall (inches) in a 24 hr. period between sampling dates | No. of the 100 infested plants with predators and range per plant |
|---|---|---|---|---|---|---|---|---|---|---|
| Aug. 2 | 299 | - | 100 | 1-12 | - | - | - | - | - | 0 |
| " 6 | 528 | 415 | 81 | 1-14 | - | 38.8 | - | 28 | 0.20 | 0 |
| " 14 | 711 | 449 | 84 | 1-24 | 14.9 | - | 2.5 | 30 | 0.15 | 1 (0-1) |
| " 20 | 679 | 406 | 63 | 1-15 | 42.9 | - | 21.7 | 36 | 1.24 | 2 (0-1) |
| " 26 | 644 | 407 | 49 | 1-17 | 40.1 | - | 22.0 | 43 | 1.40 | 2 (0-1) |
| " 31 | 672 | 435 | 68 | 1-15 | 32.4 | - | 14.6 | 33 | 0.21 | 3 (0-1) |
| Sept. 9 | - | 283 | 64 | 1-11 | 57.8 | - | 37.9 | 29 | 0.63 | 3 (0-1) |

TABLE VI

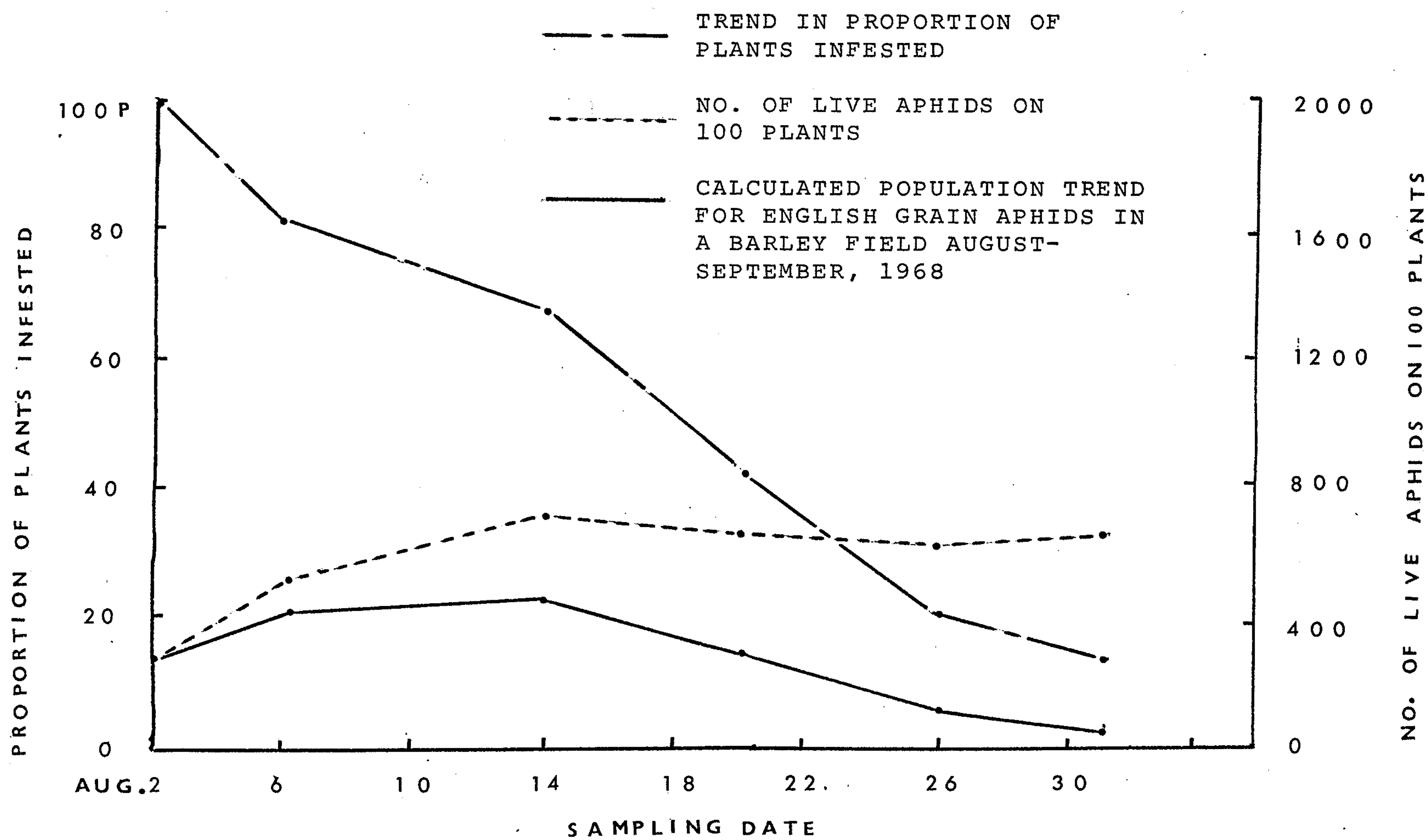
POPULATION CHANGES IN ENGLISH GRAIN APHID ON CONQUEST BARLEY, 1968, ASSOCIATED WITH EMIGRATION OR IMMIGRATION OR PARASITES OR DISEASES

| Sampling date | Stage of plant growth | Total no. of aphids counted | Total no. of dead aphids counted | Per cent parasitized | Per cent diseased | Per cent alatoid nymphs (Emigration)* | Per cent alate adults (Immigration)** |
|---|---|---|---|---|---|---|---|
| Aug. 2 | Tillering | 305 | 6 | 0 | 2.0 | 0 | 10.4 |
| " 6 | Boot | 441 | 26 | 1.6 | 4.3 | 0 | 9.4 |
| " 14 | " | 513 | 64 | 6.2 | 6.2 | 0 | 8.5 |
| " 20 | Heading | 515 | 109 | 11.5 | 9.7 | 0 | 0 |
| " 26 | " | 497 | 90 | 11.5 | 6.6 | 2.1 | 0 |
| " 31 | Headed | 516 | 81 | 12.4 | 3.3 | 4.6 | 0 |
| Sept. 9 | " | 334 | 51 | 11.7 | 3.6 | 4.6 | 0 |

* Alatoid nymphs usually leave plants by next sampling date (Johnson and Taylor, 1957).

** Alate adults appeared in the field before field populations were producing alatoid nymphs.

FIGURE 4. Population trend for English grain aphids in a barley field August - September, 1968.



TREND IN PROPORTION OF PLANTS INFESTED
NO. OF LIVE APHIDS ON 100 PLANTS
CALCULATED POPULATION TREND FOR ENGLISH GRAIN APHIDS IN A BARLEY FIELD AUGUST-SEPTEMBER, 1968
100 P
80
60
40
20
0
PROPORTION OF PLANTS INFESTED
2000
1600
1200
800
400
0
NO. OF LIVE APHIDS ON 100 PLANTS
AUG.2
6
10
14
18
22
26
30
SAMPLING DATE

having lost all their aphids than expected in the overall trend. It is suggested that heavy rains and gusty winds between August 14 and 20 and again between August 20 and 26 were associated with the large number of plants showing complete aphid losses as well as the decline in aphid numbers between August 14 and 26. Over the whole sampling period the range of number of aphids per plant varied from 1 - 24 (Table V).

Per cent net change column shows that a net increase in aphid numbers was recorded between the first and second sampling dates. Per cent net loss column shows that aphid losses were associated with weather or with parasites and fungus disease (Table VI) as predators were low in numbers in this field. At the last sampling date, September 9, aphid losses were associated with weather, parasites, fungus disease and drying of the plants (Tables V, VI, XVII). Maximum rainfall in a 24 hour period between August 31 and September 9 was 0.63 inches, but some rain occurred almost every day. Table VI shows that plants had headed before populations began to decline in this field. Losses due to parasitism varied from 1.6 to 12.4 per cent, first recorded on August 6. Losses due to fungus disease varied from 2.0 - 9.7 per cent, first noted on August 2.

Some immigration was recorded on the first three sampling dates. These immigrants may have been carried into the field by southerly winds or originated from other crops which were ripening in the area. No alatoid nymphs were recorded until August 26.

Figure 4 shows that although "trend in proportion of plants infested" decreased during the sampling period August 2 - September 9, "number of live aphids on 100 plants" increased up to August 14, decreased between August 14 and 26, and increased again between August 26 and 31. "Calculated population trend" increased slightly up to August 14 and then declined. Plants in this field were harvested while still infested with English grain aphids.

Corn leaf aphid on Manitou wheat, 1969

The corn leaf aphid was not found on wheat in 1968. Data obtained in 1969 are presented in Tables VII and VIII and trends are shown in Figure 5.

Table VII shows that the number of plants having lost all their aphids increased as the season progressed. Total number of aphids increased briefly between August 18 and 22 after which populations declined. Over the whole sampling period the range of number of aphids per plant varied from 1 - 18.

Per cent net change column shows that a net increase was recorded only between the first and second sampling dates. Per cent net loss column shows that wind, rain or predators were mostly associated with aphid losses, as no losses were recorded associated with parasites, fungus

TABLE VII

POPULATION CHANGES IN CORN LEAF APHID ON MANITOU WHEAT, 1969, ASSOCIATED WITH EFFECTS OF WIND OR RAIN OR PREDATORS

| Sampling date | | No. of live aphids on 100 plants | No. of live aphids on the 100 plants observed on the previous sampling date | No. of the 100 infested plants remaining infested since last sampling date | Range of number of aphids per plant | Per cent net change in live aphids between sampling dates: loss | Per cent net change in live aphids between sampling dates: gain | Per cent net loss associated with wind or rain or predators | Speed (mph) of maximum wind gust between sampling dates | Maximum rainfall (inches) in a 24 hr. period between sampling date | No. of the 100 infested plants with predators and range per plant |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Aug. | 18 | 592 | - | 100 | 1-15 | - | - | - | - | - | 15 (0-1) |
| " | 21 | 1051 | 697 | 76 | 1-17 | - | 17.7 | - | 23 | 0 | 21 (0-1) |
| " | 22 | 1171 | 1039 | 77 | 1-18 | 0.1 | - | 0.1 | 28 | 0 | 17 (0-1) |
| " | 25 | 977 | 723 | 68 | 1-16 | 38.2 | - | 38.2 | 31 | 0 | 18 (0-2) |
| Sept. | 1 | 677 | 514 | 56 | 1-13 | 47.3 | - | 47.3 | 37 | 0.59 | 22 (0-2) |
| " | 3 | 551 | 332 | 44 | 1-10 | 50.9 | - | 50.9 | 28 | 0 | 21 (0-2) |
| " | 10 | 331 | 168 | 31 | 1-8 | 69.8 | - | 69.8 | 44 | 1.05 | 11 (0-1) |
| " | 18 | - | 47 | 21 | 1-4 | 85.8 | - | 85.8 | 34 | 0 | 8 (0-1) |

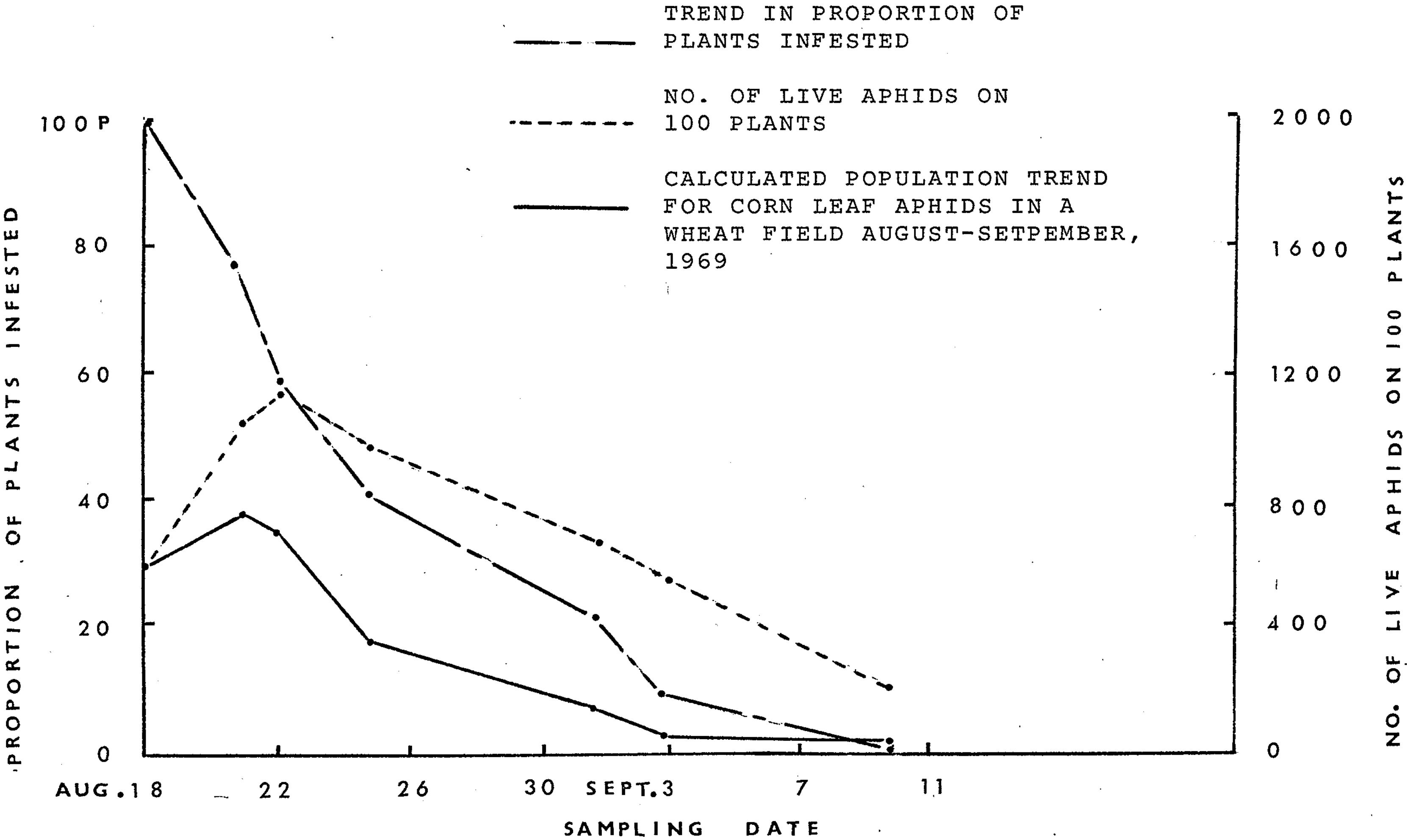
TABLE VIII

POPULATION CHANGES IN CORN LEAF APHID ON MANITOU WHEAT, 1969, ASSOCIATED WITH EMIGRATION OR IMMIGRATION OR PARASITES OR DISEASES

| Sampling date | Stage of plant growth | Total no. of aphids counted | Total no. of dead aphids counted | Per cent parasitized | Per cent diseased | Per cent alatoid nymphs (Emigration)* | Per cent alate adults (Immigration)** |
|---|---|---|---|---|---|---|---|
| Aug. 18 | Tillering | 592 | 0 | 0 | 0 | 0 | 7.1 |
| " 21 | " | 697 | 0 | 0 | 0 | 0 | 23.7 |
| " 22 | " | 1039 | 0 | 0 | 0 | 0 | 22.7 |
| " 25 | " | 723 | 0 | 0 | 0 | 0 | 12.3 |
| Sept. 1 | " | 514 | 0 | 0 | 0 | 0 | 1.4 |
| " 3 | " | 332 | 0 | 0 | 0 | 0 | 0 |
| " 10 | Boot | 168 | 0 | 0 | 0 | 0 | 0 |
| " 18 | " | 47 | 0 | 0 | 0 | 0 | 0 |

* Alatoid nymphs usually leave plants by next sampling date (Johnson and Taylor, 1957).
** Alate adults appeared in the field before field populations were producing alatoid nymphs.

FIGURE 5. Population trend for corn leaf aphids in a wheat field August - September, 1969.


TREND IN PROPORTION OF PLANTS INFESTED
NO. OF LIVE APHIDS ON 100 PLANTS
CALCULATED POPULATION TREND FOR CORN LEAF APHIDS IN A WHEAT FIELD AUGUST-SETPEMBER, 1969
PROPORTION OF PLANTS INFESTED
100 P
80
60
40
20
0
NO. OF LIVE APHIDS ON 100 PLANTS
2000
1600
1200
800
400
0
AUG.18
22
26
30
SEPT.3
7
11
SAMPLING DATE

disease or emigration (Table VIII). Per cent net losses progressively increased after August 21.

The last column in Table VII shows that predators were present throughout the season in this field. Some wheat plants had two lady beetles and a large number of plants had predators on them at each sampling date. It is suggested that the predators were effective in reducing the aphid numbers throughout the season.

Table VIII shows that corn leaf aphid populations in this field were reduced long before plants began to head. No parasitism, fungus disease or emigration was recorded in this field.

Some immigration was noted for the first half of the season resulting either from alate adults carried into the field by strong southerly winds or by alate adults flying from early seeded fields ripening in the area.

Figure 5 shows that although "trend in proportion of plants infested" decreased during the sampling period August 18 - September 18, "number of live aphids on 100 plants" increased until August 22 and then declined while "calculated population trend" increased up to August 21 and then declined.

Corn leaf aphid on Harmon oats, 1969

Corn leaf aphids were not found on oats in 1968. Data collected in 1969 are presented in Tables IX, X and Figure 6.

