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AN "*APHIS FABAE*" IN MANITOBA WHICH FEEDS ON NASTURTIUM AND NOT ON FABA BEAN

by

Reta Pearl Annette Barber

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RETA PEARL ANNETTE BARBER

A dissertation submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

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ABSTRACT

by

RETA PEARL ANNETTE BARBER

AN "APHIS FABAE" IN MANITOBA WHICH FEEDS ON NASTURTIUM AND NOT ON FABA BEAN

A black aphid collected in Manitoba from several different host plants is so similar morphologically to *Aphis fabae* Scopoli that it has been given that name for all specimens collected. The true *Aphis fabae* is an economic pest, and thrives on faba bean, *Vicia faba* L. and other beans, in Europe and some parts of North America. When it was discovered that the Manitoba "*Aphis fabae*" would not live on faba bean, the present study was initiated to determine if it is (a) a physiological race or biotype of *A.fabae*, or (b) a subspecies of A.fabae, or (c) a species distinct from *A.fabae*.

Live cultures of aphids were obtained from British Columbia and New Brunswick to compare with the Manitoba species. In field and laboratory experiments there were, from the three geographical areas, three cultures which would live on faba bean but not on nasturtium (regarded as the true *Aphis fabae*) and three cultures which would live on nasturtium, *Tropaeolum majus* L., but not on faba bean.

A biosystematic approach was used to try to find differences which would be of specific rank, which included use of the scanning electron microscope, cytotaxonomy, physiological

and ethological studies, and the conventional methods of counting and/or measuring anatomical features.

On the basis of the following observations it was decided that the species in Manitoba is not *Aphis fabae* Scopoli:

1. Host preferences; the Manitoba species lives on nasturtium and dies on faba bean. The "true" *Aphis fabae* lives on faba bean but not on nasturtium.

2. The males and oviparae of the Manitoba species appeared two weeks earlier on the winter host than did those of *Aphis fabae*.

3. Rostral IV + V is longer in alate and apterous viviparous forms, males and oviparae, of the Manitoba species.

4. Length of unguis and total length of antennae are greater in males and oviparae of the Manitoba species.

The aphid from Manitoba is probably an undescribed species.

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My thanks also go to Dr. R. Blackman of the British Museum (Natural History) for performing the genetic studies.

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CHAPTER I

INTRODUCTION

A species of aphid which has been collected over the past several years on various wild and cultivated plants in Manitoba has been considered to be the well known economic pest named *Aphis fabae* Scopoli. *A.fabae* causes great damage in eastern North America and Europe by feeding on broad bean, *Vicia faba L.*, and other plants.

The species known as *A.fabae* in Manitoba does not live on *V.faba* (faba bean). This apparent anomaly suggests that perhaps the species collected in Manitoba is not *A.fabae*.

The study reported here was designed to compare the Manitoba species with cultures of the true *A.fabae*, using taxonomic, physiological, anatomical, ethological and genetic experimental approaches. When Manitoba specimens are cleared and mounted on glass microscope slides they are not easily distinguished from specimens of *A.fabae*. Therefore, conventional methods of measuring are not sufficient to show differences, and hence a biosystematic approach, as outlined above, was used to solve this problem.

Scope of the study

Three living culture of aphids which were reported to be *A.fabae* were obtained from New Brunswick along with two living cultures from British Columbia. In the various experiments outlined here, comparisons were made with the Manitoba species.

The experiments were designed to demonstrate if (a) the Manitoba species is merely a "biotype" or "physiological race" of *A.fabae*, or (b) the Manitoba species is a subspecies of *A.fabae*, or (c) the Manitoba species is a distinct and separate species from *A.fabae*.

CHAPTER II

LITERATURE REVIEW

Aphis fabae was first described in 1763 by Scopoli. It has been redescribed as a new species several times because of its superficial resemblance to several other blackish *Aphis* spp. One of the earliest names for a black *Aphis* sp. was *Aphis rumicis* L., 1746. Jones (1942) gave a history of some of the problems caused by authors confusing the two species, *A.fabae* and *A.rumicis*, and she mentioned in particular publications by Fabricius (1794), Risso (1826), Koch (1857), Kaltenbach (1874) and Buckton (1879).

Borner and Janisch (1922) were probably the first to clearly show that *A.fabae* and *A.rumicis* are distinct species. They showed that *A.fabae* is a polyphagous species, overwintering on *Euonymus europaeus* L. (spindle tree) and migrating in the spring to several summer hosts, while *A.rumicis* is monophagous on *Rumex* spp. Another worker who differentiated *A.fabae* from *A.rumicis* was Franssen (1927, 1930).

Theobald (1929) placed *A.fabae* as a synonym of *A.rumicis* and named what he thought to be a second species on dock as *Aphis davidsoniella*. Other authors who have published data on the differences and similarities between *A.fabae* and *A.rumicis* are Hille Ris Lambers (1934) in Jones (1942), Nevsky (1929), and Balachowsky and Mesnil (1936). When Borner (1930) reclassified the Aphidoidea he placed these two species in a subgenus

Doralis. A discussion of *A. fabae* and *A. rumicis* is given fairly completely up to 1940 by Jones (1942). This author presented detailed measurements of the two species. Eastop and Hille Ris Lambers (1976) give 33 synonyms for *A. fabae*, as well as several subspecies and three synonyms for *A. rumicis*, which demonstrates the confusion that there has been because of morphological similarities but different host plants and perhaps different variations which have caused so many of them to be wrongly described as new species. Even recently, Iglisch (1975), described another new species in this complex as *A. caprifoliae*.

An important difference between *A. fabae* and *A. rumicis* exists between their sexual forms. Males of *A. fabae* were reported by Jones (1942) to be alate, and of *A. rumicis*, apterous. Oviparae of *A. fabae* were shown to have strongly swollen hind tibiae with many pseudosensoria, while oviparae of *A. rumicis* have hind tibiae which are only slightly swollen, with few pseudosensoria.

The excellent study on *A. fabae* and *A. rumicis* by Jones (1942) appeared to settle the controversy. More recently, the species *A. fabae* has become known as "*Aphis fabae* complex" because it has become increasingly more difficult to consider it as a single species physiologically or ethologically. Aphids which appear to be *A. fabae* morphologically, differ in host plant selection, or virus transmission, or longevity, or fecundity. The problem has now become how to separate the various biotypes, subspecies, or species of "A. fabae complex," or as it is sometimes called, "A. fabae group."

Biotypes are discussed by Eastop (1973). He stated: "Biotype is a taxonomic concept mostly used by non-taxonomists and has been defined as consisting of all individuals of equal genotype." Biotypes are recognized by a biological function rather than by morphological characters. Mayr (1960) used the conventional definition of a species: "Groups of actually (or potentially) interbreeding natural populations which are reproductively isolated from other such groups," and a subspecies as: "A geographically defined aggregate of local populations which differs taxonomically from other such subdivisions of the species." Mayr also discussed the terms "groups" and "complex," and said that they are most commonly applied to an assemblage of closely related taxa which one does not want to place in a separate category. A species group is a group of closely related and presumably recently evolved species. The terms "groups" and "complex" are used synonymously when defining aggregates of closely related species.

One way in which closely related species may differ from one another is in their host plant preference, or in their responses to nutrition when feeding on different host plants. One of the pioneers in this work is J. S. Kennedy. In Barbosa and Peters (1972) Kennedy has written two articles: "The experimental analysis of aphid behaviour and its bearing on current theories of instinct" and "Mechanisms of host plant selection." In another collection of symposia, by Jermy (1974), Kennedy wrote on "Host-plant finding by flying aphids." In the same book by Jermy, J. L. Auclair discussed feeding and nutrition of the pea aphid, W. F. Tjallingii told of a preliminary study of host selection and acceptance behaviour in the cabbage aphid, and F. P. Müller wrote on hosts and non-hosts in subspecies of another aphid, Aulacorthum solani (Kaltenbach).

V. F. Eastop in Lowe (1973) summarized present knowledge on biotypes, and most of the examples which he used were of host plant preferences. He stated "The Aphis fabae group contains similar-looking populations with different biologies but in the confused taxonomic state of the group terms like 'biotype' have no precise meaning." Eastop claimed that host plant specificity has formed the basis of much aphid speciation, and further stated: "Aphids and psyllids are specific to particular species of plants because specificity acted as an isolating mechanism in the early stages of evolution, isolating the new species from its progenitors, and in the later stages, host plant specificity maintains genetical variability and hence evolutionary potential, by causing each species of aphid to live in numerous isolated populations."