## TABLE IX

### POPULATION CHANGES IN CORN LEAF APHID ON HARMON OATS, 1969, ASSOCIATED WITH EFFECTS OF WIND OR RAIN OR PREDATORS

| Sampling date | No. of live aphids on 100 plants | No. of live aphids on the 100 plants observed on the previous sampling date | No. of the 100 infested plants remaining infested since last sampling date | Range of number of aphids per plant | Per cent net change in live aphids between sampling dates | | Per cent net loss associated with wind or rain or predators | Speed (mph) of maximum wind gust between sampling dates | Maximum rainfall (inches) in a 24 hr. period between sampling dates | No. of the 100 infested plants with predators and range per plant |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | loss | gain | | | | |
| Aug. 18 | 346 | - | 100 | 1-19 | - | - | - | - | - | 17 (0-1) |
| " 21 | 508 | 428 | 59 | 1-11 | - | 23.6 | - | 23 | 0 | 21 (0-2) |
| " 22 | 549 | 387 | 76 | 1-10 | 23.8 | - | 23.8 | 28 | 0 | 13 (0-1) |
| " 25 | 768 | 414 | 57 | 1-11 | 24.6 | - | 24.6 | 31 | 0 | 23 (0-2) |
| Sept. 1 | 745 | 437 | 48 | 1-15 | 43.0 | - | 43.0 | 37 | 0.59 | 21 (0-1) |
| " 3 | 579 | 224 | 31 | 1-10 | 69.9 | - | 69.9 | 28 | 0 | 11 (0-1) |
| " 10 | 265 | 59 | 13 | 1-6 | 89.8 | - | 89.8 | 44 | 1.05 | 8 (0-1) |
| " 18 | - | 30 | 16 | 1-3 | 88.6 | - | 88.6 | 34 | 0 | 7 (0-1) |

TABLE X

POPULATION CHANGES IN CORN LEAF APHID ON HARMON OATS, 1969, ASSOCIATED WITH EMIGRATION OR IMMIGRATION OR PARASITES OR DISEASES

| Sampling date | Stage of plant growth | Total no. of aphids counted | Total no. of dead aphids counted | Per cent parasitized | Per cent diseased | Per cent alatoid nymphs (Emigration)* | Per cent alate adults (Immigration)** |
|---|---|---|---|---|---|---|---|
| Aug. 18 | Tillering | 346 | 0 | 0 | 0 | 0 | 13.6 |
| " 21 | " | 428 | 0 | 0 | 0 | 0 | 23.4 |
| " 22 | " | 387 | 0 | 0 | 0 | 0 | 23.5 |
| " 25 | " | 414 | 0 | 0 | 0 | 0 | 11.6 |
| Sept. 1 | " | 437 | 0 | 0 | 0 | 0 | 0 |
| " 3 | " | 224 | 0 | 0 | 0 | 0 | 0 |
| " 10 | Boot | 59 | 0 | 0 | 0 | 0 | 0 |
| " 18 | " | 20 | 0 | 0 | 0 | 0 | 0 |

* Alatoid nymphs usually leave plants by next sampling date (Johnson and Taylor, 1957)
** Alate adults appeared in the field before field populations were producing alatoid nymphs.

FIGURE 6. Population trend for corn leaf aphids in an oat field August - September, 1969.

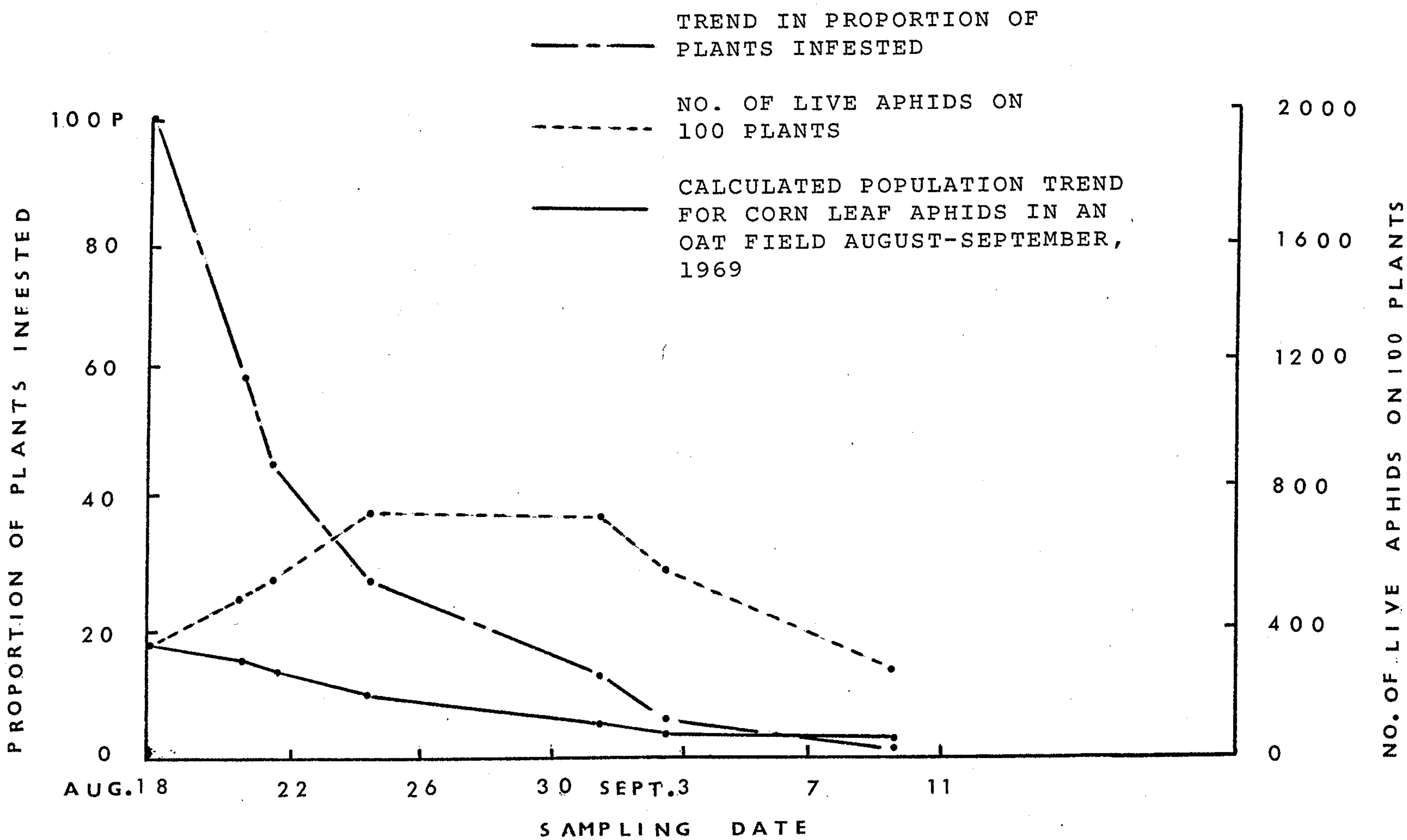

TREND IN PROPORTION OF PLANTS INFESTED
NO. OF LIVE APHIDS ON 100 PLANTS
CALCULATED POPULATION TREND FOR CORN LEAF APHIDS IN AN OAT FIELD AUGUST-SEPTEMBER, 1969
100 P
80
60
40
20
0
PROPORTION OF PLANTS INFESTED
2000
1600
1200
800
400
0
NO. OF LIVE APHIDS ON 100 PLANTS
AUG. 18
22
26
30
SEPT. 3
7
11
SAMPLING DATE

Table IX shows that the number of plants having lost all their aphids increased as the season progressed. Total number of aphids increased between August 18 and 25 after which numbers declined.

Per cent net change column shows that a net increase was recorded between the first and second sampling dates, on the same 100 plants. Per cent net loss column shows that wind, rain or predators were associated with all recorded aphid losses as no losses were recorded from parasites, fungus disease, or emigration (Table X).

The last column in Table IX shows that predators were present throughout the season in this field. Some oat plants infested with corn leaf aphids had two lady beetle predators per plant.

Table X shows that corn leaf aphid populations in this field were reduced long before plants began to head. No parasitism, fungus disease, or emigration was recorded in this field. Some immigration was noted for the first four sampling dates resulting either from alate adults carried into the field by southerly winds or from fields ripening in the area.

Figure 6 shows that although "trend in proportion of plants infested" decreased during the sampling period August 18 - September 18, "number of live aphids on 100 plants" increased until August 25 and then declined, while "calculated population trend" decreased throughout the sampling period. The relatively small numbers of corn leaf aphids on oats (Table IX) compared with numbers on barley (Table XI) indicate that oats are not a suitable host. This has been observed elsewhere (Apablaza and Robinson, 1967a).

Corn leaf aphid on Conquest barley, 1969

In 1968 corn leaf aphids were present on barley fields in the Winnipeg area but numbers were too low for research purposes. Data collected in 1969 are presented in Tables XI, XII and Figure 7.

Table XI shows that beginning with the third sampling date, July 20, not one plant lost all its aphids until August 9. Between August 3 and 9 over 70 per cent of the 100 plants first sampled on July 20 lost all their aphids. These losses were associated with predators, emigration (Table XII) and a severe hailstorm rated as a tornado on the evening of August 3. Losses on August 11 were associated with emigration (Table XII) and predators. Total numbers of live aphids on 100 plants equalled total number of live aphids at next sampling date, between July 20 and August 3 since not one plant lost all its aphids and replacements were not necessary. Total aphid numbers increased until July 25 after which numbers declined.

Over the whole sampling period the range of number

TABLE XI

POPULATION CHANGES IN CORN LEAF APHID ON CONQUEST BARLEY, 1969, ASSOCIATED WITH EFFECTS OF WIND OR RAIN OR PREDATORS

| Sampling date | No. of live aphids on 100 plants | No. of live aphids on the 100 plants observed on the previous sampling date | No. of the 100 infested plants remaining infested since last sampling date | Range of number of aphids per plant | Per cent net change in live aphids between sampling dates: loss | Per cent net change in live aphids between sampling dates: gain | Per cent net loss associated with wind or rain or predators | Speed (mph) of maximum wind gust between sampling dates | Maximum rainfall (inches) in a 24 hr. period between sampling dates | No. of the 100 infested plants with predators and range per plant |
|---|---|---|---|---|---|---|---|---|---|---|
| July 11 | 846 | - | 100 | 1-13 | - | - | - | - | - | 0 |
| " 17 | 2704 | 1556 | 82 | 1-97 | - | 83.1 | - | 24 | 0 | 0 |
| " 20 | 5506 | 5506 | 100 | 1-149 | - | 103.6 | - | 21 | 0.33 | 6 (0-1) |
| " 25 | 14375 | 14375 | 100 | 1-374 | - | 161.1 | - | 31 | 0 | 20 (0-1) |
| " 28 | 9918 | 9918 | 100 | 1-164 | 31.0 | - | 15.5 | 27 | 1.92 | 31 (0-2) |
| Aug. 2 | 5713 | 5713 | 100 | 1-126 | 42.3 | - | 7.8 | 34 | 0.41 | 49 (0-3) |
| " 3 | 2130 | 2130 | 100 | 1-79 | 62.7 | - | 13.5 | 20 | 0 | 55 (0-5) |
| " 9 | 583 | 282 | 29 | 1-13 | 86.7 | - | 25.2 | 51 | 0.35 | 29 (0-6) |
| " 11 | - | 17 | 4 | 1-5 | 97.1 | - | 41.1 | 20 | 0 | 4 (0-3) |

TABLE XII

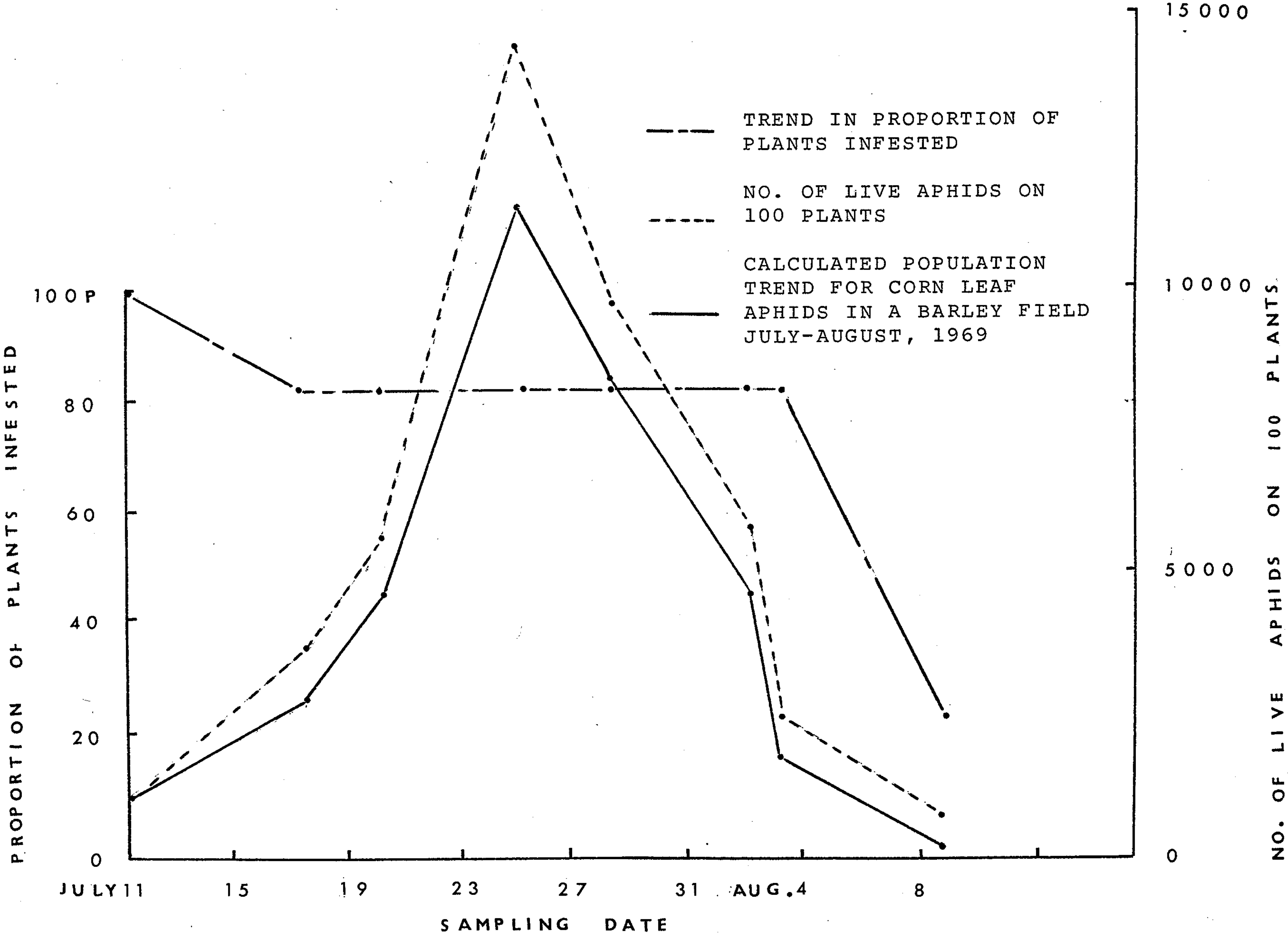
POPULATION CHANGES IN CORN LEAF APHID ON CONQUEST BARLEY, 1969, ASSOCIATED WITH EMIGRATION OR IMMIGRATION OR PARASITES OR DISEASES

| Sampling date | Stage of plant growth | Total no. of aphids counted | Total no. of dead aphids counted | Per cent parasitized | Per cent diseased | Per cent alatoid nymphs (Emigration)* | Per cent alate adults (Immigration)** |
|---|---|---|---|---|---|---|---|
| July 11 | Tillering | 846 | 0 | 0 | 0 | 0 | 7.9 |
| " 17 | " | 1556 | 0 | 0 | 0 | 0 | 8.6 |
| " 20 | " | 5506 | 0 | 0 | 0 | 0 | 5.3 |
| " 25 | " | 14375 | 0 | 0 | 0 | 15.5 | 0 |
| " 28 | Boot | 9918 | 0 | 0 | 0 | 34.5 | 1.4 |
| Aug. 2 | " | 5713 | 0 | 0 | 0 | 49.2 | 1.7 |
| " 3 | " | 2130 | 0 | 0 | 0 | 61.5 | 1.5 |
| " 9 | " | 282 | 0 | 0 | 0 | 56.0 | 4.3 |
| " 11 | " | 17 | 0 | 0 | 0 | 47.1 | 0 |

* Alatoid nymphs usually leave plants by next sampling date (Johnson and Taylor, 1957).

** Alate adults appeared in the field before and during the time field populations were producing alatoid nymphs.

FIGURE 7. Population trend for corn leaf aphids in a barley field July - August, 1969.


TREND IN PROPORTION OF PLANTS INFESTED
NO. OF LIVE APHIDS ON 100 PLANTS
CALCULATED POPULATION TREND FOR CORN LEAF APHIDS IN A BARLEY FIELD JULY-AUGUST, 1969
PROPORTION OF PLANTS INFESTED
100P
80
60
40
20
0
NO. OF LIVE APHIDS ON 100 PLANTS
15000
10000
5000
0
JULY 11
15
19
23
27
31
AUG. 4
8
SAMPLING DATE

of aphids per plant varied from 1 - 374. The high counts shown in Table XI are a reflection of the fact that the corn leaf aphid has a higher fecundity on barley than on wheat or oats (Apablaza and Robinson, 1967b).