Blackman (1974, p. 95) lists host plants for the true Aphis fabae, called the "black bean-aphid," or sometimes "blackfly." A.fabae overwinters in Britain, usually in the egg stage on the spindle tree (Euonymus sp.), but may also use the mockorange Philadelphus coronarius L., or the cranberry bush, Viburnum opulus L., as a winter host. Other species which may overwinter on these hosts are A.euonymi Fabricius which remains all year on the spindle tree, A. acanthi Schrank and A.solanella Theobald which might migrate from Euonymus sp. to thistles (Cirsium sp.) and black nightshade (Solanum sp.). A.fabae is the only species which will feed on beans, but in Britain it may also be found on many summer hosts including goosefoot (Chenopodium sp.), poppy (Papaver sp.), dock (Rumex sp.), sugar-beet (Beta sp.), and thistles (Cirsium sp.). Referring to black Aphis spp. in general, similar to A.fabae or A.rumicis, Blackman stated "If you find any aphids which might be these species, (referring to several Aphis spp.), try transferring them to potted broad-bean plants to make sure that they are not just A. fabae."

The species of aphid which has been a taxonomic problem in Manitoba has been found in the early spring on Viburnum trilobum Marsh or Philadelphus coronarius L.; these are the only known overwintering hosts in Manitoba. In the summer the aphid thrives on several species of plants, and especially burdock (Arctium minus (Hill) Bernh.) and nasturtium (Tropaeolum majus L.).

Aphis species have been previously reported, by other authors, on Tropaeolum sp., but there is no way of presently knowing if more than one species is involved, or if any or all of those species reported in the literature are the same as the

Manitoba species. Taylor (1959) compared an *Aphis* spp. from *Tropaeolum* sp. with *A.fabae*. The species which he studied would not live on *Vicia faba*, and he claimed to have found a morphological difference between it and *A.fabae*; i.e., that rostral segment IV + V in the *Tropaeolum* sp. aphid ranged in length from o.14 - 0.20 mm in specimens with body length of 1.5 - 3.0 mm compared with a measurement of 0.11 - o.16 mm in *A.fabae*. Taylor concluded, from his studies, that the aphid from *Tropaeolum* sp. was not a separate species from *A.fabae*. In Poland, Berlinski (1965) reared *Aphis fabae* on *Tropaeolum majus* and on broad bean (*Vicia faba*). He believed that many of the aphids transferred from nasturtium to broad beans were unable to insert their mouth parts to the phloem and therefore died from lack of food. He found morphological differences between each of the groups reared on the two hosts, but apparently all the aphids which he tested were *A.fabae*. Dadd and Krieger (1967) tested two *Aphis* species on sterile synthetic diets. One culture was originally obtained from dock (*Rumex* sp.) and one from *Tropaeolum* sp. Their results indicated two distinct "biotypes."

CHAPTER III

MATERIALS AND METHODS

The experimental approaches used to solve this problem of species differentiation were:

1. Scanning electron microscope.
2. Genetic material.
3. Physiological and ethological studies.
4. Conventional taxonomy (anatomical measurements).

Scanning electron microscope

Aphids were prepared, processed, examined and photographed under a Cambridge Stereoscan Mark II, by Mr. Bert Luit of the Department of Plant Science, University of Manitoba.

Comparison of chromosomes

Live aphids were placed into a freshly made mixture of three parts methanol and one part glacial acetic acid. Dr. R. Blackman of the British Museum (Natural History) had previously suggested (personal communication) that aphids, placed in this material, could be examined cytologically at a later date for chromosome counts and measurements. Samples of all six of our "*A. fabae*" cultures were sent to Dr. Blackman for his opinion about their karyotypes.

Physiological and ethological studies

As stated previously, there were six different cultures of aphids. For simplicity in recording data they were coded as follows:

1. BC Lab — This was regarded as true *Aphis fabae*. It had been reared for several years in the Laboratory of Agriculture Canada Research Station in Vancouver, B. C. on *Vicia faba* and was reared continuously in our laboratory on faba bean, *Vicia faba*.

2. BC Wild — This was regarded as true *Aphis fabae*. It was collected in a garden in Vancouver from poppy (*Papaver* sp.) and reared in our laboratory on faba bean.

3. NB-A — This was regarded as true *Aphis fabae*. It was collected in New Brunswick from *Euonymus* sp. and reared in our laboratory on faba bean.

4. NB-B — This was collected in New Brunswick on *Philadelphus* sp. and reared in our laboratory on nasturtium (*Tropaeolum majus*).

5. P-E — This was collected in New Brunswick on *Philadelphus* sp., transferred to *Euonymus* sp. in New Brunswick, and reared in our laboratory on nasturtium.

6. Man. — This was our Manitoba "*fabae*," collected on burdock *Arctium minus* and reared in our laboratory on nasturtium.

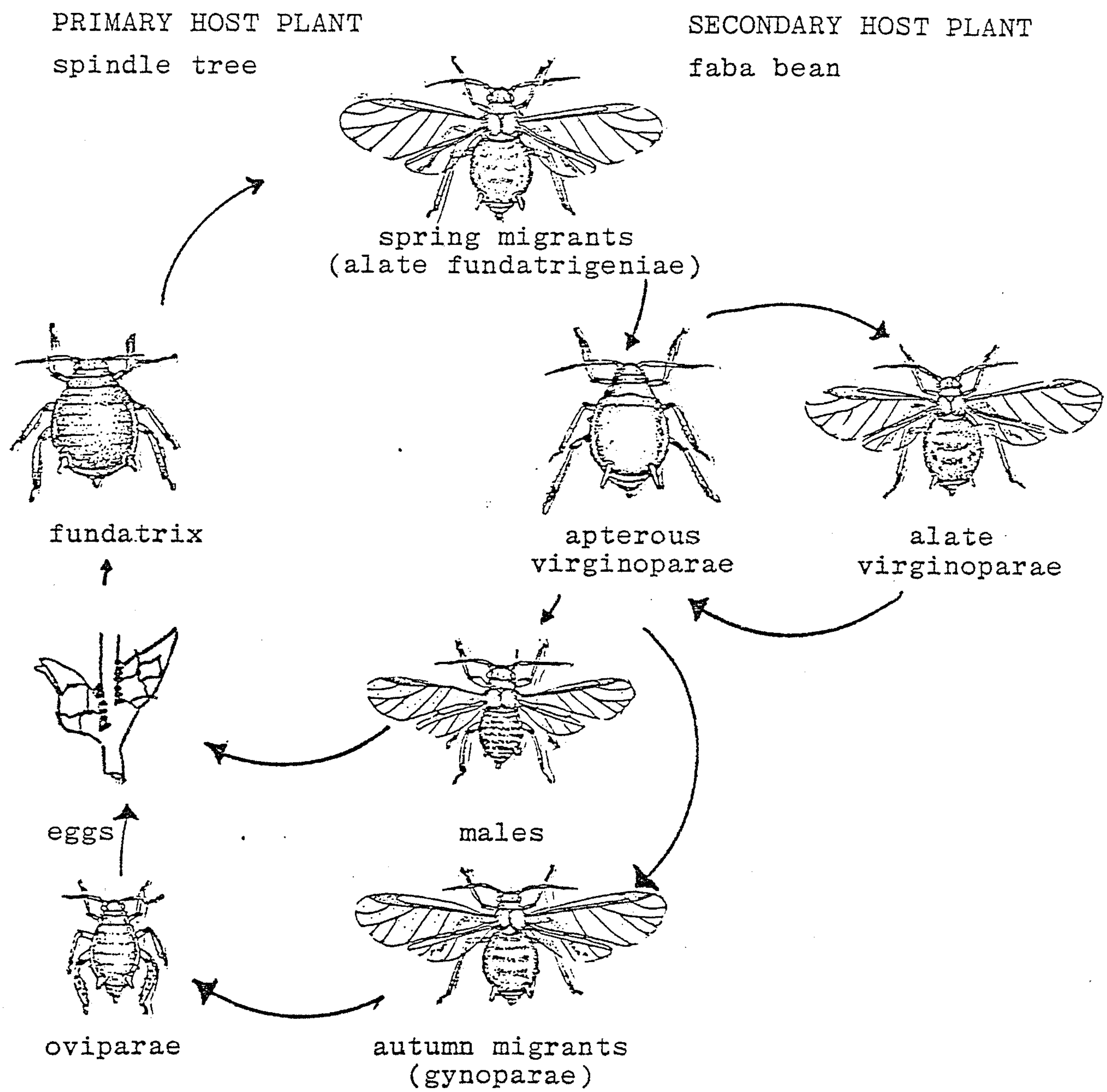
Physiological and/or ethological studies were conducted on all or some of the six cultures to test the following:

1. Successful establishment and rate of development on various host or non-host plants.
2. Developmental time in "day-degrees," including prelarviposition period, larviposition period and postlarviposition period.
3. Nymphal growth and development.
4. Fecundity during the first five days of adult life, and for total life span.
5. Longevity, mean fecundity, mean reproductive period, mean length of a generation in day-degrees and prelarviposition period.
6. Attempts to obtain males and oviparae for conventional taxonomic studies. This was done by placing cultures on potted plants in cages outdoors, to subject the aphids to changes in photoperiod and decreasing temperatures in late August, September and October.