Per cent change column shows that net increases were recorded between July 11 and 25. Net decreases occurred after August 28 and there was a gradual increase in number of plants losing their aphids until the end of the season. Between July 20 and 28 no plants lost all their aphids, but a 31.0 per cent decrease in aphid numbers was associated with heavy rains (1.92 inches) between July 25 and 28. Between August 3 and 9, an 87 per cent net decrease in aphid numbers was associated with a heavy hailstorm rated as a tornado on evening of August 3 as well as emigration (Table XII) and predators. Per cent net loss column shows that part of the losses at each sampling date after July 28 were associated with wind or rain or predators. The remaining losses between sampling dates were associated with emigration.

The last column in Table XI shows that large numbers of predators were found in this barley field infested with corn leaf aphids. The great majority were lady beetle adults and larvae. Some aphid colonies were preyed upon by as many as six lady beetles.

In Table XII, stage of plant growth shows that plants did not head and mature before aphids were destroyed on the crop. Losses due to parasitism and fungus disease were not observed for the corn leaf aphid in this field.

Some immigration was noted on the first few sampling dates resulting from alate adults flying into the field or perhaps carried into the field by strong southerly winds. Alate adults were again recorded after July 28. It is suggested that these winged forms developed on the plants because of overcrowding. The difference between the large number of alatoid nymphs recorded after July 25 and the small number of winged adults recorded after July 28 suggests that winged forms flew off the plants as soon as wings developed.

Figure 7 shows that "trend in proportion of plants infested" decreased between July 11 and 17 and remained steady between July 17 and August 3 and then declined. Not one of the 100 plants sampled after July 20 lost all their aphids. Until August 3, 82 of the 100 plants sampled were the original plants first selected on July 11, the first sampling date. Total numbers of aphids increased until July 25 and then decreased. The flat line (figure 7) for "trend in proportion of plants infested" shows one serious flaw in the method of representing this trend, because it does not show increases in proportion of plants infested, and there obviously were increases in this field of barley in 1969 that was so heavily infested.

Rose grass aphid on Conquest barley, 1968

Rose grass aphids were only found in sufficient numbers for study purposes on barley in 1968. Data are presented in Tables XIII, XIV and Figure 8.

Table XIII shows that numbers of plants having lost all their aphids progressively increased until August 26. An increase occurred between August 26 and 31 followed by a decline. It is suggested that heavy rains and gusty winds were associated with 40-50 per cent of the plants losing all their aphids between August 14 and 26. Total number of live aphids on 100 infested plants increased between August 2 and 20, and then declined. Total number of live aphids at next sampling date increased between August 2 and 31 and then decreased. Throughout the sampling period the range of number of aphids per plant varied from 1 - 34 (Table XIII).

Per cent net change column shows that net losses on the same 100 plants between sampling dates occurred through the season after August 6. It is suggested that the large losses recorded on August 20 and 26 were greater than the overall trend indicates and were associated with heavy rains and gusty winds between these dates. Per cent net loss column indicates that part of the losses between August 14 and 26 were associated with wind and rain, and the remainder with parasites and fungus disease (Table XIV). Predators were low in numbers through the season. On September 9,

TABLE XIII

POPULATION CHANGES IN ROSE GRASS APHID ON CONQUEST BARLEY, 1968, ASSOCIATED WITH EFFECTS OF WIND OR RAIN OR PREDATORS

| Sampling date | No. of live aphids on 100 plants | No. of live aphids on the 100 plants observed on the previous sampling date | No. of the 100 infested plants remaining infested since last sampling date | Range of number of aphids per plant | Per cent net change in live aphids between sampling dates | | Per cent net loss associated with wind or rain or predators | Speed (mph) of maximum wind gust between sampling dates | Maximum rainfall (inches) in a 24 hr. period between sampling dates | No. of the 100 infested plants with predators and range per plant |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | loss | gain | | | | |
| Aug. 2 | 458 | - | 100 | 1-13 | - | - | - | - | - | 7 (0-1) |
| 6 | 676 | 551 | 77 | 1-16 | - | 20.3 | - | 28 | 0.20 | 1 (0-1) |
| 14 | 993 | 593 | 63 | 1-16 | 12.2 | - | 1.6 | 40 | 0.15 | 3 (0-1) |
| 20 | 1303 | 612 | 57 | 1-17 | 38.3 | - | 24.6 | 36 | 1.25 | 2 (0-1) |
| 26 | 1194 | 851 | 48 | 1-23 | 34.6 | - | 15.0 | 43 | 1.40 | 1 (0-1) |
| 31 | 1019 | 908 | 79 | 1-34 | 23.9 | - | 1.3 | 33 | 0.21 | 2 (0-1) |
| Sept. 9 | - | 545 | 62 | 1-13 | 46.5 | - | 17.3 | 29 | 0.63 | 1 (0-1) |

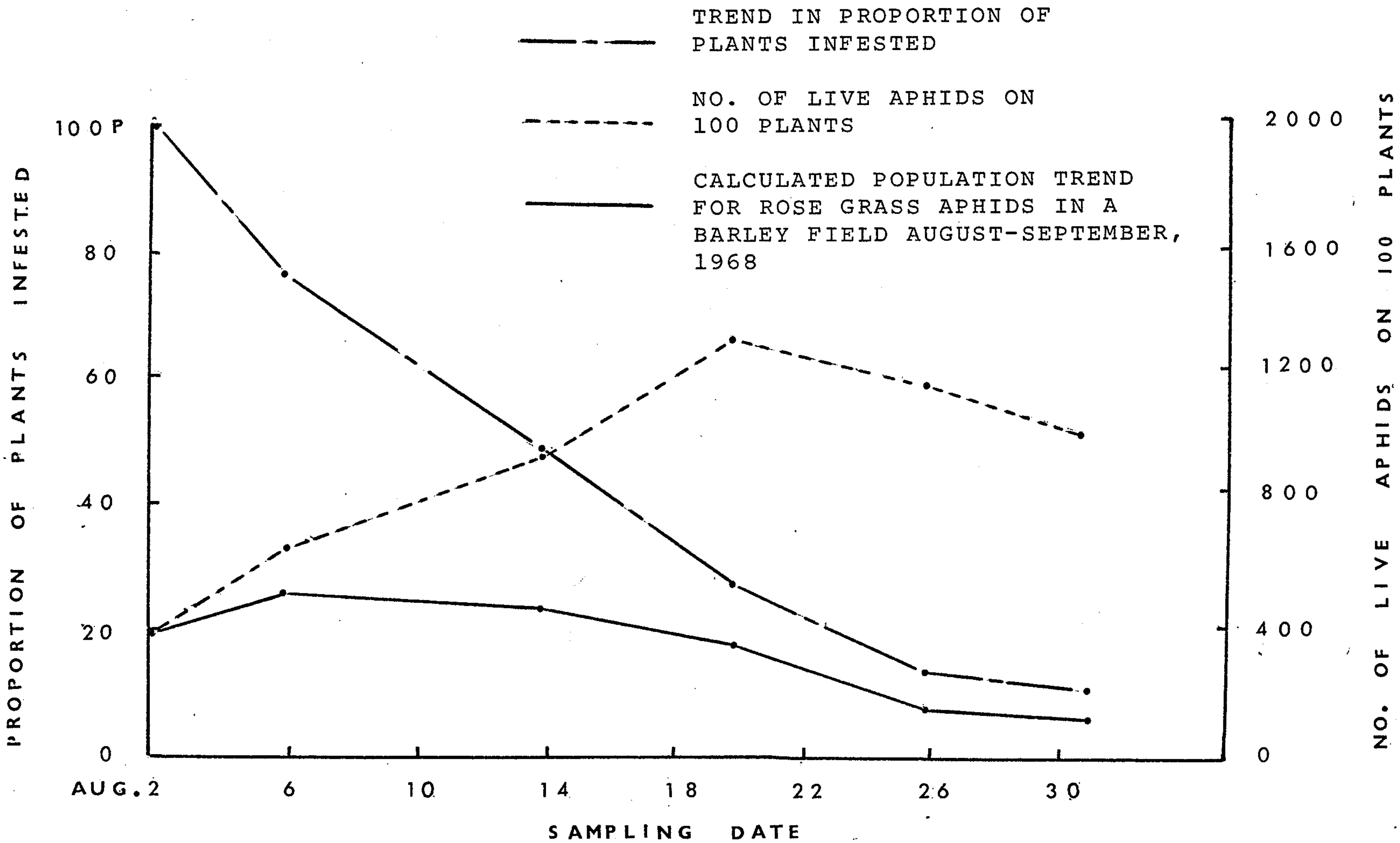
TABLE XIV

POPULATION CHANGES IN ROSE GRASS APHID ON CONQUEST BARLEY, 1968, ASSOCIATED WITH EMIGRATION OR IMMIGRATION OR PARASITES OR DISEASES

| Sampling date | Stage of plant growth | Total no. of aphids counted | Total no. of dead aphids counted | Per cent parasitized | Per cent diseased | Per cent alatoid nymphs (Emigration)* | Per cent alate adults (Immigration)** |
|---|---|---|---|---|---|---|---|
| Aug. 2 | Boot | 498 | 40 | 3.6 | 4.4 | 0 | 9.6 |
| " 6 | " | 612 | 61 | 4.4 | 5.6 | 0 | 8.2 |
| " 14 | " | 663 | 70 | 5.9 | 4.7 | 0 | 4.4 |
| " 20 | Heading | 709 | 97 | 7.9 | 5.8 | 0 | 0 |
| " 26 | " | 1058 | 207 | 6.6 | 13.0 | 0 | 0 |
| " 31 | " | 1173 | 265 | 5.8 | 16.8 | 1.3 | 0 |
| Sept. 9 | Headed | 756 | 211 | 4.9 | 23.0 | 6.8 | 0 |

* Alatoid nymphs usually leave plants by next sampling date (Johnson and Taylor, 1957).
** Alate adults appeared in the field before field populations were producing alatoid nymphs.

FIGURE 8. Population trend for rose grass aphids in a barley field August - September, 1968.


TREND IN PROPORTION OF PLANTS INFESTED
NO. OF LIVE APHIDS ON 100 PLANTS
CALCULATED POPULATION TREND FOR ROSE GRASS APHIDS IN A BARLEY FIELD AUGUST-SEPTEMBER, 1968
PROPORTION OF PLANTS INFESTED
100
80
60
40
20
0
NO. OF LIVE APHIDS ON 100 PLANTS
2000
1600
1200
800
400
0
AUG. 2
6
10
14
18
22
26
30
SAMPLING DATE

losses were associated with weather as well as parasites and fungus disease. Total rainfall in a 24 hour period was 0.63 inches but some rain fell nearly every day between August 31 and September 9.

Table XIV shows that losses associated with parasites occurred throughout the season and ranged from 3.6 - 7.9 per cent. Losses due to fungus disease were recorded throughout the season and increased as the season progressed. Losses varied from 4.4 - 23.0 per cent.

Immigration was noted on the first three sampling dates resulting either from alates flying into the field from plants which were ripening in the area or from aphids being carried into the field on southerly winds. No alatoid nymphs were noted until August 31.

Figure 8 shows that "trend in proportion of plants infested" decreased through the season (August 2 - September 9). Total number of aphids on 100 infested plants increased until August 20, and then decreased. "Calculated population trend" increased up to August 20 and then declined. Plants were still infested with rose grass aphids when they were harvested.

Position of aphids on plants and stage of plant growth

Tables XV - XXI show on which part of the plants the most aphids were found, and the number of ripe plants, on the various sampling dates. The first leaf is the lowest on the plant.

Tables XV and XVI show that English grain aphids in early July were found somewhat evenly distributed over the second, third and fourth leaves. Later in the month more were found on the third and fourth leaves and eventually as the plants headed some began to move on to the heads. In both these examples sampling did not continue after August 9 and 11 because of catastrophic weather conditions. Table XVII shows an example of sampling English grain aphid on late-seeded barley. In early August more aphids were found on third and fourth leaves, and as heading of the plants began more aphids were found on the heads at each sampling date. As the month terminated more and more plants ripened. This resulted in rapidly decreasing numbers on the leaves, although aphids were still found on the heads. Also, as the plants ripened, there was a general decrease in population numbers (Table VI, September 9).

Tables XVIII and XIX show on which parts of wheat or oats corn leaf aphids were found, beginning in early August, 1969. No aphids were found on first and second leaves. In both cases the numbers found on third and fourth leaves were almost the same for the first two sampling dates, but as the month progressed more and more were found on the fourth leaves than on the third.

Table XX shows corn leaf aphid on its most favored host, barley (Robinson and Hsu, 1963). As the aphid

TABLE XV

PERCENTAGE DISTRIBUTION OF ENGLISH GRAIN APHIDS ON LEAVES 1, 2, 3, 4 AND HEAD OF 100 MANITOU WHEAT PLANTS, 1969

| Sampling date | Leaf no. 1 | 2 | 3 | 4 | Head | Number of ripe plants |
|---|---|---|---|---|---|---|
| July 8 | 0 | 37 | 31 | 32 | 0 | 0 |
| " 15 | 0 | 31 | 33 | 36 | 0 | 0 |
| " 20 | 0 | 14 | 48 | 38 | 0 | 0 |
| " 25 | 0 | 5 | 32 | 63 | 0 | 0 |
| " 30 | 0 | 0 | 31 | 68 | 1 | 0 |
| Aug. 3 | 0 | 0 | 32 | 64 | 4 | 0 |
| " 11* | 0 | 0 | 11 | 67 | 14 | 0 |

* 8 samples not found.

TABLE XVI

PERCENTAGE DISTRIBUTION OF ENGLISH GRAIN APHIDS ON LEAVES 1, 2, 3, 4 AND HEAD OF 100 HARMON OAT PLANTS, 1968

| Sampling date | Leaf no. 1 | 2 | 3 | 4 | Head | Number of ripe plants |
|---|---|---|---|---|---|---|
| July 7* | 0 | 26 | 29 | 44 | 0 | 0 |
| " 18 | 0 | 19 | 34 | 47 | 0 | 0 |
| " 19 | 0 | 13 | 38 | 49 | 0 | 0 |
| " 26 | 0 | 15 | 31 | 54 | 0 | 0 |
| " 29 | 0 | 8 | 35 | 57 | 0 | 0 |
| Aug. 1 | 0 | 11 | 42 | 44 | 3 | 0 |
| " 9** | 0 | 0 | 48 | 37 | 11 | 0 |

* 1 sample not found
** 4 samples not found

TABLE XVII

PERCENTAGE DISTRIBUTION OF ENGLISH GRAIN APHIDS ON LEAVES 1, 2, 3, 4 AND HEAD OF 100 CONQUEST BARLEY PLANTS, 1968

| Sampling date | Leaf no. 1 | 2 | 3 | 4 | Head | Number of ripe plants |
|---|---|---|---|---|---|---|
| Aug. 2 | 0 | 11 | 48 | 41 | 0 | 0 |
| " 6* | 0 | 13 | 41 | 40 | 3 | 0 |
| " 14 | 0 | 6 | 44 | 42 | 8 | 0 |
| " 20 | 0 | 12 | 24 | 44 | 20 | 11 |
| " 26 | 0 | 15 | 18 | 29 | 38 | 15 |
| " 31** | 0 | 16 | 14 | 18 | 46 | 17 |
| Sept. 9*** | 0 | 19 | 11 | 11 | 54 | 34 |

* 3 samples not found
** 6 samples not found
*** 5 samples not found

TABLE XVIII

PERCENTAGE DISTRIBUTION OF CORN LEAF APHIDS ON LEAVES 1, 2, 3, 4 AND HEAD OF 100 MANITOU WHEAT PLANTS, 1969

| Sampling date | Leaf no. 1 | 2 | 3 | 4 | Head | Number of ripe plants |
|---|---|---|---|---|---|---|
| Aug. 8 | 0 | 0 | 54 | 46 | 0 | 0 |
| " 21 | 0 | 0 | 52 | 48 | 0 | 0 |
| " 22 | 0 | 0 | 47 | 53 | 0 | 0 |
| " 25 | 0 | 0 | 44 | 56 | 0 | 0 |
| Sept. 1 | 0 | 0 | 34 | 66 | 0 | 0 |
| " 3 | 0 | 0 | 17 | 83 | 0 | 0 |
| " 10 | 0 | 0 | 11 | 89 | 0 | 0 |
| " 18 | 0 | 0 | 6 | 94 | 0 | 0 |

TABLE XIX

PERCENTAGE DISTRIBUTION OF CORN LEAF APHIDS ON LEAVES 1, 2, 3, 4 AND HEAD OF 100 HARMON OAT PLANTS, 1969

| Sampling date | Leaf no. 1 | 2 | 3 | 4 | Head | Number of ripe plants |
|---|---|---|---|---|---|---|
| Aug. 8 | 0 | 0 | 47 | 53 | 0 | 0 |
| " 21 | 0 | 0 | 42 | 58 | 0 | 0 |
| " 22 | 0 | 0 | 34 | 66 | 0 | 0 |
| " 25 | 0 | 0 | 29 | 71 | 0 | 0 |
| Sept. 1 | 0 | 0 | 17 | 83 | 0 | 0 |
| " 3 | 0 | 0 | 14 | 86 | 0 | 0 |
| " 10 | 0 | 0 | 11 | 89 | 0 | 0 |
| " 18 | 0 | 0 | 9 | 91 | 0 | 0 |

TABLE XX

PERCENTAGE DISTRIBUTION OF CORN LEAF APHIDS ON LEAVES 1, 2, 3, 4 AND HEAD OF 100 CONQUEST BARLEY PLANTS, 1969

| Sampling date | Leaf no. 1 | 2 | 3 | 4 | Head | Number of ripe plants |
|---|---|---|---|---|---|---|
| Aug. 8 | 0 | 0 | 42 | 58 | 0 | 0 |
| " 17 | 0 | 0 | 39 | 61 | 0 | 0 |
| " 20 | 0 | 5 | 41 | 54 | 0 | 0 |
| " 25 | 23 | 26 | 22 | 29 | 0 | 0 |
| " 28 | 16 | 24 | 29 | 31 | 0 | 0 |
| Sept. 2 | 16 | 14 | 34 | 36 | 0 | 0 |
| " 3 | 15 | 15 | 31 | 39 | 0 | 0 |
| " 9* | 12 | 8 | 13 | 66 | 0 | 0 |
| " 11 | 0 | 3 | 11 | 86 | 0 | 0 |

* 1 plant not found

populations increased on third and fourth leaves, the over-crowding resulted in a downward movement of aphids to first and second leaves.