Plants used in the various experiments are listed in Table 1 at the end of this chapter. Field tests were conducted in the summer of 1977 at Kenora, Ontario and laboratory tests in the winter of 1977 - 1978 at the Department of Entomology, University of Manitoba.

<u>Life history of Aphis fabae</u>

"Fundatrices" or "stem mothers" are the female individuals which hatch from the overwintering eggs (Figure 1). All their offspring are female "fundatrigeniae" which produce female "alatae" when primary woody overwintering host plants


PRIMARY HOST PLANT
spindle tree
SECONDARY HOST PLANT
faba bean
spring migrants
(alate fundatrigeniae)
fundatrix
apterous
virginoparae
alate
virginoparae
eggs
males
oviparae
autumn migrants
(gynoparae)

such as Euonymus sp., Philadelphus sp., or Viburnum sp. become an unsuitable food source in the spring. The precise cause of host unsuitability is not known, with various authors suggesting that overcrowding is the main cause for alate forms appearing (Blackman (1974), Dixon (1973)), or alternately that a number of "switch mechanisms" occur which are environmentally sensitive (i.e., the "biological clock" hypothesis Lees (1959, 1960, 1963 a,b), Mittler (1969) and Tsitsipis (1977)).

The alatae then leave the primary host plants to produce colonies of apterous viviparous females on secondary, herbaceous host plants such as Vicia faba (faba bean) or Tropaeolum majus (nasturtium), and are known as the "spring migrants." Apterous viviparous females or apterae are parthenogenetic wingless forms and alate viviparous females or alatae are parthenogenetic winged forms. Gynoparae are autumn migrants, the parents of sexual females. These alatae are produced when fresh herbaceous plant growth becomes scarce in the fall and overwintering woody host plants are utilized for the purpose of producing sexual, egg-laying females or oviparae. At approximately the same time winged males are produced within the diminishing summer host plant colonies. These males fly to the overwintering host, mate with mature oviparae which then lay eggs on the stem or winter buds of the woody plant; thus sexual forms produce the overwintering egg phase of the aphid. The males die after mating with several females but the oviparae may live on the winter host for a time and be killed by frost or natural causes Blackman (1974).

The embryos within the eggs require a cold period before they can complete their development. This physiological state of ("diapause") ensures that they will not hatch before spring. The hatch is in synchrony with the rise of sap in the branches of the winter host and concurrent bud swelling; i.e., with their food source. The young nymphs insert their stylets into the soft buds and begin feeding. According to Blackman (1974) the nymphs are resistant to frost at this stage and develop quickly. These are termed fundatrix nymphs or "stem mothers," the first individuals of a future aggregate of asexually reproduced progeny. All their offspring are female fundatrigeniae which produce dense colonies throughout the spring months, until the cycle repeats itself and alate forms appear again on the woody primary host prior to colonizing herbaceous secondary herbs.

Aphididae possess a variety of polymorphisms with an alternation of asexual and sexual generations. Heteroecious, migratory or host-alternating are terms applied to aphids. Their primary, overwintering host is usually a woody plant and the secondary host(s) a short-lived herbaceous plant or annual crop. Holocyclic describes the possession of an annual phase in which parthenogenesis is interrupted by the production of male and female sexual morphs.

Host plant experiments

Nymphal development is the time taken for progeny to develop from birth to the adult state. Prelarviposition period is the time it takes to produce young once the aphid has reached adulthood.

Blackman (1974) believes that development time is temperature dependent and suggests that the use of a physiological time scale would allow other experiments performed at different temperatures to be used as comparisons. The results are converted by calculating the mean temperature in ^{O}C for every 24 hours of the experiment, then subtracting $4^{O}C$ to obtain an approximate temperature threshold of aphid development. Accumulated daily values equal "day-degrees." A 95% confidence coefficient was used.

Ten apterous viviparous female aphids were used for each host plant suitability test. Wingless parthenogenetic aphids were placed singly on leaves of nasturtium or faba bean to determine nymphal development time, prelarviposition period, fecundity during the first five days of adult life, and total fecundity.

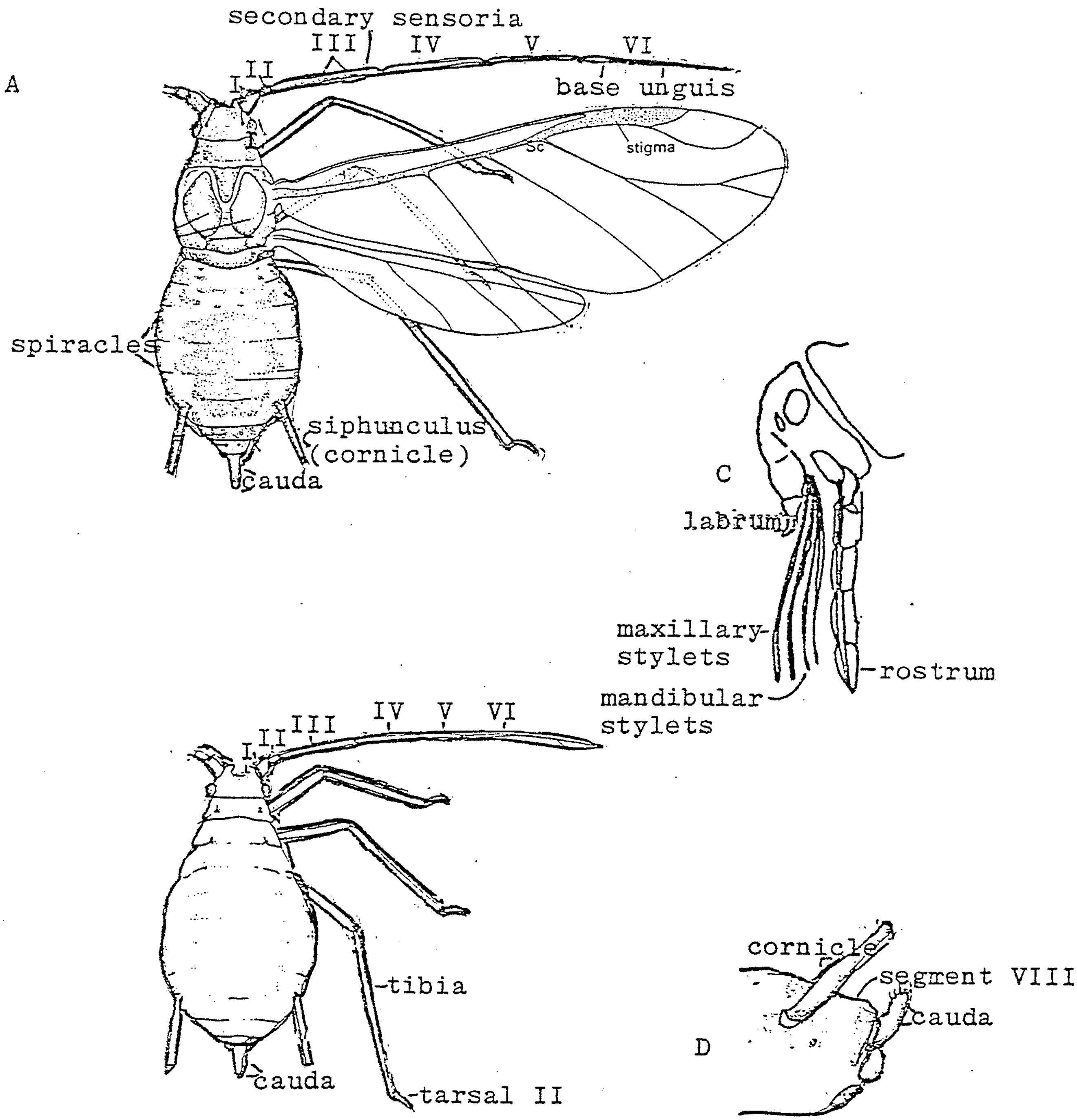
Mean fecundity is obtained by dividing the number of offspring by 10 (n). The reproductive period is that period in days over which the nymphs were produced. The mean length of a generation is calculated by taking the number of days an aphid requires to produce half its offspring and adding the day-degrees from nymphal development. This technique illustrates the number of generations a field or laboratory population may pass through given a certain length of time (in day-degrees), in spite of overlapping generations.

Conventional taxonomic studies

Aphids were cleared and mounted on glass microscope slides, and measurements made of various parts and appendages using an ocular micrometer in a Wild (Heerbrugg) 18302 microscope. Samples of usually ten specimens of alate and apterous viviparous females were measured in most cases, as n=10 was considered to be adequate for the statistical parameters used.

Measurements were normally made of the following: total body length of the mounted aphid (not including cauda); length of cauda; number of hairs (setae) on cauda; length of cornicles (siphunculi); lengths of antennal segments III, IV, V, base and unguis (terminal process); total length of antenna; length of longest hair on antennal segment III; number of secondary sensoria on antennal segments III, IV and V; length of rostral IV + V; length of hind tibia; length of hind tarsal II; number of hairs on rostral IV + V; number of hairs dorsally on abdominal tergite VIII. Drawings to illustrate these parts and appendages are shown in Figure 2.

Figure 2A is the dorsal view of an alate viviparous female; 2B a dorsal view of an apterous viviparous female; 2C a lateral view of mouthparts; 2D a lateral view of the end of the abdomen. All are external aphid characters. The main difference between winged and wingless forms of the


A
secondary sensoria
III
IV
V
VI
I
II
base unguis
Sc
stigma
spiracles
siphunculus
(cornicle)
cauda
C
labrum
maxillary-
stylets
mandibular
stylets
rostrum
B
I
II
III
IV
V
VI
tibia
cauda
tarsal II
D
cornicle
segment VIII
cauda

same species is the meso-and metathorax which carry two pairs of wings. Secondary sensoria are nearly always present on segment III, and perhaps segments IV, V and VI of the alatae Blackman (1974).

The data from all these measurements were used in two different ways, (a) some of the measurements were subjected to analysis of variance (ANOVA) and (b) some were used as ratios, as listed below.

<u>Antennae</u>

Ratios $\frac{\text{length of antennal segment IV}}{\text{length of antennal segment III}}$

$\frac{\text{length of antennal segment V}}{\text{length of antennal segment III}}$

$\frac{\text{length of antennal segment VI (base)}}{\text{length of antennal segment III}}$

$\frac{\text{length of antennal segment VI (unguis)}}{\text{length of antennal segment III}}$

The values for the $\frac{\text{highest ratio}}{\text{lowest ratio}}$ for $\frac{\text{segment IV}}{\text{segment III}}$, $\frac{\text{segment V}}{\text{segment III}}$, $\frac{\text{base segment VI}}{\text{segment III}}$, $\frac{\text{unguis segment VI}}{\text{segment III}}$ show the least and greatest variation in relation to segment III. Cottier (1953, p. 53) believed that it is useful to determine these variations and stated: "The relative proportions which antennal segments bear to one another and to cornicles and cauda. Therefore antennal segments IV, V, base of VI, and flagellum (unguis) of VI have been expressed as a ratio of antennal segment III in each antenna." The variation which exists with actual measurements of antennal segments, cornicles and cauda are apparently of limited importance according to Cottier.

Cornicles

$$\text{Ratio } \frac{\text{cornicle length}}{\text{length of antennal segment III}}$$

The ratio was calculated in each specimen by dividing each cornicle length by the mean of the two third antennal segments, and values for $\frac{\text{highest ratio}}{\text{lowest ratio}}$ determined.

Cauda

$$\text{Ratio } \frac{\text{length of cauda}}{\text{length of antennal segment III}}, \frac{\text{length of cauda}}{\text{mean length of cornicles}}$$

The ratio was calculated by dividing the length of the cauda of each specimen by the mean length of the two antennal segments and mean length of the cornicles, then values for $\frac{\text{highest ratio}}{\text{lowest ratio}}$ calculated.

Frequency distribution of numbers of hairs on the cauda of all six cultures was also tabulated.

Sensoria

Frequency distributions of secondary sensoria were from the third antennal segments of alate forms.

Actual measurements are very useful in comparing individuals within and between populations under ordinary circumstances, but when very large numbers of populations are being used over a period of several months, changes may occur in individual size over a whole population due to temperature and nutrition. It then becomes impossible to make direct comparisons of actual measurements. In these cases ratios of measurements should be used. Cottier (1953) believes that the errors which have occurred in describing the same insect under different names are a result of insufficient knowledge of the variations in a species' characters. Ideally, the breeding of large numbers from single individuals using constant laboratory conditions, would allow one to study these variations of taxonomic characters and provide a background for description of species.

TABLE I

Table I. List of the plants tested in the laboratory and field by six aphid cultures

Common name	Scientific name
Spindle tree	*Euonymus europaeus* L.
Mockorange	*Philadelphus coronarius* L.
Highbush cranberry	*Viburnum trilobum* Marsh
Garden nasturtium	*Tropaeolum majus* L.
Faba bean	*Vicia faba* L.
Burdock	*Arctium minus* (Hill) Bernh.
Poppy	*Papaver* sp.
Seeded dahlia	*Dahlia* sp.
Tuberous rooted dahlia	*Dahlia* sp.
Green garden bean	*Phaseolus vulgaris* L.
Yellow garden bean	*Phaseolus vulgaris* L.
Scarlet runner bean	*Phaseolus coccineus* L.
Kidney bean	*Phaseolus vulgaris* L.
Lima bean	*Phaseolus limensis* MacFady
Garden pea	*Pisum sativum* L.
Hybrid squash	*Cucurbita* sp.
Potato	*Solanum tuberosum* L.
Swiss chard	*Beta vulgaris cicla* mag.
Beet	*Beta vulgaris* L.
Spinach	*Spinacia oleracea* L.
Rhubarb	*Rheum* sp.
Chia	*Salvia* sp.

CHAPTER IV

RESULTS AND DISCUSSION OF PHYSIOLOGICAL AND ETHOLOGICAL STUDIES

Scanning electron microscope

Mr. Bert Luit, operator of the scanning electron microscope, devised a technique which he used to prepare whole aphids for examination. Several views were made of specimens from each of the six cultures and photographs of views were processed by Mr. Luit. Particular attention was paid to views of the cauda and rostrum. It was hoped that we could find constant differences in sculpturing of the integument, or in size and shape of setae, or in setal patterns, and that these constant differences might be used as taxonomic "markers" for species differentiation, if any of the six cultures were indeed different species from each other.

Results from all Mr. Luit's work gave no assistance in differentiating between the six cultures. In actual fact, sculpturing of the integument, as shown under magnification of 1000x, varied not only between the specimens of the different cultures, but also between dorsal and ventral views of the same cauda. It was decided that further use of the scanning electron microscope was not a productive method in trying to differentiate between the six cultures, and no further work was done by this method.

Comparison of chromosomes

Live specimens of aphids from each of the six cultures were placed separately in vials of a freshly made mixture of three parts of methanol to one part of glacial acetic acid. The vials were sent to Dr. R. Blackman, British Museum (Natural History), London, England. Dr. Blackman examined the chromosomes of a specimen from each sample, and reported that he could not find any cytological differences in size, shape or number of the chromosomes, between any of the six different cultures.

Host plant experiments

Table II shows the results obtained when attempts were made to colonize the six aphid cultures on various host plants. Not every culture was attempted on every plant, and in particular, the culture BC Wild was not obtained until 1978, so it was not available for tests conducted in 1977. All six cultures successfully colonized the European spindle tree, Euonymus europaeus. All of the cultures lived on burdock, Arctium minus except that BC Wild was not tested. The remaining attempts demonstrated that the six cultures were of two general categories, BC Lab, BC Wild and NB-A probably the true Aphis fabae, which would live on faba bean and not on nasturtium; and Man., NB-B and P-E which would live on nasturtium and not on faba bean.

Tables III - XXV give the results obtained in the host suitability tests outlined in Chapter III. The cultures

Man., NB-B and P-E were tested on both nasturtium and faba bean, but none lived on faba bean. The cultures BC Lab, BC Wild and NB-A were also tested on both nasturtium and faba bean, and none lived on nasturtium. Therefore Tables III - XXV show only the results of successful host plant acceptance, and the parameters measured.

TABLE II

Successful development (+) or failure to establish and develop (-) among six aphid cultures by adult apterous viviparous females caged singly on the leaves of various host plants* in the laboratory and field; ten aphids tested from each culture.