The rose grass aphid is seldom found on wheat or oats. Table XXI shows that on barley it occurred in early August on second, third and fourth leaves, and that as the month progressed it was found on third and fourth leaves only, with greatest numbers on the fourth leaves. Although plants were ripening during the second sampling period, no rose grass aphids were found on the heads.

TABLE XXI

PERCENTAGE DISTRIBUTION OF ROSE GRASS APHIDS ON LEAVES 1, 2, 3, 4 AND HEAD OF 100 CONQUEST BARLEY PLANTS, 1968

| Sampling date | Leaf no. 1 | 2 | 3 | 4 | Head | Number of ripe plants |
|---|---|---|---|---|---|---|
| Aug. 2 | 0 | 13 | 38 | 49 | 0 | 0 |
| " 6 | 0 | 0 | 43 | 57 | 0 | 0 |
| " 14 | 0 | 0 | 45 | 55 | 0 | 0 |
| " 20 | 0 | 0 | 33 | 67 | 0 | 9 |
| " 26 | 0 | 0 | 28 | 72 | 0 | 14 |
| " 31 | 0 | 0 | 19 | 81 | 0 | 23 |
| Sept. 9 | 0 | 0 | 13 | 87 | 0 | 32 |

## CHAPTER V

## A STUDY OF THE VORACITY, FECUNDITY AND DEVELOPMENTAL RATES OF THE COMMON LADY BEETLE PREDATORS ON APHIDS ON CEREAL CROPS IN MANITOBA

The common lady beetle species found on aphids on grain crops in 1968 and 1969 were *Hippodamia tredicimpunctata tibialis* (Say) (thirteen spotted lady beetle), *H. convergens* Guerin-Méneville (convergent lady beetle), *Coccinella transversoguttata* Faldermann (transverse lady beetle), *Adalia bipunctata* (Linnaeus) (two spotted lady beetle), and *H. parenthesis* (Say) (Parenthesis lady beetle), in order of importance. This chapter is concerned with determining the voracity, fecundity and developmental rates of these species of lady beetles on the common aphids found on cereal crops in Manitoba. Tables XXII-XXXVII and Figures 9-12 show the results of these tests. The data were analyzed by means of two and three way analysis of variance.

### The number of cereal aphids eaten by an adult female lady beetle in 24 hours

First generation adult lady beetles were brought into the laboratory from the field and females were confined in cages (Figure 1) with a specific third larval instar aphid species. Each of the five lady beetle species tested were fed for five days on each aphid species. In the experiments sufficient prey were added every twelve hours to ensure that predators were never without food. Table XXII shows average weights of replicates of five individuals of each species of lady beetle, and third instar larvae of aphids. Table XXIII shows that C. transversoguttata consumed more of each species of aphid than did any of the other four lady beetle species. Table XXIV shows the statistical analysis of the data in Table XXIII. The results suggest that voracity of the smaller coccinellids is correlated with the relative weight of predators and inversely correlated with weight of prey, except that H. tredecimpunctata tibialis and H. convergens were equally voracious, though the latter weighs more. Figure 9 is a graphic portrayal of the combined data of Tables XXII and XXIII. The average number of third instar larvae of each species consumed in 24 hours can be read from the ordinates opposite a point on the abscissa corresponding to the average weight of each lady beetle species (Table XXII).

All lady beetle species consumed more of R. maidis than of any other aphid species. In general, numbers of aphids consumed varied inversely with the weight of the prey.

Fecundity of lady beetles fed on a diet of each aphid species for a period of ten days

Female lady beetles of the four most important

TABLE XXII

THE AVERAGE LIVE WEIGHTS OF FIVE ADULT FEMALE LADY BEETLE SPECIES AND FIVE THIRD INSTAR APHID SPECIES (FIVE REPLICATES FOR EACH SPECIES)

| Lady beetle species | Weight (milligrams) | Aphid species | Weight (micrograms) |
|---|---|---|---|
| *H. parenthesis* | 11.9 | *R. maidis* | 130 |
| *A. bipunctata* | 12.4 | *R. padi* | 160 |
| *H. tredecimpunctata tibialis* | 13.5 | *S. graminum* | 195 |
| *H. convergens* | 19.6 | *M. avenae* | 355 |
| *C. transversoguttata* | 32.7 | *M. dirhodum* | 375 |

TABLE XXIII

AVERAGE NUMBER OF THIRD INSTAR LARVAL APHIDS EATEN BY ONE ADULT FEMALE LADY BEETLE IN 24 HOURS

| Lady beetle | Aphid | Number of Replicates | No. aphids eaten in 24 hours Mean | Range |
|---|---|---|---|---|
| C. transversoguttata | R. maidis | 5 | 180± 8.9 | 166-194 |
| | R. padi | 5 | 173± 2.4 | 168-176 |
| | S. graminum | 5 | 169± 2.7 | 165-173 |
| | M. avenae | 5 | 125± 8.9 | 111-135 |
| | M. dirhodum | 5 | 131± 9.4 | 113-139 |
| H. convergens | R. maidis | 5 | 159± 5.7 | 152-167 |
| | R. padi | 5 | 151±14.0 | 123-164 |
| | S. graminum | 5 | 137±10.1 | 131-152 |
| | M. avenae | 5 | 109±10.8 | 94-127 |
| | M. dirhodum | 5 | 105± 1.9 | 103-108 |
| H. tredecimpunctata tibialis | R. maidis | 5 | 164±11.5 | 147-182 |
| | R. padi | 5 | 155±14.2 | 135-179 |
| | S. graminum | 5 | 151±23.8 | 123-167 |
| | M. avenae | 5 | 108± 4.1 | 103-115 |
| | M. dirhodum | 5 | 111± 6.3 | 104-122 |
| A. bipunctata | R. maidis | 5 | 103± 5.9 | 94-112 |
| | R. padi | 5 | 96± 7.7 | 85-107 |
| | S. graminum | 5 | 91± 7.1 | 83-103 |
| | M. avenae | 5 | 82± 7.4 | 74- 94 |
| | M. dirhodum | 5 | 80± 4.2 | 74- 86 |
| H. parenthesis | R. maidis | 5 | 81± 9.6 | 67- 94 |
| | R. padi | 5 | 78±10.4 | 67- 95 |
| | S. graminum | 5 | 72±10.6 | 68- 86 |
| | M. avenae | 5 | 60±12.3 | 50- 67 |
| | M. dirhodum | 5 | 58± 7.4 | 49- 69 |

TABLE XXIV

STATISTICAL ANALYSIS OF THE DATA IN TABLE XXIII*

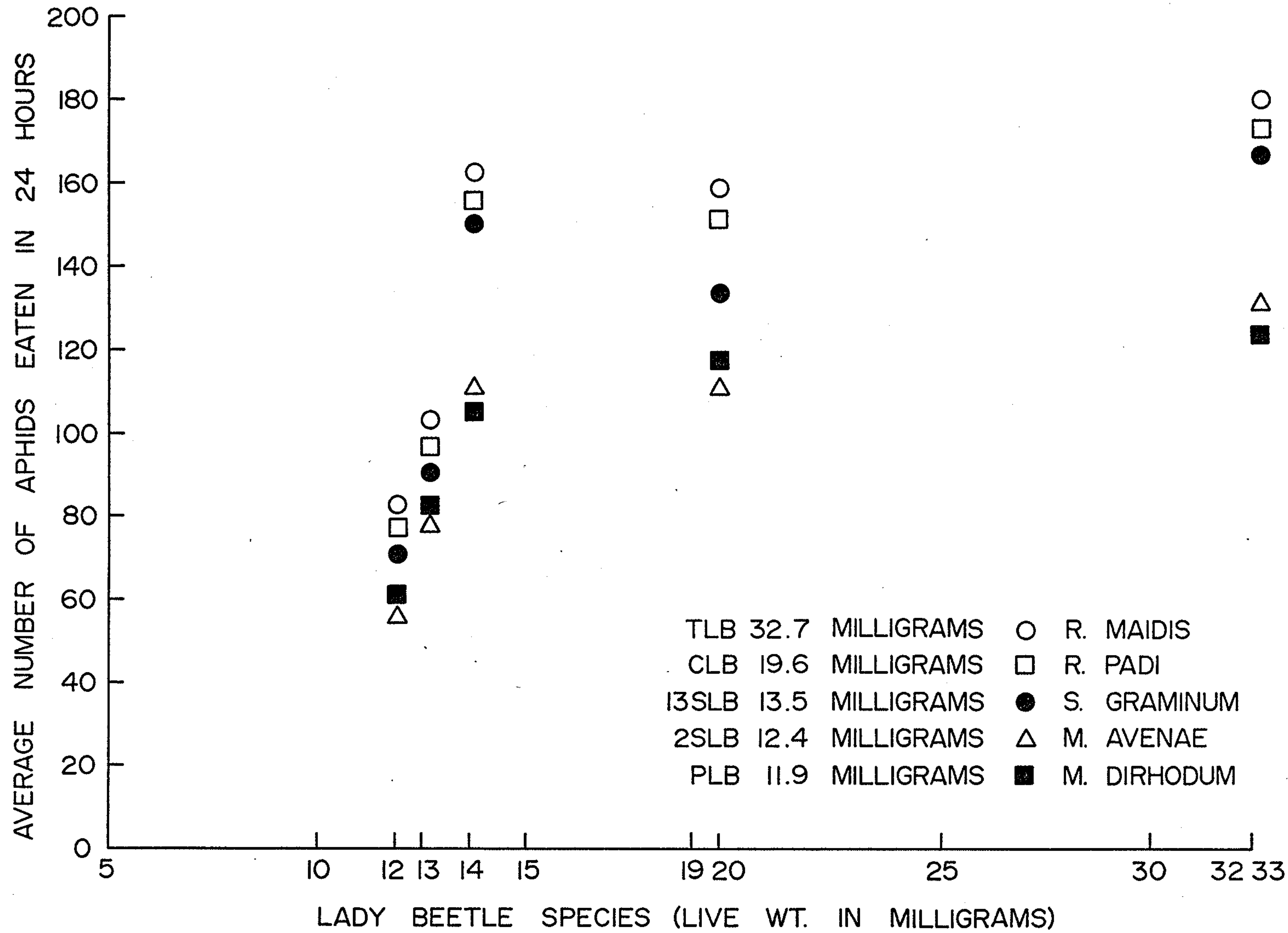
| Source of variation | d.f. | S.S. | Mean square | F | 5% | 1% |
|---|---|---|---|---|---|---|
| Lady beetle species | 4 | 0.49536318 | 0.12384079 | 72.34** | 2.45 | 3.48 |
| Aphid species | 4 | 2.11918524 | 0.52979631 | 309.49** | 2.45 | 3.48 |
| Aphid X lady beetle | 16 | 0.02635610 | 0.00164720 | .96 | 1.75 | 2.19 |
| Error | 100 | 0.17118040 | 0.00171180 | | | |
| Total | 124 | 2.81208492 | -- | | | |

*Logarithms of observed data were analyzed to show that apparent significant interaction, when whole numbers were used, was due to scaling (a wider range of aphids eaten by larger beetles as opposed to smaller ones). Data converted to logs show no significant interaction.

**Significant at 1% level.

FIGURE 9. The average number of third instar larvae of 5 aphid species eaten in 24 hours by individuals of 5 lady beetle species. Lady beetle species read from points on abscissa corresponding to average live weights.

TLB - Transverse lady beetle
CLB - Convergent lady beetle
13SLB - Thirteen spotted lady beetle
2SLB - Two spotted lady beetle
PLB - Parenthesis lady beetle


AVERAGE NUMBER OF APHIDS EATEN IN 24 HOURS
0
20
40
60
80
100
120
140
160
180
200
5
10
12
13
14
15
19
20
25
30
32
33
LADY BEETLE SPECIES (LIVE WT. IN MILLIGRAMS)
TLB 32.7 MILLIGRAMS
CLB 19.6 MILLIGRAMS
13SLB 13.5 MILLIGRAMS
2SLB 12.4 MILLIGRAMS
PLB 11.9 MILLIGRAMS
R. MAIDIS
R. PADI
S. GRAMINUM
M. AVENAE
M. DIRHODUM

species were fed on one aphid species for a period of ten days. Numbers of eggs produced in the last five days of this period were recorded every 24 hours and totalled. Table XXV shows the results for all four lady beetle species and the five aphid species, and Table XXVI gives a statistical analysis of the data. Figure 10 presents the data graphically. The results indicate that the number of eggs produced by females of each of the lady beetle species varies with the species of aphid consumed.

Numbers of aphids consumed by second, third and fourth instar larvae of four species of lady beetles reared on five species of aphids

In another series of tests, lady beetle larvae obtained from eggs produced in the laboratory were fed through the developmental period on one aphid species. First instar lady beetle larvae were not included in the tests until they had moulted once, because during the first instar the smaller species were not big enough to ingest third instar aphids. Tables XXVII, XXVIII and XXIX show the averages of the maximum numbers of aphids eaten in a 24 hour period throughout each instar by second, third and fourth larval instars of the lady beetles respectively. The greatest numbers of prey were consumed near the middle of each instar period, as observed by Smith (1965a). Table XXX shows a statistical analysis of the data from Tables XXVII, XXVIII and XXIX. Second instar larvae of the heavier adult beetles (Table XXVII) consumed more aphids than did

TABLE XXV

NUMBER OF EGGS LAID DURING THE SIXTH TO TENTH DAYS INCLUSIVE, BY FOUR ADULT LADY BEETLE SPECIES WHILE SUBSISTING FOR TEN DAYS ON A DIET OF EACH OF FIVE APHID SPECIES

| Lady beetle | Aphid | Number of Replicates | No. of eggs in 5 days Mean | Range |
|---|---|---|---|---|
| C. transversoguttata | R. maidis | 5 | 116±12.8 | 93-131 |
| | R. padi | 5 | 100±11.5 | 87-115 |
| | S. graminum | 5 | 98± 6.9 | 90-108 |
| | M. avenae | 5 | 25± 9.7 | 22- 56 |
| | M. dirhodum | 5 | 51±16.2 | 21- 70 |
| H. convergens | R. maidis | 5 | 110± 4.9 | 106-119 |
| | R. padi | 5 | 98±10.4 | 85-109 |
| | S. graminum | 5 | 106± 7.1 | 95-108 |
| | M. avenae | 5 | 96±12.1 | 84-117 |
| | M. dirhodum | 5 | 82± 7.6 | 73- 95 |
| H. tredecimpunctata tibialis | R. maidis | 5 | 123±17.1 | 101-151 |
| | R. padi | 5 | 90±12.4 | 82-103 |
| | S. graminum | 5 | 89±11.9 | 72-108 |
| | M. avenae | 5 | 88± 5.4 | 79- 89 |
| | M. dirhodum | 5 | 59±18.1 | 38- 82 |
| A. bipunctata | R. maidis | 5 | 79±19.3 | 61-111 |
| | R. padi | 5 | 76±11.1 | 67- 96 |
| | S. graminum | 5 | 35±14.6 | 17- 61 |
| | M. avenae | 5 | 33±11.4 | 22- 54 |
| | M. dirhodum | 5 | 42± 9.3 | 28- 57 |

TABLE XXVI

STATISTICAL ANALYSIS OF THE DATA IN TABLE XXV

| Source of variation | d.f. | S.S. | Mean Square | F | 5% | 1% |
|---|---|---|---|---|---|---|
| Lady beetle species | 3 | 27,502.16 | 9,167.34 | 4.96** | 2.76 | 4.13 |
| Aphid species | 4 | 38,065.64 | 9,516.41 | 5.15** | 2.53 | 3.65 |
| Aphid X lady beetle | 12 | 15,515.24 | 1,292.94 | 6.99** | 1.92 | 2.50 |
| Error | 80 | 14,783.20 | 184.79 | | | |
| Total | 99 | 96,466.24 | | | | |

**Significant at 1% level.

FIGURE 10. Number of eggs produced in five days by four lady beetle species, each fed for a period of ten days on one of five aphid species.

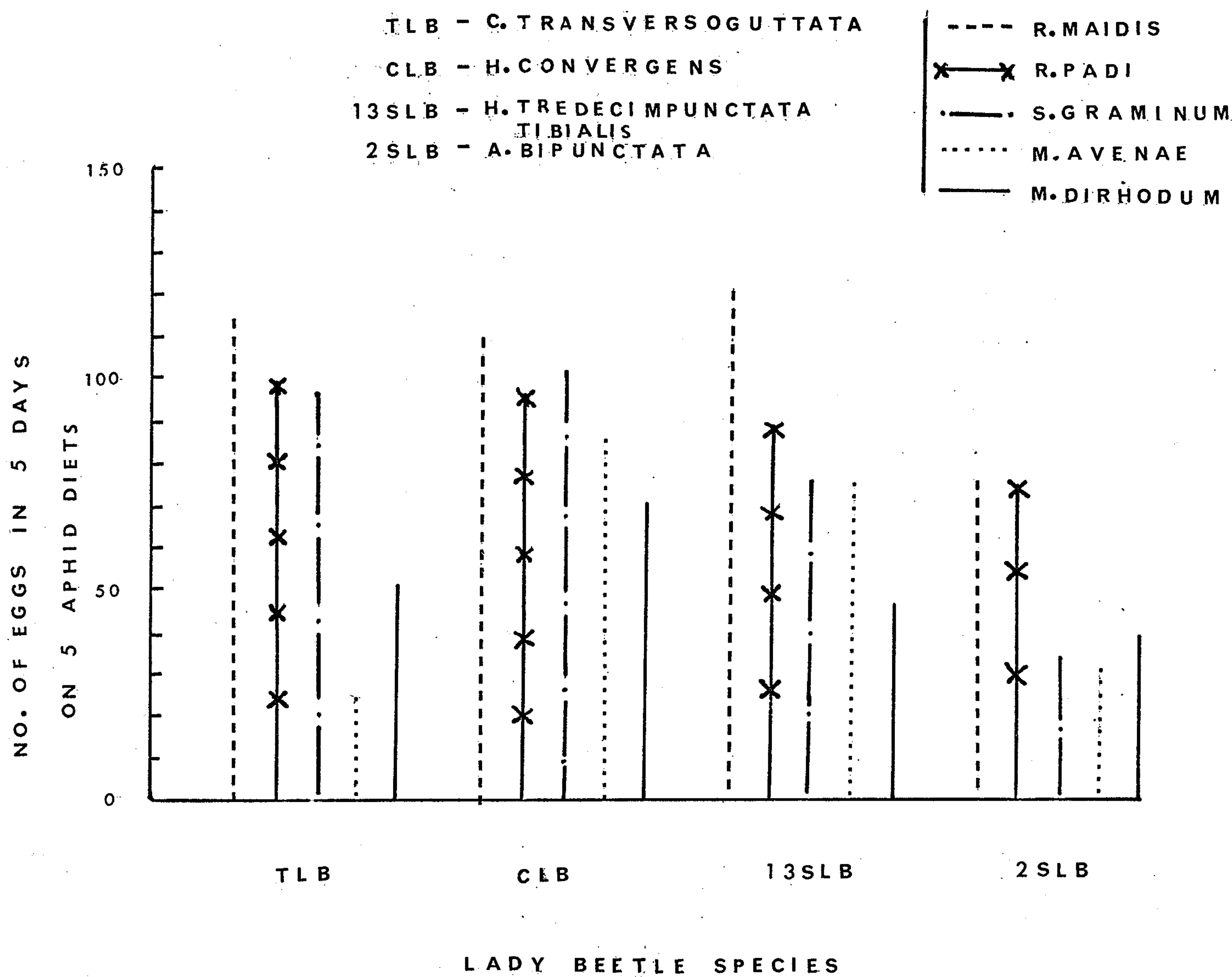

TLB - C. TRANSVERSOGUTTATA
CLB - H. CONVERGENS
13SLB - H. TREDECIMPUNCTATA TIBIALIS
2SLB - A. BIPUNCTATA
R. MAIDIS
R. PADI
S. GRAMINUM
M. AVENAE
M. DIRHODUM
NO. OF EGGS IN 5 DAYS ON 5 APHID DIETS
150
100
50
0
TLB
CLB
13SLB
2SLB
LADY BEETLE SPECIES

TABLE XXVII

THE AVERAGE NUMBER OF THIRD INSTAR LARVAL APHIDS CONSUMED BY SECOND INSTAR LARVAL LADY BEETLES

| Lady beetle | Aphid | Number of Replicates | Number eaten Mean | Number eaten Range |
|---|---|---|---|---|
| C. transversoguttata | R. maidis | 3 | 66± 3.7 | 62-71 |
| | R. padi | 3 | 44± 8.4 | 38-50 |
| | S. graminum | 3 | 46±10.6 | 39-54 |
| | M. avenae | 3 | 34± 4.2 | 31-37 |
| | M. dirhodum | 3 | 40± 6.6 | 31-47 |
| H. convergens | R. maidis | 3 | 34± 5.1 | 31-38 |
| | R. padi | 3 | 27± 6.4 | 22-31 |
| | S. graminum | 3 | 29± 6.4 | 20-35 |
| | M. avenae | 3 | 29± 6.4 | 22-25 |
| | M. dirhodum | 3 | 21± 3.7 | 18-24 |
| H. tredecimpunctata tibialis | R. maidis | 3 | 40± 9.2 | 33-46 |
| | R. padi | 3 | 38± 7.6 | 31-47 |
| | S. graminum | 3 | 38± 9.8 | 30-43 |
| | M. avenae | 3 | 33± 6.1 | 30-38 |
| | M. dirhodum | 3 | 32± 4.2 | 29-35 |
| A. bipunctata | R. maidis | 3 | 38± 3.7 | 36-41 |
| | R. padi | 3 | 37± 6.1 | 34-42 |
| | S. graminum | 3 | 33± 5.1 | 30-37 |
| | M. avenae | 3 | 25± 6.4 | 21-30 |
| | M. dirhodum | 3 | 25± 8.4 | 19-31 |

TABLE XXVIII

THE AVERAGE NUMBER OF THIRD INSTAR LARVAL APHIDS CONSUMED BY THIRD INSTAR LARVAL LADY BEETLES

| Lady beetle | Aphid | Number of replicates | Number eaten Mean | Number eaten Range |
|---|---|---|---|---|
| *C. transversoguttata* | R. maidis | 3 | 103± 6.7 | 96-112 |
| | R. padi | 3 | 89±10.1 | 75- 98 |
| | S. graminum | 3 | 79±13.1 | 66- 97 |
| | M. avenae | 3 | 48± 5.6 | 43- 56 |
| | M. dirhodum | 3 | 56± 4.5 | 51- 62 |
| *H. convergens* | R. maidis | 3 | 69±11.5 | 54- 82 |
| | R. padi | 3 | 59±13.7 | 42- 71 |
| | S. graminum | 3 | 54± 8.5 | 42- 61 |
| | M. avenae | 3 | 42± 7.2 | 35- 52 |
| | M. dirhodum | 3 | 41± 5.6 | 36- 49 |
| *H. tredecimpunctata tibialis* | R. maidis | 3 | 72± 3.7 | 68- 77 |
| | R. padi | 3 | 69± 8.1 | 58- 77 |
| | S. graminum | 3 | 72± 3.4 | 65- 76 |
| | M. avenae | 3 | 58± 8.6 | 46- 66 |
| | M. dirhodum | 3 | 58± 4.5 | 53- 64 |
| *A. bipunctata* | R. maidis | 3 | 68± 4.9 | 61- 72 |
| | R. padi | 3 | 62± 2.9 | 58- 65 |
| | S. graminum | 3 | 54± 5.7 | 49- 62 |
| | M. avenae | 3 | 52± 7.2 | 43- 61 |
| | M. dirhodum | 3 | 48± 6.9 | 39- 56 |

TABLE XXIX

THE AVERAGE NUMBER OF THIRD INSTAR LARVAL APHIDS CONSUMED BY FOURTH INSTAR LARVAL LADY BEETLES

| Lady beetle | Aphid | Number of Replicates | Number eaten Mean | Number eaten Range |
|---|---|---|---|---|
| *C. transversoguttata* | R. maidis | 3 | 144± 4.9 | 138-150 |
| | R. padi | 3 | 133±16.9 | 120-156 |
| | S. graminum | 3 | 126±20.9 | 102-153 |
| | M. avenae | 3 | 66± 9.9 | 57- 81 |
| | M. dirhodum | 3 | 76± 9.9 | 62- 84 |
| *H. convergens* | R. maidis | 3 | 90±10.8 | 80-103 |
| | R. padi | 3 | 83±14.6 | 66- 98 |
| | S. graminum | 3 | 79±13.1 | 63- 95 |
| | M. avenae | 3 | 63± 7.8 | 53- 72 |
| | M. dirhodum | 3 | 60± 8.1 | 51- 69 |
| *H. tredecimpunctata tibialis* | R. maidis | 3 | 109± 9.9 | 98-122 |
| | R. padi | 3 | 98± 6.4 | 89-104 |
| | S. graminum | 3 | 100±11.5 | 85-113 |
| | M. avenae | 3 | 87± 6.6 | 78- 94 |
| | M. dirhodum | 3 | 77± 8.8 | 68- 89 |
| *A. bipunctata* | R. maidis | 3 | 82±10.4 | 75- 88 |
| | R. padi | 3 | 81± 3.5 | 78- 86 |
| | S. graminum | 3 | 81± 8.4 | 69- 88 |
| | M. avenae | 3 | 66± 7.7 | 57- 76 |
| | M. dirhodum | 3 | 58± 8.8 | 46- 67 |

TABLE XXX

STATISTICAL ANALYSIS OF THE DATA IN
TABLES XXVII, XXVIII AND XXIX

| Source of variation | d.f. | S.S. | Mean square | F | 5% | 1% |
|---|---|---|---|---|---|---|
| Larval stage | 2 | 4.91 | 2.45 | 532.7** | 3.07 | 4.79 |
| Lady beetle species | 3 | 0.83 | 0.28 | 60.9** | 2.68 | 3.95 |
| Stage X lady beetle species | 6 | 0.05 | 0.01 | 1.7 | 2.10 | 2.96 |
| Aphid species | 4 | 0.99 | 0.24 | 53.3** | 2.45 | 3.48 |
| Lady beetle X aphid | 8 | 0.02 | 0.003 | 0.62 | 2.02 | 2.66 |
| Stage X aphid species | 12 | 0.16 | 0.01 | 2.83** | 1.83 | 2.34 |
| Stage X lady beetle X aphid | 24 | 0.06 | 0.003 | 0.58 | 1.61 | 1.95 |
| Error | 120 | 0.55 | 0.005 | | | |
| Total | 179 | 7.58 | | | | |

**Significant at 1% level.

the same larval stages of the lighter lady beetle species. Third instar larvae (Table XXVIII) also consumed more of *R. maidis*, and also the heavier lady beetle, *C. transversoguttata* ate more aphids than did the other lighter lady beetle species.

Table XXIX shows numbers consumed by fourth instar larvae of the lady beetles, but does not show that *C. transversoguttata* failed to complete development to pupation on *M. avenae* and *M. dirhodum*, and also that *A. bipunctata* did not complete development on a diet of *M. dirhodum*. As was the case in the two previous instars, greater numbers of *R. maidis* were consumed than of the other aphid species and the heavier lady beetle species ate more than the lighter ones. Figure 11 is a graphic representation of the data in Tables XXVII, XXVIII, and XXIX.

### Number of days spent in the larval and pupal stages for each of four species of lady beetles reared on five species of aphids

While the data were being recorded for Tables XXVII, XXVIII and XXIX, a record was kept for the time spent in larval and pupal stage. The data for larval development, including the first instar, are shown in Table XXXI. The statistical analysis shown in Table XXXII does not include cases where mortality occurred. Table XXXIII shows time spent in the pupal stages, with statistical analysis in Table XXXIV. The average length of time from egg to adult for the four lady

FIGURE 11. Log of number of aphids eaten by second, third and fourth instar larvae of four lady beetle species, each developing exclusively on a diet of a single aphid species.

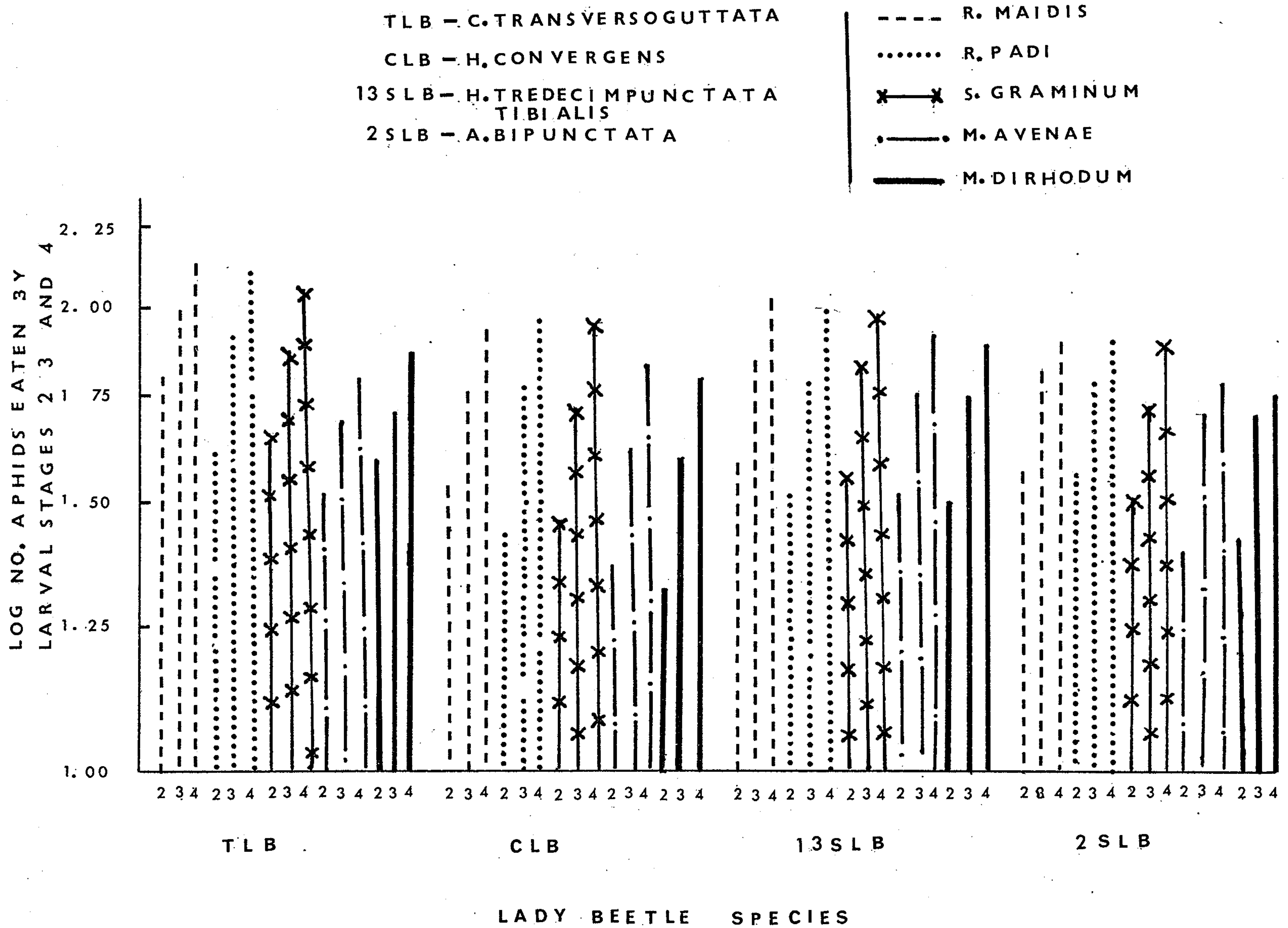

TLB — C. TRANSVERSOGUTTATA
CLB — H. CONVERGENS
13SLB — H. TREDECIMPUNCTATA TIBIALIS
2SLB — A. BIPUNCTATA
R. MAIDIS
R. PADI
S. GRAMINUM
M. AVENAE
M. DIRHODUM
LOG NO. APHIDS EATEN BY LARVAL STAGES 2 3 AND 4
2.25
2.00
1.75
1.50
1.25
1.00
TLB
CLB
13SLB
2SLB
LADY BEETLE SPECIES

TABLE XXXI

THE AVERAGE LENGTH OF LARVAL DEVELOPMENT FOR EACH OF FOUR SPECIES OF LADY BEETLES REARED ON EACH OF FIVE SPECIES OF APHIDS

| Lady beetle | Aphid | Number of Replicates | Number of days in larval stage Mean | Range |
|---|---|---|---|---|
| *C. transversoguttata* | R. maidis | 3 | 13.3± .46 | 13-14 |
| | R. padi | 3 | 14 | - |
| | S. graminum | 3 | 14.7± .46 | 14-15 |
| | M. avenae | 3 | Died in fourth instar; age 17 days | |
| | M. dirhodum | 3 | Died in fourth instar; age 17 days | |
| *H. convergens* | R. maidis | 3 | 10 | - |
| | R. padi | 3 | 10 | - |
| | S. graminum | 3 | 10 | - |
| | M. avenae | 3 | 10 | - |
| | M. dirhodum | 3 | 10 | - |
| *H. tredecimpunctata tibialis* | R. maidis | 3 | 10 ± .81 | 9-10 |
| | R. padi | 3 | 11 | - |
| | S. graminum | 3 | 10.7± .46 | 10-11 |
| | M. avenae | 3 | 10.3± .46 | 10-11 |
| | M. dirhodum | 3 | 10.3± .46 | 10-11 |
| *A. bipunctata* | R. maidis | 3 | 12 | - |
| | R. padi | 3 | 12 | - |
| | S. graminum | 3 | 12 | - |
| | M. avenae | 3 | 12 | - |
| | M. dirhodum | 3 | Died in fourth instar; age 12 days | |

TABLE XXXII

STATISTICAL ANALYSIS OF THE DATA IN TABLE XXXI

| Source of variation | d.f. | S.S. | Mean square | F | 5% | 1% |
|---|---|---|---|---|---|---|
| Lady beetle species | 3 | 86.1 | 28.70 | 171.86** | 3.01 | 4.72 |
| Aphid species | 2 | 1.7 | 0.85 | 5.09* | 3.40 | 5.61 |
| Aphid X lady beetle | 6 | 2.5 | 0.41 | 2.49 | 2.51 | 3.67 |
| Error | 24 | 4.0 | 0.16 | | | |
| Total | 35 | 94.3 | | | | |

**Significant at 1% level.

*Significant at 5% level.