Host plant	Man.	NB-B	P-E	BCLab.	BCWild	NB-A
Spindle tree European spindle tree	+	+	+	+	+	+
Mockorange Waterton	+	+	+	-	-	-
Highbush cranberry	+	-	-	-	-	-
Garden nasturtium Whirly Bird	+	+	+	-	-	-
Faba bean Acker perle	-	-	-	+	+	+
Burdock	+	+	+	+		+
Poppy Double Shirley	-	-	-			+
Seeded dahlia Sprite Mixed	-	-	-	-		-
Tuberous dahlia Gina Lombard	-	+	-			-
Garden green bean Tendergreen Improved	-	-			+	+
Yellow garden bean Round Pod Kidney Wax	-	-		+		+
Scarlet runner bean Scarlet Runner	-	-		+		+
Kidney bean Dark Red	-	-				+
Lima bean Fordhook	-	-		+		+
Garden pea Lincoln Homesteader	-	-		+		+
Hybrid Squash Diplomat	-	-		-		-
Potato Netted Gem	+	-	+	-	-	-
Potato Pontiac	+	-	+	-	-	-
Swiss chard Lucullus	-	-				+
Beet Burgundy	-	-				+
Spinach Melody Hybrid	-	-				+
Rhubarb	+	+	-		-	-
Chia	-	-	+	-	-	-
California mint						

* If there is no mark opposite a plant, that plant was not tested for that aphid culture.

TABLE III

Nymphal development time, prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, and physiological development time in "day-degrees" for ten apterous viviparous female aphids from culture Man. reared singly on leaves of nasturtium, in the laboratory.

day	1	2	3	4	5	6
mean temperature	24	23	22	22	22	22
$-4^{o}C$	20	19	18	18	18	18
accumulated day-degrees	20	39	57	75	93	111
prelarviposition period	1 day					
mean fecundity first five days	31.6 $\pm$ 12.59					
mean total fecundity	76.7 $\pm$ 16.97					
physiological development time	111 day-degrees					

TABLE IV

Nymphal development time, prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, and physiological development time in "day-degrees," for ten apterous viviparous female aphids from culture NB-B reared singly on leaves of nasturtium, in the laboratory.

day	1	2	3	4	5	6	7	8	9
mean temperature	24	23	22	22	22	22	22	24	24
$-4^{o}C$	20	19	18	18	18	18	18	20	20
accumulated day-degrees	20	39	57	75	93	111	129	149	169
prelarviposition period	1 day								
mean fecundity first 5 days	17.3 ± 18.32								
mean total fecundity	52.9 ± 12.61								
physiological development time	169 day-degrees								

TABLE V

Nymphal development time, prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, and physiological development time in "day-degrees," for ten apterous viviparous female aphids from culture P-E reared singly on leaves of nasturtium, in the laboratory.

day	1	2	3	4	5	6	7
mean temperature	24	23	22	22	22	22	22
$-4^{o}C$	20	19	18	18	18	18	18
accumulated day-degrees	20	39	57	75	93	111	129
prelarviposition period	1-2 days						
mean fecundity first 5 days	16.8 ± 14.39						
mean total fecundity	35.4 ± 19.91						
physiological development time	129 day-degrees						

TABLE VI

Nymphal development time, prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, and physiological development time in "day-degrees," for ten apterous viviparous female aphids from culture BC Lab reared singly on leaves of faba bean, in the laboratory.

day	1	2	3	4	5	6	7	8
mean temperature	24	23	22	22	22	22	22	24
-4°C	20	19	18	18	18	18	18	20
accumulated day-degrees	20	39	57	75	93	111	129	149
prelarviposition period	1-2 days							
mean fecundity first 5 days	10.8 ± 1.03							
mean total fecundity	24.1 ± 5.60							
physiological development time	149 day-degrees							

TABLE VII

Nymphal development time, prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, physiological development time in "day-degrees," for ten apterous viviparous female aphids from culture BC Wild reared on leaves of faba bean, in the laboratory.

day	1	2	3	4	5	6	7	8
mean temperature	24	23	22	22	22	22	22	24
-4^{o}C	20	19	18	18	18	18	18	20
accumulated day-degrees	20	39	57	75	93	111	129	149
prelarviposition period	1-2 days							
mean fecundity first 5 days	10.4 ± 4.39							
mean total fecundity	23.4 ± 4.76							
physiological development time	149 day-degrees							

TABLE VIII

Nymphal development time, prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, physiological development time in "day-degrees," for ten apterous viviparous female aphids from culture NB-A reared singly on leaves of faba bean, in the laboratory.

day	1	2	3	4	5	6	7	8
mean temperature	24	23	22	22	22	22	22	24
-4°C	20	19	18	18	18	18	18	20
accumulated day-degrees	20	39	57	75	93	111	129	149
prelarviposition period	1 day							
mean fecundity first 5 days	10.4 ± 3.11							
mean total fecundity	23.7 ± 4.79							
physiological development time	149 day-degrees							

TABLE IX

Nymphal development time, prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, and physiological development time in "day-degrees," for ten apterous viviparous female aphids from culture Man. reared singly on nasturtium leaves in the field.

day	1	2	3	4	5	6
mean temperature	22	22	19	24	23	20
-4°C	18	18	15	20	19	16
accumulated day-degrees	18	36	51	71	90	106
prelarviposition period	1 day					
mean fecundity first 5 days	39.5 + 14.18					
mean total fecundity	79.0 ± 19.16					
physiological development time	106 day-degrees					

TABLE X

Nymphal development time, prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, and physiological development time in "day-degrees," for ten apterous viviparous female aphids from laboratory culture NB-B reared singly on leaves of nasturtium in the field.

day	1	2	3	4	5	6	7	8	9
mean temperature	21	20	23	22	23	23	22	25	20
$-4^{o}C$	17	16	19	18	19	19	18	21	16
accumulated day-degrees	17	33	52	70	89	108	126	147	163
prelarviposition period	1 day								
mean fecundity first 5 days	17.4 ± 6.51								
mean total fecundity	31.3 ± 10.72								
physiological development time	163 day-degrees								

TABLE XI

Nymphal development time, prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, and physiological development time in "day-degrees," for ten apterous viviparous female aphids from laboratory culture P-E reared singly on leaves of nasturtium in the field.

day	1	2	3	4	5	6	7
mean temperature	21	20	23	22	23	23	22
$-4^{O}C$	17	16	19	18	19	19	18
accumulated day-degrees	17	33	52	70	80	108	126
prelarviposition period	1-2 days						
mean fecundity first 5 days	5.7 ± 11.06						
mean total fecundity	26.8 ± 12.34						
physiological development time	126 day-degrees						

TABLE XII

Nymphal development time, prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, and physiological development time in "day-degrees," for ten apterous viviparous female aphids from laboratory culture BC Lab reared singly on faba bean leaves in the field.

day	1	2	3	4	5	6	7	8
mean temperature	21	20	23	22	23	23	23	25
$-4^{o}C$	17	16	19	18	19	19	19	21
accumulated day-degrees	17	33	52	70	89	108	126	147
prelarviposition period	1-2 days							
mean fecundity first 5 days	22.2 + 3.68							
mean total fecundity	33.3 + 5.36							
physiological development time	147 day-degrees							

TABLE XIII

Nymphal development time, prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, and physiological development time in "day-degrees," for ten apterous viviparous female aphids from laboratory culture NB-A reared singly on faba bean leaves in the field.

day	1	2	3	4	5	6	7	8
mean temperature	21	20	23	22	23	23	22	25
$-4^{o}C$	17	16	19	18	19	19	18	21
accumulated day-degrees	17	33	52	70	89	108	126	147
prelarviposition period	1-2 days							
mean fecundity first five days	9.40 ± 2.56							
mean total fecundity	26.2 ± 2.47							
physiological development time	147 day-degrees							

TABLE XIV

Summary of observations on nymphal development time, prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity and physiological development time in "day-degrees," for six aphid cultures on either nasturtium or faba bean, in laboratory or field.