TABLE XXXIII

THE AVERAGE DURATION OF THE PUPAL INSTAR FOR EACH OF FOUR SPECIES OF LADY BEETLES REARED ON EACH OF FIVE SPECIES OF APHIDS

| Lady beetle | Aphid | Number of Replicates | Number of days in pupa stage Mean | Range |
|---|---|---|---|---|
| C. transversoguttata | R. maidis | 3 | 6 ± .81 | 5-7 |
| | R. padi | 3 | 5.3± .46 | 5-6 |
| | S. graminum | 3 | 5.0± .81 | 4-6 |
| | M. avenae | 3 | Died in fourth instar | |
| | M. dirhodum | 3 | Died in fourth instar | |
| H. convergens | R. maidis | 3 | 4 | - |
| | R. padi | 3 | 4 | - |
| | S. graminum | 3 | 4 | - |
| | M. avenae | 3 | 4 | - |
| | M. dirhodum | 3 | 4 | - |
| H. tredecimpunctata tibialis | R. maidis | 3 | 4.7± .46 | 4-5 |
| | R. padi | 3 | 4 | - |
| | S. graminum | 3 | 4 | - |
| | M. avenae | 3 | 4 | - |
| | M. dirhodum | 3 | 5.7± .81 | 5-6 |
| A. bipunctata | R. maidis | 3 | 5 | - |
| | R. padi | 3 | 5 | - |
| | S. graminum | 3 | 6 | - |
| | M. avenae | 3 | 6 | - |
| | M. dirhodum | 3 | Died in fourth instar | |

TABLE XXXIV

STATISTICAL ANALYSIS OF THE DATA IN TABLE XXXIII

| Source of variation | d.f. | S.S. | Mean square | F | 5% | 1% |
|---|---|---|---|---|---|---|
| Lady beetle species | 3 | 14.7 | 4.9 | 22.3** | 3.01 | 4.72 |
| Aphid species | 2 | 0.7 | 0.35 | 1.59 | 3.40 | 5.61 |
| Aphid X lady beetle | 6 | 4.1 | 0.68 | 3.10* | 2.51 | 3.67 |
| Error | 24 | 5.3 | 0.22 | | | |
| Total | 35 | 24.8 | | | | |

* Significant at 5% level.
**Significant at 1% level.

beetles reared on the five species of aphids is given in Table XXXV, with statistical analysis in Table XXXVI. Figure 12 is a graphic portrayal of the data from Table XXXV.

*H. convergens* developed faster than the other three lady beetles (Table XXXI). *C. transversoguttata* developed faster on *R. maidis* than on *S. graminum* or *R. padi* and did not complete larval development on *M. avenae* or *M. dirhodum*. *H. convergens* and *H. tredecimpunctata tibialis* completed larval development on all five species of aphids, but *Adalia bipunctata* could not finish larval development on *M. dirhodum*. In the three instances where larvae did not complete development, mortality occurred in the fourth instar, either because they could no longer ingest the food provided, or because of low nutritive value of the food, or both as suggested by Blackman (1965, 1967).

Table XXXIII shows the duration of the pupal stage, after having completed larval development on the various species of aphids. *C. transversoguttata* that developed on *R. maidis* spent slightly longer time in the pupal stage than those that developed on *R. padi* and *S. graminum*. *H. convergens* and *H. tredecimpunctata tibialis* spent about the same time in the pupal stage (4 days) for all aphid species, except that the latter spent a longer time as a pupa when fed on *R. maidis* and *M. dirhodum*. *A. bipunctata* spent five days in the pupal stage when fed as a larva on *R. maidis* and *R. padi*, and six days when fed as larva on *S. graminum* and *M. avenae*.

Table XXXV shows total time from egg to adult for each of the four lady beetles reared on five species of aphids. *H. convergens* developed faster on all species of aphids than any of the other three lady beetles. It passed through all larval instars and the pupal stage in 14 days. *H. tredecimpunctata tibialis* required slightly longer development times (14 - 16 days), *A. bipunctata* 17 - 18 days, and *C. transversoguttata* 18 - 20 days.

Based on voracity, *H. convergens* and *H. tredecimpunctata tibialis* appeared to be effective predators of all five species of aphids. It is interesting that they are commonly collected species in grain fields in Manitoba. Table XXXVII shows percentage collected of the five species of lady beetles in barley fields in 1968 and 1969.

TABLE XXXV

THE TOTAL DURATION OF LARVAL AND PUPAL DEVELOPMENT FOR EACH OF FOUR SPECIES OF LADY BEETLES REARED ON EACH OF FIVE SPECIES OF APHIDS

| Lady beetle | Aphid | Number of Replicates | Number of days from egg-adult Mean | Range |
|---|---|---|---|---|
| C. transversoguttata | R. maidis | 3 | 19.3± .46 | 19-20 |
| | R. padi | 3 | 19.3± .46 | 19-20 |
| | S. graminum | 3 | 18.7± .87 | 18-19 |
| | M. avenae | 3 | Died in fourth instar | |
| | M. dirhodum | 3 | Died in fourth instar | |
| H. convergens | R. maidis | 3 | 14 | - |
| | R. padi | 3 | 14 | - |
| | S. graminum | 3 | 14 | - |
| | M. avenae | 3 | 14 | - |
| | M. dirhodum | 3 | 14 | - |
| H. tredecimpunctata tibialis | R. maidis | 3 | 14.7± .46 | 14-15 |
| | R. padi | 3 | 15 | - |
| | S. graminum | 3 | 14.7± .46 | 14-15 |
| | M. avenae | 3 | 14.3± .46 | 14-15 |
| | M. dirhodum | 3 | 16 | - |
| A. bipunctata | R. maidis | 3 | 17 | |
| | R. padi | 3 | 17 | |
| | S. graminum | 3 | 18 | |
| | M. avenae | 3 | 18 | |
| | M. dirhodum | 3 | Died in fourth instar | |

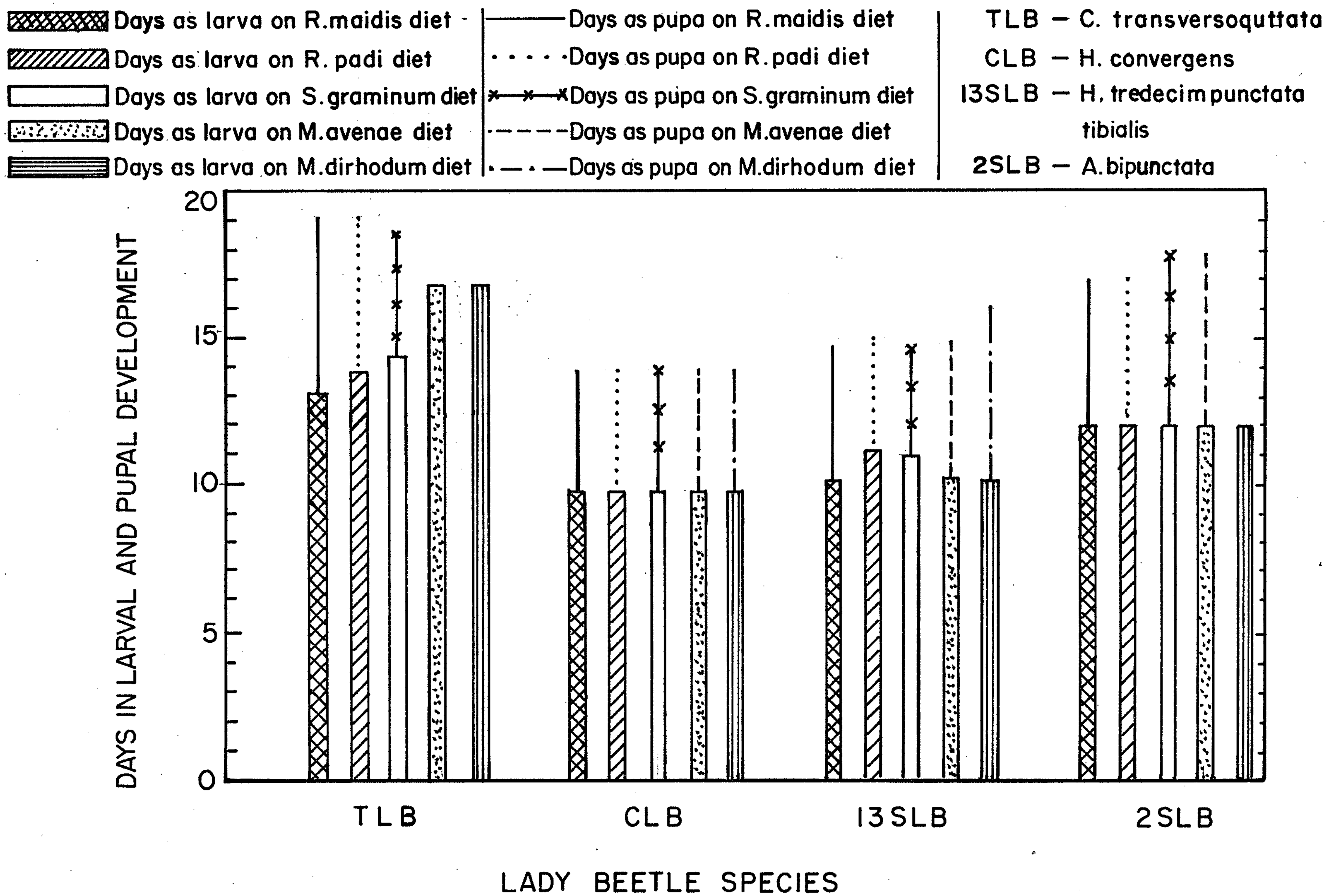
TABLE XXXVI

STATISTICAL ANALYSIS OF THE DATA IN TABLE XXXV

| Source of variation | d.f. | S.S. | Mean square | F | 5% | 1% |
|---|---|---|---|---|---|---|
| Lady beetle species | 3 | 143.66 | 47.89 | 354.74** | 3.01 | 4.72 |
| Aphid species | 2 | 0.05 | 0.02 | 0.18 | 3.40 | 5.61 |
| Aphid X lady beetle | 6 | 4.28 | 0.71 | 5.28** | 2.51 | 3.67 |
| Error | 24 | 3.23 | 0.13 | | | |
| Total | 35 | 151.22 | | | | |

**Significant at 1% level.

FIGURE 12. Number of days spent in larval and pupal stages by four lady beetle species developing on diets of five species of aphids.



Days as larva on R.maidis diet
Days as larva on R. padi diet
Days as larva on S.graminum diet
Days as larva on M.avenae diet
Days as larva on M.dirhodum diet
Days as pupa on R.maidis diet
Days as pupa on R.padi diet
Days as pupa on S.graminum diet
Days as pupa on M.avenae diet
Days as pupa on M.dirhodum diet
TLB — C. transversoquttata
CLB — H. convergens
13SLB — H. tredecimpunctata tibialis
2SLB — A.bipunctata
DAYS IN LARVAL AND PUPAL DEVELOPMENT
20
15
10
5
0
TLB
CLB
13SLB
2SLB
LADY BEETLE SPECIES

TABLE XXXVII

THE RELATIVE NUMBER (PER CENT) OF LADY BEETLE SPECIES COLLECTED IN A 100 FOOT STRAIGHT LINE TRANSECT, PREYING ON APHIDS ON BARLEY IN 1968 AND 1969 (5 REPLICATES EACH YEAR DURING PEAK LADY BEETLE POPULATION)

| Lady beetle predator | M. avenae dominant aphid prey on barley in 1968 | R. maidis dominant aphid prey on barley in 1969 |
|---|---|---|
| H. tredecimpunctata tibialis | 52.0% | 62.4% |
| H. convergens | 43.8% | 14.6% |
| C. transversoguttata | 4.2% | 20.8% |
| A. bipunctata | - | 1.1% |
| H. parenthesis | - | 1.1% |

CHAPTER VI

# SURVEYS OF PREDATORS AND PARASITES OF APHIDS ON AGRICULTURAL CROPS, ORNAMENTALS AND WEEDS AT WINNIPEG, 1968 AND 1969

During 1968 and 1969 predators and parasites of aphids were collected at every opportunity. Results of these collections are shown in Tables XXXVIII and XXXIX with aphid host for each predator or parasite, the plant on which the aphids were feeding and the months during which they were collected. The predators and parasites are listed in alphabetical order. The host plants are designated as agricultural crop, tree or shrub, or weed. In Table XXXIX both primary parasites and hyperparasites are given. Table XL shows the Orders and Families to which each predator or parasite belongs.

While these lists of predators and parasites of aphids are by no means exhaustive for Manitoba, they are indicative of the more important Families of predators and parasites and also probably contain most of those which prey on aphids found on cereal crops. Most numerous in species of the predators are the lady beetles (Coccinellidae) followed by syrphids (Syrphidae), lacewings (Neuroptera), anthocorids (Anthocoridae) and chamaemyiids (Chamaemyiidae). Parasites

TABLE XXXVIII

PREDATORS OF SOME MANITOBA APHIDS

| Predator | Prey | Host Plant | Date |
|---|---|---|---|
| Adalia bipunctata (L.) | Drepanaphis acerifoliae (Thomas) | Acer negundo (T.S.) | June-July |
| | Macrosiphum avenae (Fabricius) | Avena sativa (A.) | July-Sept. |
| | | Hordeum vulgare (A.) | June-Sept. |
| | | Triticum aestivum (A.) | June-Sept. |
| | Rhopalosiphum maidis (Fitch) | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Triticum aestivum | June-Sept. |
| | Schizaphis graminum (Rondani) | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Triticum aestivum | June-Sept. |
| | Metopolophium dirhodum (Walker) | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Prunus sp. (T.S.) | July |
| | | Triticum aestivum | June-Sept. |
| | Rhopalosiphum padi (L.) | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Prunus sp. | June-Sept. |
| | | Triticum aestivum | June-Sept. |
| | Calaphis sp. | Betula sp. (T.S.) | June-July |

TABLE XXXVIII (Continued)

| Predator | Prey | Host Plant | Date |
|---|---|---|---|
| | Betulaphis quadrituberculata (Kaltenbach) | Betula sp. | June-July |
| | Euceraphis sp. | Betula sp. | June-July |
| | Acyrthosiphon caraganae (Cholodkovsky) | Caragana sp. (T.S.) | June-July |
| | Dactynotus cirsii (L.) | Cirsium arvense (W.) | July-Sept. |
| | Aphis helianthi (Monell) | Cornus stolonifera (T.S.) | June-Aug. |
| | Aphis neogillettei Palmer | Cornus stolonifera | June-July |
| | Rhopalosiphum fitchii (Sanderson) | Cotoneaster sp. (T.S.) | June-Aug. |
| | | Crataegus sp. (T.S.) | June |
| | | Malus sp. (T.S.) | July |
| | Aphis pomi De Geer | Cotoneaster acutifolia | June |
| | | Sorbus sp. (T.S.) | June |
| | Rhopalosiphum rufulum (Richards) | Crataegus sp. | June |
| | Capitophorus hippophaes (Walker) | Eleagnus angustifolia (T.S.) | June-July<br>Sept.-Oct. |
| | | Eleagnus commutata (T.S.) | June-July |
| | | Shepherdia argentea (T.S.) | June |

TABLE XXXVIII (Continued)

| Predator | Prey | Host Plant | Date |
|---|---|---|---|
| | Rhopalomyzus lonicerae (Siebold) | Philadelphus sp. (T.S.) | June-July |
| | Cinara pinea (Mordvilko) | Pinus sylvestris (T.S.) | June-July |
| | Chaitophorus populifolii (Essig.) | Populus sp. (T.S.) | June-July |
| | Aphis maculatae Oestlund | Populus sp. | June |
| | Rhopalosiphum nymphaeae (L.) | Prunus sp. | June-Sept. |
| | Hyalopterus pruni (Geoffroy) | Prunus sp. | Sept. |
| | Stegophylla quercicola (Monell) | Quercus sp. (T.S.) | June |
| | Aphis nasturtii Kaltenbach | Rhamnus davurica | June |
| | Kakimia cynosbati (Oestlund) | Ribes alpinum (T.S.)<br>Ribes aureum (T.S.) | June<br>July |
| | Kakimia ribiella (Davis) | Ribes aureum | June-July |
| | Macrosiphum euphorbiae (Thomas) | Rosa sp. (T.S.) | July |
| | Chaetosiphon fragaefolii (Cockerell) | Rosa sp. | July |

TABLE XXXVIII (Continued)

| Predator | Prey | Host Plant | Date |
|---|---|---|---|
| | Cavariella aegopodii (Scopoli) | Salix sp. (T.S.) | June |
| | Eriosoma americanum (Riley) | Ulmus americana (T.S.) | June-July |
| | Myzocallis ulmifolii (Monell) | Ulmus americana | June |
| | Neoceruraphis viburnicola (Gillette) | Viburnum sp. | June |
| Adalia disjuncta (Rand) | Aphis helianthii | Cornus stolonifera | June-Aug. |
| | Rhopalosiphum fitchii | Cotoneaster sp.<br>Crataegus sp. | June-Aug.<br>June-Sept. |
| | Rhopalosiphum rufulum | Crataegus sp. | June |
| | Rhopalosiphum maidis | Hordeum vulgare | June-Sept. |
| | Neoceruraphis viburnicola | Viburnum sp. | June |
| Adalia frigida (Schn.) | Aphis neogillettei | Cornus stolonifera | June-July |
| | Macrosiphum avenae | Hordeum vulgare | June-Sept. |
| | Rhopalosiphum maidis | Hordeum vulgare | June-Sept. |

TABLE XXXVIII (Continued)

| Predator | Prey | Host Plant | Date |
|---|---|---|---|
| | Chaitophorus populifolii | Populus sp. | June-July |
| | Aphis nasturtii Kaltenbach | Rhammus davurica | June |
| Anisocalvia-12-maculata Gebl. | Chaitophorus populifolii | Populus sp. | June-July |
| Anthocoris sp. | Cavariella aegopodii | Salix sp. | June |
| Chrysopa carnea Stephens | Macrosiphum avenae | Avena sativa<br>Hordeum vulgare | June-Sept.<br>June-Sept. |
| | Acyrthosiphon caraganae | Caragana sp. | June-July |
| | Aphis helianthi | Cornus stolonifera | June-Aug. |
| | Aphis neogillettei | Cornus stolonifera | June-July |
| | Rhopalosiphum fitchii | Cotoneaster | June-Aug. |
| | Aphis pomi | Cotoneaster acutifolia | June-Aug. |
| | Metopolophium dirhodum | Hordeum vulgare | June-Sept. |
| | Chaitophorus populifolii | Populus sp. | June-July |
| | Rhopalosiphum padi | Prunus sp. | June-Sept. |

TABLE XXXVIII (Continued)

| Predator | Prey | Host Plant | Date |
|---|---|---|---|
| | Kakimia ribiella | Ribes aureum | June-July |
| | Macrosiphum euphorbiae | Rosa sp. | July |
| | Cavariella aegopodii | Salix sp. | June |
| | Eriosoma americanum | Ulmus americana | June-July |
| | Myzocallis ulmifolii | Ulmus americana | June-July |
| | Neoceruraphis viburnicola | Viburnum sp. | June |
| Chrysopa oculata Say | Macrosiphum avenae | Avena sativa<br>Hordeum vulgare | June-Sept.<br>June-Sept. |
| | Acyrthosiphon caraganae | Caragana sp. | June-July |
| | Aphis helianthi | Cornus stolonifera | June-Aug. |
| | Aphis neogillettei | Cornus stolonifera | June-July |
| | Rhopalosiphum fitchii | Cotoneaster sp. | June-Aug. |
| | Aphis pomi | Cotoneaster acutifolia | June-Aug. |
| | Metopolophium dirhodum | Hordeum vulgare | June-Sept. |
| | Rhopalosiphum padi | Prunus sp. | June-Sept. |

TABLE XXXVIII (Continued)

| Predator | Prey | Host Plant | Date |
|---|---|---|---|
| | Kakimia ribiella | Ribes aureum | June-July |
| | Neoceruraphis viburnicola | Viburnum sp. | June |
| Cleis picta (Rand.) | Macrosiphum avenae | Hordeum vulgare | June-Sept. |
| Coccinella transverso-guttata Falderman | Macrosiphum avenae | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Triticum aestivum | June-Sept. |
| | Rhopalosiphum maidis | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Triticum aestivum | June-Sept. |
| | Schizaphis graminum | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Triticum aestivum | June-Sept. |
| | Metopolophium dirhodum | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Prunus sp. | July |
| | | Triticum aestivum | June-Sept. |
| | Rhopalosiphum padi | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Prunus sp. | June-Sept. |
| | | Triticum aestivum | June-Sept. |

TABLE XXXVIII (Continued

| Predator | Prey | Host Plant | Date |
|---|---|---|---|
| | Calaphis sp. | Betula sp. | June-July |
| | Acyrthosiphon caraganae | Caragana sp. | June-July |
| | Dactynotus cirsii (L.) | Cirsium arvense | July-Sept. |
| | Aphis helianthi Monell | Cornus stolonifera | June-Aug. |
| | Rhopalosiphum fitchii | Crataegus sp. | June |
| | Rhopalosiphum rufulum | Crataegus sp. | June |
| | Kakimia robinsoni Richards | Delphinium sp. (A.) | June |
| | Capitophorus hippophaes | Eleagnus commutata | June |
| | Macrosiphum euphorbiae | Fragaria sp. (A.) | July |
| | Aphis fabae Scopoli | Philadelphus sp. (T.S.) | June-July |
| | Aphis nasturtii | Rhamnus davurica | June |
| | Macrosiphum euphorbiae | Rosa sp. | July |
| | Dactynotus sp. | Solidago sp. (W.) | Aug.-Sept. |
| Coccinella trifasciata L. | Aphis nasturtii | Rhamnus davurica | June |

TABLE XXXVIII (Continued)

| Predator | Prey | Host Plant | Date |
|---|---|---|---|
| Deraecoris aphidiphagus Knight | Eriosoma americanum | Ulmus americana | June-July |
| Deraecoris fasciolus Knight | Neoceruraphis viburnicola | Viburnum sp. | June |
| Hippodamia convergens Guerin | Macrosiphum avenae | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Triticum aestivum | June-Sept. |
| | Rhopalosiphum maidis | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Triticum aestivum | June-Sept. |
| | Schizaphis graminum | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Triticum aestivum | June-Sept. |
| | Metopolophium dirhodum | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Prunus sp. | July |
| | | Triticum aestivum | June-Sept. |
| | Rhopalosiphum padi | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Prunus sp. | June-Sept. |
| | | Triticum aestivum | June-Sept. |
| | Calaphis sp. | Betula sp. | June-July |

TABLE XXXVIII (Continued)

| Predator | Prey | Host Plant | Date |
|---|---|---|---|
| | Euceraphis sp. | Betula sp. | June-July |
| | Myzus persicae (Sulzer) | Brassica oleracea (A.) | July-Sept. |
| | Acyrthosiphon caraganae | Caragana sp. | June-July |
| | Dactynotus cirsii | Cirsium arvense | July-Sept. |
| | Aphis helianthi | Cornus stolonifera | June-Aug. |
| | Aphis neogillettei | Cornus stolonifera | June-July |
| | Rhopalosiphum fitchii | Cotoneaster sp. | June-Aug. |
| | | Crataegus sp. | June |
| | Aphis pomi | Cotoneaster acutifolia | June |
| | Rhopalosiphum rufulum | Crataegus sp. | June |
| | Capitophorus hippophaes | Eleagnus commutata | June-July |
| | Macrosiphum euphorbiae | Lactuca scariola (W.) | August |
| | Acyrthosiphon pisum (Harris) | Medicago sativa (A.) | July-Aug. |
| | | Melilotus sp. (A.) | July-Aug. |
| | Chaitophorus populifolii | Populus sp. | June-July |

TABLE XXXVIII (Continued)

| Predator | Prey | Host Plant | Date |
|---|---|---|---|
| | Aphis nasturtii | Rhamnus davurica | June |
| | Hyperomyzus lactucae (L.) | Taraxacum officinale (W.) | Aug.-Sept. |
| | Eriosoma americanum | Ulmus americana | June-July |
| | Myzocallis ulmifolii | Ulmus americana | June |
| | Neoceruraphis viburnicola | Viburnum sp. | June |
| Hippodamia parenthesis (Say) | Rhopalosiphum maidis | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Triticum aestivum | June-Sept. |
| | Calaphis sp. | Betula sp. | June-July |
| | Dactynotus cirsii | Cirsium arvense | July-Sept. |
| | Rhopalosiphum fitchii | Cotoneaster sp. | June-Aug. |
| | | Crataegus sp. | June |
| | Rhopalosiphum rufulum | Crataegus sp. | June |
| | Macrosiphum avenae | Hordeum vulgare | June |
| Hippodamia tredecimpunctata tibialis Say | Macrosiphum avenae | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Triticum aestivum | June-Sept. |

TABLE XXXVIII (Continued)

| Predator | Prey | Host Plant | Date |
|---|---|---|---|
| | Rhopalosiphum maidis | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Triticum aestivum | June-Sept. |
| | Schizaphis graminum | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Triticum aestivum | June-Sept. |
| | Metopolophium dirhodum | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Prunus sp. | July |
| | | Triticum aestivum | June-Sept. |
| | Rhopalosiphum padi | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | | Prunus sp. | June-Sept. |
| | | Triticum aestivum | June-Sept. |
| | Calaphis sp. | Betula sp. | June-July |
| | Euceraphis sp. | Betula sp. | June-July |
| | Macrosiphum euphorbiae | Brassica sp. (W.) | July-Aug. |
| | Acyrthosiphon caraganae | Caragana sp. | June-July |
| | Dactynotus cirsii | Cirsium arvense | July-Sept. |
| | Aphis helianthi | Cornus stolonifera | June-Aug. |

TABLE XXXVIII (Continued)

| Predator | Prey | Host Plant | Date |
|---|---|---|---|
| | Aphis neogillettei | Cornus stolonifera | June-July |
| | Rhopalosiphum fitchii | Cotoneaster sp.<br>Crataegus sp.<br>Malus sp. | June-Aug.<br>June<br>July |
| | Macrosiphum euphorbiae | Rosa sp. | July |
| | Cavariella aegopodii | Salix sp. | June |
| | Hyperomyzus lactucae | Sonchus oleraceus (W.)<br>Taraxacum officinale | Aug.-Sept.<br>Aug.-Sept. |
| | Eriosoma americanum | Ulmus americana | June-July |
| | Myzocallis ulmifolii | Ulmus americana | June |
| | Aphis craccae (L.) | Vicia craccae (W.) | July-Aug. |
| Leucopis americana Malloch | Capitophorus hippophaes | Eleagnus commutata | June-July |
| Leucopis (Leucopis) n.sp. | Acyrthosiphon caraganae | Caragana sp. | June-July |
| | Aphis neogillettei | Cornus stolonifera | June-July |
| | Rhopalosiphum fitchii | Crataegus sp. | June |
| | Rhopalosiphum padi | Prunus sp. | June-Sept. |

TABLE XXXVIII (Continued)

| Predator | Prey | Host Plant | Date |
|---|---|---|---|
| | Macrosiphum euphorbiae | Rosa sp. | July |
| | | Spiraea sp. | June-July |
| | Cavariella aegopodii | Salix sp. | June |
| | Neoceruraphis viburnicola | Viburnum sp. | June |
| Metasyrphus sp. | Acyrthosiphon caraganae | Caragana sp. | June-July |
| | Aphis helianthi Monell | Cornus stolonifera | June-Aug. |
| | Aphis neogillettei | Cornus stolonifera | June-July |
| | Macrosiphum avenae | Hordeum vulgare | June-Sept. |
| | Macrosiphum euphorbiae | Rosa sp. | July |
| Platycheirus sp. | Macrosiphum avenae | Hordeum vulgare | June-Sept. |
| | Rhopalosiphum maidis | Hordeum vulgare | June-Sept. |
| Scaeva pyrastri L. | Rhopalosiphum maidis | Hordeum vulgare | June-Sept. |
| Sphaerophoria contiqua Macq. | Macrosiphum avenae | Avena sativa | June-Sept. |
| | | Hordeum vulgare | June-Sept. |
| | Rhopalosiphum maidis | Hordeum vulgare | June-Sept. |
| | Metopolophium dirhodum | Hordeum vulgare | June-Sept. |

TABLE XXXVIII (Continued)

| Predator | Prey | Host Plant | Date |
|---|---|---|---|
| Sphaerophoria robusta | Macrosiphum avenae | Avena sativa<br>Hordeum vulgare | June-Sept.<br>June-Sept. |
| | Rhopalosiphum maidis | Hordeum vulgare | June-Sept. |
| | Metopolophium dirhodum | Hordeum vulgare | June-Sept. |
| Syrphus bigelowi Curran | Rhopalosiphum padi | Prunus sp. | June-Sept. |
| Syrphus vitripennis Meigen | Dactynotus cirsii | Cirsium arvense | July-Sept. |
| | Aphis pomi | Cotoneaster acutifolia | June-Aug. |
| | Rhopalosiphum fitchii | Crataegus sp. | June |
| | Capitophorus hippophaes | Eleagnus commutata | June-July |
| | Rhopalosiphum padi | Prunus sp. | June-Sept. |
| | Aphis nasturtii | Rhamnus davurica | June |
| | Macrosiphum euphorbiae | Rosa sp. | July |
| | Neoceruraphis viburnicola | Viburnum sp. | June |
| Tetraphleps latipennis Van D. | Rhopalosiphum fitchii | Crataegus sp. | June |

TABLE XXXVIII (Continued)

| Predator | Prey | Host Plant | Date |
|---|---|---|---|
| | Eriosoma americanum | Ulmus americana | June-July |

A - Agricultural Crop
TS - Tree or Shrub
W - Weed

TABLE XXXIX

PARASITES OF SOME MANITOBA APHIDS

| Parasite | Prey | Host Plant | Date |
|---|---|---|---|
| Adialytus salicaphis Fitch | Chaitophorus populifolii (Essig) | Populus sp. (T.S.) | June-July |
| Alloxysta sp. | Macrosiphum avenae (Fabricius) | Hordeum vulgare (A.) | June-Sept. |
| Aphelinus mali (Hald.) | Macrosiphum avenae | Avena sativa (A.)<br>Hordeum vulgare<br>Triticum aestivum | June-Sept.<br>June-Sept.<br>June-Sept. |
| | Metopolophium dirhodum (Walker) | Avena sativa<br>Hordeum vulgare<br>Triticum aestivum | June-Sept.<br>June-Sept.<br>June-Sept. |
| | Schizaphis graminum (Rondani) | Hordeum vulgare | June-Sept. |
| Aphelinus sp. | Eriosoma americanum (Riley) | Ulmus americana (T.S.) | June-July |
| Aphidius aquilus Mackauer | Calaphis sp. | Betula sp. (T.S.) | June-July |
| | Betulaphis quadrituberculata (Kaltenbach) | Betula sp. | June-July |
| | Euceraphis sp. | Betula sp. | June-July |

TABLE XXXIX (Continued)

| Parasite | Prey | Host Plant | Date |
|---|---|---|---|
| Aphidius avenaphis (Fitch) | Macrosiphum avenae | Avena sativa | July-Sept. |
| | | Hordeum vulgare | July-Sept. |
| | Metopolophium dirhodum | Avena sativa | July-Sept. |
| | | Hordeum vulgare | July-Sept. |
| | | Triticum aestivum | July-Sept. |
| | Rhopalosiphum padi (L.) | Hordeum vulgare | July-Sept. |
| | Schizaphis graminum | Hordeum vulgare | July-Sept. |
| Aphidius polygonaphis Fitch | Dactynotus sp. | Ambrosia sp. (W.) | June-July |
| Aphidius pulcher Baker | Acyrthosiphon caraganae (Cholodkovsky) | Caragana sp. (T.S.) | June-July |
| Aphidius sp. | Macrosiphum geranii Oestlund | Geranium sp. (A.) | July |
| | Rhopalomyzus lonicerae (Siebold) | Lonicera sp. (T.S.) | August |
| | Kakimia ribiella (Davis) | Ribes aureum (T.S.) | June-July |
| Asaphes fletcheri (Ashmead) | Macrosiphum avenae | Avena sativa | July-Sept. |
| | | Hordeum vulgare | July-Sept. |

TABLE XXXIX (Continued)

| Parasite | Prey | Host Plant | Date |
|---|---|---|---|
| | Metopolophium dirhodum | Avena sativa | July-Sept. |
| | | Hordeum vulgare | July-Sept. |
| | | Rosa sp. (T.S.) | July |
| | | Triticum aestivum | July-Sept. |
| | Kakimia ribiella | Ribes aureum | June-July |
| | Cavariella aegopodii (Scopoli) | Salix sp. (T.S.) | June |
| | Myzocallis ulmifolii (Monell) | Ulmus americana (T.S.) | June-July |
| Binodoxys carolinensis Smith | Aphis helianthi Monell | Cornus stolonifera(T.S.) | June-Aug. |
| | Aphis neogillettei Palmer | Cornus stolonifera | June-July |
| Charips sp. | Betulaphis quadrituberculata | Betula sp. | June-July |
| | Euceraphis sp. | Betula sp. | June-July |
| | Acyrthosiphon caraganae | Caragana sp. | June-July |
| | Dactynotus cirsii (L.) | Cirsium arvense (W.) | June-Aug. |
| | Aphis helianthi | Cornus stolonifera | June-July |
| | Aphis neogillettei | Cornus stolonifera | June-July |

TABLE XXXIX (Continued)

| Parasite | Prey | Host Plant | Date |
|---|---|---|---|
| | Aphis pomi De Geer | Cotoneaster acutifolia (T.S.) | June-Aug. |
| | Rhopalosiphum fitchii (Sanderson) | Crataegus sp. (T.S.) | June |
| | Kakimia robinsoni Richards | Delphinium sp. (A.) | June |
| | Rhopalosiphum maidis (Fitch) | Hordeum vulgare | July-Sept. |
| | Chaitophorus populifolii (Essig) | Populus sp. | June-July |
| | Macrosiphum avenae | Triticum aestivum | June-Sept. |
| | Neoceruraphis viburnicola (Gillette) | Viburnum sp. | June |
| Diaretiella rapae McIntosh | Rhopalosiphum fitchii | Crataegus sp. | June |
| Diplazon laetatorius (F.) | Neoceruraphis viburnicola | Viburnum sp. | June |
| Ephedrus sp. | Macrosiphum avenae | Hordeum vulgare | July-Sept. |
| Euaphidius cinqualatus Ruthe | Cavariella aegopodii | Salix sp. | June |
| Lygocerus sp. | Euceraphis sp. | Betula sp. | June-July |