	Man.		NB-B		P-E		BC Lab		BC Wild		NB-A	
	nasturtium						faba bean					
	Lab	Field	Lab	Field	Lab	Field	Lab	Field	Lab	Field	Lab	Field
nymphal development time (days)	6	6	9	9	7	7	8	8	8	–	8	8
prelarviposition period (days)	1	1	1	1	1-2	1-2	1-2	1-2	1-2	–	1	1-2
mean fecundity first 5 days	31.6	39.5	17.3	17.4	16.8	5.7	10.8	22.2	10.4	–	10.4	9.4
mean total fecundity	76.7	79.0	52.9	31.3	35.4	26.8	24.1	33.3	23.4	–	23.7	26.2
physiological development time day degrees	111	106	169	163	129	126	149	147	149	–	149	147

Table XIV is a summary of the main results from Tables III - XIII. The three aphid cultures which are believed to be the true Aphis fabae were remarkably homogeneous in development and reproduction, in both laboratory and field tests. BC Wild was not available for a field test in 1977 when the other field tests were made. Temperature extremes were not great in the field tests, because they were conducted during July - August, when nights were not normally cold. Nymphal development time and prelarviposition period (Table XIV) are almost identical for all three cultures, both laboratory and field tests, as was also physiological development time. These three parameters are in a category of "development," as opposed to the other main category of "fecundity" or reproductive capacity. In measurements of both "fecundity of the first five days of adult life," and "total fecundity," results once again were uniform, except for the culture BC Lab in field tests, where more offspring were produced. This may be attributed to the fact that when you have a relatively small sample such as n = 10, one or two female aphids producing either an unusually large number or an unusually small number may result in larger or smaller than normal differences. A few females in the BC Lab field test produced larger than normal numbers of young, resulting in the means of 22.2 and 33.3 young for the fecundity counts.

The differences among the three cultures Man., NB-B and P-E are not so easily understood or interpreted. Each culture is reasonably uniform between its laboratory and field tests, but there are considerable differences between the three cultures (Table XIV). One could conjecture that these are evolutionary "offshoots" from the genetically stable main stem of the true Aphis fabae. Individually and as a group, the three cultures differ both in development and reproductive capacity from the three cultures BC Lab, BC Wild and NB-A.

TABLE XV

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of a generation in "day-degrees" (time taken for an aphid to produce half its offspring), for ten apterous viviparous female aphids from culture Man. reared singly on nasturtium leaves, in the laboratory.

							6.5																							
days of adult life	1	2	2	3	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
mean length of adult life	21 days																													
mean fecundity per aphid	4.1	4.4	6.5	8.2	8.4	4.9	6.3	6.4	7.4	6.4	3.2	2.5	2.0	1.3	1.7	0.7	0.9	0.2	1.2	0	0	0	0	0	0	0	0	0	0	0
mean reproductive period	16 days																													
mean temperature	22	24	24	25	23	23	24	24	24	24	24	24	22	25	22	21	22	21	23	23	23	23	23	22	22	23	23	23	23	23
$-4^{o}C$	18	20	20	21	19	19	$20 \times \frac{1}{2} = 9.5$																							
accumulated day-degrees	18	38	58	57	99	118	127.5																							
mean length of generation	111 + 127.5 = 238.5 day-degrees																													

TABLE XVI

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of a generation in "day-degrees" (time taken for an aphid to produce half its offspring), for ten apterous viviparous female aphids from culture NB-B reared singly on nasturtium leaves, in the laboratory.

days of adult life	1	2	3	4	5	6	6.5 7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
mean length of adult life	21 days																				
mean fecundity per aphid	.2	.6	5.0	5.6	6.5	5.7	4.1	5.0	3.7	2.4	2.6	2.2	2.5	1.7	.3	4.1	0	0	0	0	0
mean reproductive period	16 days																				
mean temperature	22	24	24	24	25	23	23	24	24	24	24	24	24	22	22	21	22	21	22	23	23
$-4^{o}C$	18	20	20	20	21	19	19 x ½ = 9.5														
accumulated day-degrees	18	38	58	78	99	118															
mean length of generation	169 + 127.5 = 296.5 day-degrees.																				

TABLE XVII

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of a generation in "day-degrees" (time taken for an aphid to produce half its offspring), for ten apterous viviparous female aphids from culture P-E reared singly on nasturtium leaves, in the laboratory.

							6.5									
days of adult life	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
mean length of adult life	12 days															
mean fecundity per aphid	0	.5	6.0	2.1	2.4	5.8	4.2	4.2	4.2	2.9	1.4	1.2	.5	0	0	0
mean reproductive period	10 days															
mean temperature	22	24	24	24	25	23	23	24	24	24	24	24	23	23	23	22
$-4^{\circ}C$	18	20	20	20	21	19	$19 \times \frac{1}{2} = 9.5$									
accumulated day-degrees	18	38	58	78	99	118	<u>127.5</u>									
mean length of generation	129 + 127.5 = <u>256.5 day-degrees</u>															

TABLE XVIII

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of a generation in "day-degrees" (time taken for an aphid to produce half its offspring), for ten apterous viviparous female aphids from culture BC Lab reared singly on faba bean leaves, in the laboratory.

days of adult life	1	2	3	4	5	6	6.5 7	8	9	10	11	12	13	14	15	16	17	18	19	20
mean length of adult life	11 days																			
mean fecundity per aphid	2.1	2.3	1.9	2.2	2.3	2.3	3.0	1.5	1.2	1.2	1.4	.9	.4	.3	.4	.3	0	.1	.3	0
mean reproductive period	10 days																			
mean temperature	22	24	24	24	25	23	23	24	24	24	24	24	22	22	22	21	22	21	23	23
$-4^{\circ}C$	18	20	20	20	21	19	$19 \times \frac{1}{2} = 9.5$													
accumulated day-degrees	18	38	58	78	99	108.5														
mean length of generation	149 + 108.5 = 257.5 day-degrees																			

TABLE XIX

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of a generation in "day-degrees" (time taken for an aphid to produce half its offspring), for ten apterous viviparous female aphids from culture BC Wild reared singly on faba bean leaves, in the laboratory

						6.5														
days of adult life	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
mean length of adult life	12 days																			
mean fecundity per aphid	11	23	22	30	17	0.6	1.6	1.6	1.4	1.1	.7	1.7	.4	.7	1.1	.6	1.4	0	.1	.1
mean reproductive period	10 days																			
mean temperature	22	24	24	24	25	23	23	24	24	24	24	24	22	22	22	21	22	21	23	23
$-4^{o}C$	18	20	20	20	21	$19 \times \frac{1}{2} = 9.5$														
accumulated day-degrees	18	38	58	78	99	108.5														
mean length of generation	149 + 108.5 = 257.5 day-degrees																			

TABLE XX

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of a generation in "day-degrees" (time taken for an aphid to produce half its offspring), for ten apterous viviparous female aphids from culture NB-A reared singly on faba bean leaves, in the laboratory.

							6.5														
days of adult life	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
mean length of adult life	12 days																				
mean fecundity per aphid	2.3	1.9	2.3	2.6	1.3	1.2	1.6	1.7	2.0	1.2	1.0	.5	1.2	1.4	.7	.4	0	0	.2	.1	.1
mean reproductive period	11 days																				
mean temperature	22	24	24	24	25	23	24	24	24	24	24	22	22	22	21	21	22	21	23	23	23
$-4^{o}C$	18	20	20	20	21	$19 \times \frac{1}{2} = 9.5$															
accumulated day-degrees	18	38	57	78	99	108.5															
mean length of generation	149 + 108.5 = 257.5 day-degrees																				

TABLE XXI

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of a generation in "day-degrees" (time taken for an aphid to produce half its offspring), for ten apterous viviparous female aphids from culture Man. reared singly on faba bean leaves, in the field.

						6.5									
days of adult life	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
mean length of adult life	13 days														
mean fecundity per aphid	3.	4.4	5.	9.	6.5	6.7	9.	6.	9.	9.	6.5	0.9	1.1	2.1	0.8
mean reproductive period	10 days														
mean temperature	22	11	19	18	18	18	19	19	18	18	17	17	18	18	18
$-4^{O}C$	18	18	15	14	14	14	x ½	= 7							
accumulated day-degrees	18	36	51	65	79	93	<u>100</u>								
mean length of a generation	106 + 100 = <u>206 day-degrees</u>														

TABLE XXII

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of a generation in "day-degrees" (time taken for an aphid to produce half its offspring), for ten apterous viviparous female aphids from culture NB-B reared singly on faba bean leaves, in the field.

							6.5								
days of adult life	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
mean length of adult life	12 days														
mean fecundity	1	1.5	1.8	3.	3.5	5.	5.5	4.	.5	.2	.5	.2	.9	1.9	1.8
mean reproductive period	9 days														
mean temperature	22	22	19	19	18	20	18	18	19	18	17	18	19	19	20
$-4^{o}C$	18	18	15	15	14	16	18	x ½ =	9						
accumulated day-degrees	18	36	51	66	80	96	105								
mean length of a generation	163 + 105 = 260 day-degrees														

TABLE XXIII

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of a generation in "day-degrees" (time taken for an aphid to produce half its offspring), for ten apterous viviparous female aphids from culture P-E reared singly on faba bean leaves, in the field.