TABLE XXXIX (Continued)

| Parasite | Prey | Host Plant | Date |
|---|---|---|---|
| | Aphis helianthi | Cornus stolonifera | June-Aug. |
| | Macrosiphum avenae | Hordeum vulgare | July-Sept. |
| | Chaetosiphon fragaefolii (Cockerell) | Rosa sp. | July |
| | Cavariella aegopodii | Salix sp. | June |
| Lysaphidius sp. | Neoceruraphis viburnicola | Viburnum sp. (T.S.) | June |
| Lysiphlebus testaceipes (Curran) | Aphis neogillettei | Cornus stolonifera | June-July |
| | Rhopalosiphum fitchii | Crataegus sp. | June |
| | Kakimia robinsoni | Delphinium sp. | June |
| | Macrosiphum avenae | Hordeum vulgare | July-Sept. |
| | Rhopalosiphum padi | Prunus sp. | June-Sept. |
| | Neoceruraphis viburnicola | Viburnum sp. (T.S.) | June |
| Pachyneuron siphonophorae (Ashmead) | Macrosiphum avenae | Hordeum vulgare | July-Sept. |
| Perilitus coccinellae (Shrank) | Neoceruraphis viburnicola | Viburnum sp. | June |

TABLE XXXIX (Continued)

| Parasite | Prey | Host Plant | Date |
|---|---|---|---|
| Praon aguti (Smith) | Dactynotus sp. | Ambrosia sp. | June-July |
| | Macrosiphum avenae | Hordeum vulgare | July-Sept. |
| | Metopolophium dirhodum | Hordeum vulgare | July-Sept. |
| Praon occidentale Baker | Acyrthosiphon caraganae | Caragana sp. | June-July |
| Praon pequodorum Viereck | Macrosiphum euphorbiae | Brassica sp. (W.) | July-Aug. |
| | Acyrthosiphon pisum | Melilotus sp. (A.) | July-Aug. |
| Praon sp. | Euceraphis sp. | Betula sp. | June-July |
| | Aphis helianthi | Cornus stolonifera | June-Aug. |
| | Aphis neogillettei | Cornus stolonifera | June-July |
| | Aphis pomi | Cotoneaster acutifolia | June-Aug. |
| | Kakimia robinsoni | Delphinium sp. | June |
| | Kakimia ribiella | Ribes aureum | June-July |
| | Kakimia cynosbati (Oestlund) | Ribes aureum | July |
| | Neoceruraphis viburnicola | Viburnum sp. | June |

TABLE XXXIX (Continued)

| Parasite | Prey | Host Plant | Date |
|---|---|---|---|
| Testrastichus chrysopidae (Crawford) | Macrosiphum avenae | Hordeum vulgare | June-Sept. |

A - Agricultural Crop
TS - Tree or Shrub
W - Weed

TABLE XL

A LIST OF PREDATORS AND PARASITES IN TABLES XXXVIII AND XXXIX BY ORDERS AND FAMILIES

(Coleoptera: Coccinellidae)

Adalia bipunctata (L.)
Adalia disjuncta (Radn.)
Adalia frigida (Schn.)
Anisocalvia-12-maculata Gebl.
Cleis picta (Rand.)
Coccinella transversoguttata Falderman
Coccinella trifasciata L.
Hippodamia convergens Guerin
Hippodamia parenthesis (Say)
Hippodamia tredecimpunctata tibialis Say

(Diptera: Syrphidae)

Metasyrphus sp.
Platycheirus sp.
Scaeva pyrastri L.
Sphaerophoria contiqua Macq.
Sphaerophoria robusta Curran
Syrphus bigelowi Curran
Syrphus vitripennis Meigen

(Neuroptera: Chrysopidae)

Chrysopa carnea Stephens
Chrysopa oculata Say

(Hemiptera: Anthocoridae)

Anthocoris sp.
Deraecoris aphidiphagus Knight
Tetraphleps latipennis Van D.

(Diptera: Chamaemyiidae)

Leucopis americana Malloch
Leucopis (Leucopis) N. sp. 1

TABLE XL (Continued)

(Hymenoptera: Aphidiidae) (P)

Adialytus salicaphis Fitch
Aphidius aquilus Mackauer
Aphidius avenaphis (Fitch)
Aphidius polygonaphis Fitch
Aphidius pulcher Baker
Binodoxys carolinensis Smith
Diaeretiella rapae McIntosh
Ephedrus sp.
Euaphidius cinqualatus Ruthe
Lysaphidius sp.
Lysiphlebus testaceipes (Curran)
Praon aguti Smith
Praon aquilus Smith
Praon occidentale Baker
Praon pequodorum Vierech
Praon sp.
Trioxys sp.

(Hymenoptera: Cynipidae) (P)

Alloxysta sp. 2
Charips sp. 3

(Hymenoptera: Pteromalidae) (P)

Asaphes fletcheri (Ashmead) 4
Pachyneuron siphonophorae (Ashmead) 5

(Hymenoptera: Aphelinidae) (P)

Aphelinus mali (Hald.)

(Hymenoptera: Ceraphronidae) (P)

Lygocerus sp. 6

(Hymenoptera: Ichneumonidae) (P)

Diplazon laetatorius (F.) 7
Perilitus coccinellae (Shrank) 8

TABLE XL (Continued)

| | |
|---|---|
| (Hymenoptera: Eulophidae) (P) | |
| Testrastichus chrysopidae (Crawford) 9 | |

1. Genus needs revision
2. Hyperparasite
3. "
4. "
5. "
6. "
7. Parasite on syrphid larva
8. Parasite on coccinellid larva
9. Parasite on chrysopid larva

p. Primary parasite

in the list belonged to the families Ichneumonidae, Aphidiidae and Aphelinidae. The hyperparasites are indicated in Table XL.

Adult lady beetles were found in many habitats preying on one or two aphids. In larger colonies of aphids lady beetle larvae were also found.

A. bipunctata occurred among aphid colonies on trees and shrubs in the spring and summer, as observed by Smith (1958) and Putnam (1964). Hodek (1967) also found this for A. bipunctata, and thought that this habitat choice might be due to humidity preferences.

H. tredecimpunctata tibialis preyed on fundatrices and fundatrigeniae on trees and shrubs in the spring, and in the summer it preyed upon aphids on agricultural crops, weeds and flowers. It was also found feeding on aphids on trees and shrubs through the summer.

H. convergens was found on trees and shrubs in the spring and on agricultural crops, flowers and weeds through the summer.

C. transversoguttata was the largest in size of the common coccinellids found in Manitoba. It was found only in large aphid colonies. The remaining coccinellid predators found in Manitoba occurred sporadically on trees, shrubs, weeds and agricultural plants.

A parasite of coccinellid larvae was found in cages in which larvae were being reared to the adult stage for identification. This parasite was identified as Perilitus coccinellae (Shrank).

Table XXXVIII shows that syrphid larvae were the second most commonly collected predators on aphids in Manitoba. Results suggest that habitat specificity seems to be the important factor attracting syrphid adults to oviposit on a plant close to an aphid colony so that their larval progeny can prey upon the aphids which infest the plant. Table XXXVIII shows that Sphaerophoria species were abundant on agricultural crops, as noted by Dusek and Laska (1966) and Schneider (1969). Platycheirus species was found preying on many aphid species over a wide range of habitats, as described by Evenhuis (1966). Syrphus spp. preferred aphids on trees and shrubs.

In some cases the parasite Diplazon laetotorius (F) emerged from syrphid larvae collected in the field and brought into the laboratory. The syrphid larvae were parasitized in the aphid colony as they preyed upon aphids.

Two species of the family Chrysopidae were found in Manitoba preying upon aphids. They were Chrysopa carnea Stephens and Chrysopa oculata Say. Neither species showed host or habitat specificity. The larvae were found only on plants with high densities of aphids, as observed by Hagen

(1950), and Hagen and Van Den Bosch (1968). *Tetrastichus chrysopae* was found parasitizing chrysopid larvae.

The genus *Leucopis* occurred mainly on trees and shrubs with high aphid numbers. Some species of this genus were utilized in controlling the balsam woolly aphid in the Pacific Northwest (Mitchell and Wright, 1967).

Several genera of the family Anthocoridae were found preying upon aphids in trees and shrubs with high aphid densities. Adults of *Deraecoris aphidiphagus* Knight and *Deraecoris fasciolus* Knight occur in curled leaves feeding on aphids and honeydew excretions, as observed by Blatchley (1926). Blatchley (1926) described *Tetraphleps latipennis* as an aphid predator but gave no details of its host or habitat specificity. It was found preying upon aphids in curled leaves of *Malus*, *Ulmus*, and *Crataegus* species.

Parasite surveys were restricted to aphids on grain crops and ornamentals. The main hymenopterous parasites on aphids feeding on exposed leaf surfaces of grain crops (*M. avenae* and *M. dirhodum*) were *Aphidius avenaphis*, *Aphelinus mali*, *Lysiphlebus testaceipes* and *Praon* species. Several species of Hymenoptera were found parasitizing aphids on ornamental trees and shrubs. *Praon* species were most widely distributed both on ornamentals and cereal crops. The majority of collections showed that many primary aphid parasites had also been parasitized. The hyperparasites found were *Asaphes fletcheri*, *Pachyneuron siphonophorae*, *Charips* sp., *Alloxysta* sp., and *Lygocerus* species. They did not show host specificity, as observed by Hagen and Van Den Bosch (1968). Hyperparasites were generally found in all aphid colonies in which aphids were parasitized by primary parasites.

# CHAPTER VII

## SUMMARY OF OBSERVATIONS

The fluctuations of numbers of aphids on cereal crops were studied in field plots in 1968 and 1969 at Glenlea Research Station, Manitoba. Colonies of aphids on individual plants were examined at intervals and notes were made on increase or decrease in numbers of aphids in the colony, presence of predators, parasites or fungus disease, stage of growth of the plant and weather conditions. Each sample of one aphid species on one plant species began with 100 plants. At each observation date plants which had lost all the aphids observed on them at the previous sampling date were replaced with infested plants to bring the total again to 100 plants.

On the first three sampling dates for English grain aphids on Manitou wheat in 1969 approximately 25 per cent of the plants showed a total loss of aphid colonies, and losses increased above 25 per cent on the succeeding three sampling dates. Although these large numbers of plants were void of aphids at each sampling date, there were indications that total number of aphids in the field increased for a period of time, and then began to decrease. This same pattern of fluctuation was observed for all situations studied in 1968 and 1969, except for corn leaf aphid on barley. English grain aphids in the wheat field sampled were preyed upon by lady beetles. Eventually predator pressure as well as wind, rain, parasites and fungus disease brought about almost total disappearance of the aphids from the fields. Heavy rains prior to July 30 and a severe storm with hail, rain and strong winds on the evening of August 3 caused "catastrophic" losses to the aphid population. Over the whole sampling period for English grain aphid on Manitou wheat, range of size of colonies varied from 1 - 30. There were some additions to the field by alate adults during the early part of the season, and some losses associated with emigration at the end of the season.

Population changes of English grain aphid on Harmon oats were studied in 1968. The same pattern of initial increase in total aphid numbers was followed by a rapid decline, associated with heavy rain. Predators had less influence on aphid numbers than did wind and rain. Aphid numbers throughout the season varied from 1 - 28, and declined before plants began to head. There were small losses due to parasites and diseases. In the early season alates flew into the field and some alates probably emigrated out of the field at the end of the season.

Population changes of English grain aphid on Conquest barley were studied in 1968. Numbers of predators were low and aphid losses were associated mainly with wind, rain, parasitism, disease and ripening of the plants. Range of size of colonies varied from 1 - 24. Some immigration was noted on the first three sampling dates and some losses were associated with emigration after August 26.

Population changes of corn leaf aphid on Manitou wheat were studied in 1969. Range of size of colonies varied from 1 - 18. Per cent net losses progressively increased through the sampling period, due to wind, rain and predators. There were no observations of losses due to parasites, fungus disease or emigration.

Data were obtained in 1969 for populations of corn leaf aphid on Harmon oats. Populations in the field increased at first and then declined. Decrease in aphid numbers was associated with wind, rain and predators. No losses were recorded from parasitism, fungus disease, or emigration. Range of size of colonies varied from 1 - 19. Predators were present in substantial numbers at every sampling date. Aphid numbers were low by the time plants began to head.

Population changes of corn leaf aphid on Conquest barley were studied in 1969. The trend described above was not observed i.e. for several sampling dates all plants had colonies still on them when observed at the next sampling date. The range of size of aphid colonies varied from 1 to 374. Corn leaf aphids were found colonizing the leaf whorls of barley and it is suggested that this afforded some protection from wind, rain and predators. Also low numbers of predators were recorded for the first few sampling dates. Between August 2 and 3, 50 per cent aphid losses were associated with emigration. Between August 3 and 9 over 70 per cent of the 100 plants first sampled on July 20 lost all their aphids. This was associated with a severe hail-storm on August 3. These losses occurred before plants began to head. Aphid losses due to parasitism and disease were not recorded in this field.

Data for population changes for the rose grass aphid were obtained for barley only, in 1968. Fifty per cent of the plants had infestations reduced between August 14 - 20 and August 20 - 26, due to heavy rains and gusty winds. Range of size of aphid colonies varied from 1 - 34. Predators were low in numbers throughout the season, but losses due to parasitism and fungus disease were recorded throughout the season. At the end of the season some aphid losses were associated with ripening and drying of the barley.

Positions of the aphid colonies on the plants, at each sampling date, were correlated with stage of plant growth. The stages noted were first, second, third and fourth leaf, or the heads. The English grain aphid was the only species found on the heads of grain.

The five species of lady beetles most commonly found on aphids on cereal crops in 1968 and 1969 were: Hippodamia tredecimpunctata tibialis, H. convergens, H. parenthesis, Coccinella transversoguttata and Adalia bipunctata. Average weights of the adults of these species were determined, as well as the average weights of the third instars of five aphid species mainly associated with cereal crops in Manitoba: Rhopalosiphum maidis, R. padi, Schizaphis graminum, Macrosiphum avenae and Metopolophium dirhodum.

In a laboratory experiment adult females of each of the five species of lady beetles were fed as many as they could consume of third instar larvae of each of the five aphid species over a period of five days. C. transversoguttata consumed more of each species of aphids than did any of the other lady beetles. All lady beetle species consumed more of the corn leaf aphid than of any other aphid species. In general, numbers of aphids consumed varied inversely with the weight of the prey.

In another experiment females of the lady beetle species (not including H. parenthesis) were fed on one aphid species for a period of ten days, and the numbers of eggs produced in the last five days of this period were recorded every 24 hours and totalled. H. tredecimpunctata tibialis produced more eggs than any of the other lady beetles. There was evidence that fecundity of the females of the different species of lady beetles varied with the aphid species consumed.

In another series of laboratory tests, lady beetle larvae (second, third and fourth instars) were fed on third instar nymphs of each of the aphid species. The greatest number of prey were consumed near the middle of each instar period. Larvae of the heavier lady beetles consumed more aphids than larvae of the lighter lady beetles. *C. transversoguttata* failed to complete development to pupation on a diet of either the English grain aphid or the rose grass aphid. *Adalia bipunctata* failed to complete development to pupation on a diet of *M. dirhodum*.

After the larvae mentioned above had pupated, a record was kept of the time spent in the pupal stage for each of the four species of lady beetles. *H. convergens* spent only four days in the pupal stage, regardless of which aphid species the larvae fed on. The pupal stage of *H. tredecimpunctata tibialis* was slightly longer than four days when fed on corn leaf aphid, and just over five days when fed on the rose grass aphid. The pupal stages of *A. bipunctata* and *C. transversoguttata* took 5 - 6 days, except in those cases where the larvae failed to complete development.

Based on voracity, *H. convergens* and *H. tredecimpunctata tibialis* appeared to be the most effective predators on all five species of aphids. Field collections of lady beetle adults showed these to be the most commonly found species of lady beetles in grain fields.

Predators and parasites of aphids were collected on agricultural and horticultural crops, trees, shrubs and weeds whenever possible in 1968 and 1969. When necessary these were reared to the adult stage so they could be identified. Twenty-four species of predators, twenty-one species of parasites, and five species of hyperparasites were found. Coccinellidae were the most commonly found of the predators followed by species of Syrphidae, Chrysopidae, Anthocoridae and Chamaemyiidae. Parasites found belonged to the families Ichneumonidae, Aphelinidae, and Aphidiidae. Hyperparasites belonging to the families Pteromalidae, Cynipidae and Ceraphronidae were recovered from aphids which had been parasitized by primary aphid parasites.

Aphids occur on cereal crops every year in Manitoba. They vary in numbers among species and among field crops, from year to year. In some years they cause economic damage, not only because of their numbers on the plants, but also when they transmit virus diseases of crops, such as barley yellow dwarf of oats and barley. When farmers observe large numbers of aphids on a crop, they ask for advice on use of insecticides for chemical control. Entomologists do not yet have sufficient knowledge of the reasons for population fluctuations of aphids to be able to say at what population level chemical controls should be applied, to avoid economic damage. In all the fields studied for this thesis, populations declined before causing economic damage. Under other environmental conditions, in other years, they may not decline, and chemicals should be applied. Observations made during the present studies indicate the very great importance of weather as a cause of aphid losses. Further studies are required to elucidate the role of plant maturity, and of predators, parasites or diseases, as factors affecting aphid populations.

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