							6.5				
days of adult life	1	2	3	4	5	6	7	8	9	10	11
mean length of adult life	9 days										
mean fecundity per aphid	.2	.5	4.5	2	3	3	4.5	6.1	2.1	.7	.2
mean reproductive period	6 days										
mean temperature	22	22	19	19	18	20	18	18	19	18	17
$-4^{o}C$	18	18	15	15	18	16	14 x ½ = 7				
accumulated day-degrees	18	36	51	66	84	100	107				
mean length of generation	126 + 107 = 233 day-degrees										

TABLE XXIV

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of a generation in "day-degrees" (time taken for an aphid to produce half its offspring), for ten apterous viviparous female aphids from culture BC Lab reared singly on faba bean leaves, in the field.

							6.5							
days of adult life	1	2	3	4	5	6	7	8	9	10	11	12	13	14
mean length of adult life	10 days													
mean fecundity per aphid	2.9	3.1	2	1.8	2	2.2	4.1	3.8	1.4	1.1	2	2	2	2.9
mean reproductive period	7 days													
mean temperature	20	20	18	19	17	18	20	20	18	17	17	18	18	18
-4^{O}C	16	16	14	15	13	14	16 x ½ = 8							
accumulated day-degrees	16	32	46	61	74	88	96							
mean length of generation	147 + 96 = 243 day-degrees													

TABLE XXV

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of a generation in "day-degrees" (time taken for an aphid to produce half its offspring), for ten apterous viviparous female aphids from culture NB-A reared singly on faba bean leaves in the field.

days of adult life	1	2	3	4	5	6	6.5 7	8	9	10	11	12	13	14	15
mean length of adult life	10 days														
mean fecundity	1.5	2.5	1.5	2	1.9	1.8	2	1.5	1.9	1.7	2.5	1.5	1.5	1.3	1.1
mean reproductive period	7 days														
mean temperature	20	20	18	19	17	18	20	20	18	17	17	18	18	18	18
$-4^{o}C$	16	16	14	15	13	14	16 x ½ = 8								
accumulated day-degrees	16	32	46	61	74	88	96								
mean length of a generation	147 + 96 = 243 day-degrees														

TABLE XXVI

Summary of observations on mean length of adult life, mean reproductive period and mean length of a generation in day-degrees for six aphid cultures on either nasturtium or faba bean, in laboratory or field.

	Man.		NB-B		P-E		BC Lab		BC Wild		NB-A	
	nasturtium						faba bean					
	Lab	Field	Lab	Field	Lab	Field	Lab	Field	Lab	Field	Lab	Field
mean length of adult life (days)	21	13	21	12	12	9	11	10	12	-	12	10
mean reproductive period (days)	16	10	16	9	10	6	10	7	10	-	11	7
mean length of a generation (days)	238.5	206	296.5	260	256.5	233	257.5	243	257.5	-	257.5	243

Table XXVI summarizes the main measurements extracted from the results reported in Tables XV to XXV. In these tests the same adults used in the experiments reported in Tables II to XIII remained in their cages until they died, and records were kept of total length of adult life, total reproductive period and a calculation was made of "mean length of a generation in day-degrees" (Blackman 1974, pp. 130 - 131). The mean length of generation is a rough estimate only, and is used as a method of determining the number of generations the summer forms in a colony of aphids may have. Table XXVI shows that all the field tests resulted in fewer day-degrees than in the corresponding laboratory tests. This probably resulted from higher temperatures in the microclimate of the cages in the field tests, than the maximum - minimum temperatures supplied by the Meteorological Service at Kenora, Ontario. Otherwise "mean length of a generation" (Table XXVI) is uniform for the culture BC Lab, BC Wild and NB-A, but the other three cultures of Man., NB-B and P-E differ from one another. In the other two measurements made, mean length of adult life, and mean reproductive period, Man. and NB-B are similar in number of days, both laboratory and field, but P-E differs from Man. and NB-B in having fewer days.

An interesting observation from the data in Tables XV to XXV is that in all cultures, both laboratory and field tests, half the offspring were produced in the first 6.5

TABLE XXVII

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of a generation in "day-degrees' (time taken for an aphid to produce half its offspring), for ten apterous viviparous female aphids from laboratory culture NB-B reared singly on burdock leaves in the field.

					5.5								
days of adult life	1	2	3	4	5	6	7	8	9	10	11	12	13
mean length of adult life	12 days												
mean fecundity per aphid	4	2.2	1.9	2.9	3.2	4.4	2.2	2.2	1.8	1.2	2	0	0
mean reproductive period	11 days												
mean temperature	22	22	19	19	18	20	18	18	19	18	17	18	19
$-4^{o}C$	18	18	15	15	14	16 x ½ = 8							
accumulated day-degrees	18	36	51	66	80	96							
mean length of a generation	163 + 96 = 259 day-degrees												

TABLE XXVIII

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of a generation in "day-degrees" (time taken for an aphid to produce half its offspring), for ten apterous viviparous female aphids from culture P-E reared singly on burdock leaves in the field.

				4.5							
days of adult life	1	2	3	4	5	6	7	8	9	10	11
mean length of adult life	9 days										
mean fecundity per aphid	3.4	4.5	4.7	3	2.6	1.3	1.2	0	0	0	0
mean reproductive period	7 days										
mean temperature	22	22	19	19	18	20	18	18	19	18	17
$-4^{o}C$	18	18	15	15	14 x ½ = 7						
accumulated day-degrees	18	36	51	66	73						
mean length of a generation	126 + 73 = 199 day-degrees										

TABLE XXIX

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period, and mean length of a generation in "day-degrees" (time taken for an aphid to produce half its offspring), for ten apterous viviparous female aphids from laboratory culture BC Lab, reared singly on burdock leaves in the field.

					4.5						
days of adult life	1	2	3	4	5	6	7	8	9	10	11
mean length of adult life	10 days										
mean fecundity per aphid	2.3	3.2	2.7	2.2	2.1	3	3.4	1.8	.8	.6	0
mean reproductive period	10 days										
mean temperature	22	22	19	19	18	20	18	18	19	18	17
$-4^{o}C$	18	18	15	15	14 x ½ = 7						
accumulated day-degrees	18	36	51	66	73						
mean length of a generation	147 + 73 = 220 day-degrees										

TABLE XXX

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period, and mean length of a generation in "day-degrees" (time taken for an aphid to produce half its offspring), for ten apterous viviparous female aphids from laboratory culture NB-A reared singly on burdock leaves in the field.

				3.5								
days of adult life	1	2	3	4	5	6	7	8	9	10	11	12
mean length of adult life	12 days											
mean fecundity per aphid	.7	3.1	2.2	2.3	3.1	2	.7	.6	1.3	1.3	1	0
mean reproductive period	11 days											
mean temperature	22	22	19	19	18	20	18	18	19	18	17	18
$-4^{\circ}C$	18	18	15	$15 \times \frac{1}{2} = 7.5$								
accumulated day-degrees	18	36	51	58.5								
mean length of a generation	147 + 58.5 + 205.5 day-degrees											

TABLE XXXI

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of life of a generation in "day-degrees" (time taken for an aphid to produce half its offspring), for ten apterous viviparous female aphids from laboratory culture NB-A reared singly on poppy leaves in the field.

			2.5					
days of adult life	1	2	3	4	5	6	7	8
mean length of adult life	8 days							
mean fecundity per aphid	2.7	2.6	4.7	2.9	2.4	2.6	.2	0
mean reproductive period	7 days							
mean temperature	22	22	19	19	18	18	19	18
$-4^{\circ}C$	18	18	15 x ½ = 7.5					
accumulated day-degrees	18	36	51	58.5				
mean length of a generation	147 + 58.5 = 205.5 day-degrees							

TABLE XXXII

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of a generation in "day-degrees" (time taken for an aphid to produce half its offspring), for ten apterous viviparous female aphids from laboratory culture NB-B reared singly on tuberous dahlia leaves in the field.

days of adult life	1	2	3	4	4.5 5	6	7	8	9
mean length of adult life	8 days								
mean fecundity per aphid	5.4	5.4	5.1	4.1	3.9	.8	1	1.4	0
mean reproductive period	8 days								
mean temperature	22	22	21	19	20	19	19	18	18
$-4^{o}C$	18	18	17	15	16 x ½ = 8				
accumulated day-degrees	18	36	53	68	76				
mean length of a generation	163 + 76 = 239 day-degrees								

TABLE XXXIII

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of a generation in "day-degrees" (time taken for an aphid to produce half its offspring), for ten apterous viviparous female aphids from laboratory culture P-E reared singly on potato leaves in the field - Pontiac.

			2.5				
days of adult life	1	2	3	4	5	6	7
mean length of adult life	7 days						
mean fecundity per aphid	.2	2.8	3.5	3.8	2.5	.6	0
mean reproductive period	6 days						
mean temperature	22	22	21	19	20	19	19
-4°C	18	18	17 x ½ = 8.5				
accumulated day-degrees	18	36	53	61.5			
mean length of a generation	126 + 61.5 = 187.5 day-degrees						

TABLE XXXIV

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of a generation in "day-degrees" (time taken by an aphid to produce half its offspring), for ten apterous viviparous female aphids from laboratory culture Man., reared singly on rhubarb leaves in the field.

					5.5					
days of adult life	1	2	3	4	5	6	7	8	9	10
mean length of adult life	7 days									
mean fecundity	0	0	.1	.6	.3	.3	.2	.1	0	0
mean reproductive period	6 days									
mean temperature	22		19	18	18	18	19	19	18	18
$-4^{o}C$	18	18	15	14	14	14 x ½ = 7				
accumulated day-degrees	18	36	51	65	79	86				
mean length of a generation	106 + 86 = 192 day-degrees									

TABLE XXXV

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of a generation in "day-degrees" (time taken by an aphid to produce half its offspring), for ten apterous viviparous female aphids from laboratory culture NB-B reared singly on rhubarb leaves in the field.

						5.5					
days of adult life	1	2	3	4	5	6	7	8	9	10	11
mean length of adult life	10 days										
mean fecundity per aphid	0	.1	4.5	.4	.5	.5	.5	.4	.2	.2	0
mean reproductive period	9 days										
mean temperature	22	21	20	19	17	18	19	21	21	22	22
$-4^{O}C$	18	17	16	15	12	$18 \times \frac{1}{2} = 9$					
accumulated day-degrees	18	35	51	65	78	<u>87.0</u>					
mean length of a generation	126 + 87.0 = <u>213 day-degrees</u>										

TABLE XXXVI

Days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of a generation in "day-degrees" (time taken by an aphid to produce half its offspring), for ten apterous viviparous female aphids from laboratory culture P-E reared singly on leaves of chia in the field.

				4.5					
days of adult life	1	2	3	4	5	6	7	8	9
mean length of adult life	9 days								
mean fecundity per aphid	0	2.0	1.9	4.3	5.1	4.9	4.0	1.5	0
mean reproductive period	8 days								
mean temperature	22	21	20	19	17	18	19	21	21
-4^{o}C	18	17	16	15	13 x ½ = 6.5				
accumulated day-degrees	18	35	51	66	72.5				
mean length of a generation	126 = 72.5 = 198.5 day-degrees								

TABLE XXXVII

Mean length of adult life, mean fecundity during first five days of adult life, mean reproductive period, and mean length of a generation in day-degrees of some aphid cultures on some host plants, field tests in 1977.

	burdock				poppy	tuberous dahlia	potato	rhubarb		chia
	NB-B	P-E	BC Lab	NB-A	NBA	NB-B	P-E	Man.	NB-B	P-E
mean length of adult life (days)	12	9	10	12	8	8	7	7	10	9
mean fecundity first five days	28.4	36.4	25	22.8	30.6	47.8	25.6	2	11	26.6
mean reproductive period (days)	11	7	10	11	7	8	6	6	9	8
mean length of a generation in day-degrees	259	199	220	205.5	205.5	239	187.5	192	213	198.5

Table II gave results which showed the successful or unsuccessful establishment of the various cultures on miscellaneous summer hosts. Not all cultures were attempted on all plants, and successful establishments were irregular and unpredictable. Most of the host plants chosen had been reported at one time or another to be hosts of Aphis fabae.

Table XXXVII is a summary of successful field test trials with available cultures on some of the plants listed in Table II. Details of the experiments are given in Tables XXVII to XXXVI. In general, aphids in field tests did not live as long as those in laboratory tests, and there was usually only a brief postlarviposition period before death. The four cultures tested on burdock all thrived, and gave comparable results for the parameters measured. Poppy and dahlia were apparently very suitable hosts for the NB-A and NB-B cultures respectively, and rhubarb was not a good host for either Man. or NB-B.

TABLE XXXVIII

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture Man. reared singly on leaves of the spindle tree.

			3.5					
day	1	2	3	4	5	6	7	8
mean temperature	26	25	24	24	24	24	25	26
$-4^{o}C$	22	21	20	24 x ½ = 12				
accumulated day-degrees	22	43	63	75				
prelarviposition period	1 day							
mean fecundity first five days	16.2 + 6.74							
mean total fecundity	17.0 $\pm$ 8.63							
mean reproductive period	6 days							
mean length of a generation	111 & 75 = 186 day-degrees							

TABLE XXXIX

Prelarvipositon period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture NB-B reared singly on leaves of the spindle tree.

day	1	2	2.5 3	4	5	6	7	8	9	10	11	12	13
mean temperature	26	25	24	24	24	24	25	26	24	24	24	24	24
$-4^{o}C$	22	21	21 x ½ = 10.5										
accumulated day-degrees	22	23	33.5										
prelarviposition period	1 day												
mean fecundity first five days	15.9 ± 8.42												
mean total fecundity	23.7 ± 3.16												
mean reproductive period	12 days												
mean length of a generation	169 + 33.5 = 202.5 day-degrees												

TABLE XL

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period, and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture P-E reared singly on leaves of the spindle tree.

			2.5																			
day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
mean temperature	26	25	24	24	24	24	24	25	26	24	24	24	24	24	24	24	24	24	24	24	24	24
$-4^{o}C$	22	21	20 x $\frac{1}{2}$ = 10																			
accumulated day-degrees	22	43	53																			
prelarviposition period	1 day																					
mean fecundity during first five days	19.0 $\pm$ 10.78																					
mean total fecundity	25.8 $\pm$ 11.77																					
mean reproductive period	16 days																					
mean length of a generation	129 + 53 = 182 day-degrees																					

TABLE XLI

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period, and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture BC Lab reared singly on leaves of the spindle tree.

day	1	2	3	4	5	6	6.5 7	8	9	10	11	12	13	14	15	16	17
mean temperature	26	25	24	24	24	24	25	26	24	24	24	24	24	24	24	24	24
$-4^{\circ}C$	22	21	21	21	21	21	21 x ½ = 10.5										
accumulated day-degrees	22	43	64	84	104	124	134.5										
prelarviposition period	1 day																
mean fecundity first five days	10.2 + 4.56																
mean total fecundity	34.0 + 6.06																
mean reproductive period	15 days																
mean length of a generation	149 + 134.5 = 283.5 day-degrees																

TABLE XLII

Prelarvipositon period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture BC Wild reared singly on leaves of the spindle tree.

							6.5														
day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
mean temperature	26	25	24	24	24	24	25	24	24	24	24	24	24	24	24	24	24	24	24	24	24
$-4^{o}C$	22	21	20	20	20	20	21 x ½ = 10.5														
accumulated day-degrees	22	43	64	84	104	124	134.5														
prelarviposition period	1 day																				
mean fecundity during first five days	14.1 ± 3.54																				
mean total fecundity	36.1 ± 6.08																				
mean reproductive period	20 days																				
mean length of a generation	149 + 134.5 + 283.5 day-degrees																				

TABLE XLIII

Prelarviipositon period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture NB-A reared singly on leaves of the spindle tree.

							6.5						
day	1	2	3	4	5	6	7	8	9	10	11	12	13
mean temperature	26	25	24	24	24	24	25	26	24	24	24	24	24
$-4^{o}C$	22	21	21	20	20	20	$21 \times \frac{1}{2} = 10.5$						
accumulated day-degrees	22	43	64	84	104	124	134.5						
prelarviposition period	1 day												
mean fecundity during first five days	11.1 ± 5.23												
mean total fecundity	31.5 ± 8.02												
mean reproductive period	13 days												
mean length of a generation	149 + 134.5 = 283.5 day-degrees												

TABLE XLIV

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture Man. reared singly on leaves of Mockorange.

day	1	2	3	3.5 4	5	6	7
mean temperature	24	24	24	24	24	24	24
$-4^{o}C$	20	20	20	20 x ½ = 10			
accumulated day-degrees	20	40	60	<u>70</u>			
prelarviposition period	1 day						
mean fecundity first five days	18.9 ± 5.97						
mean total fecundity	18.9 ± 5.97						
mean reproductive period	5 days						
mean length of a generation	111 + 70 = <u>181 day-degrees</u>						

TABLE XLV

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture Man. reared singly on leaves of highbush cranberry.

day	1	2	2.5 3	4	5	6	7	8	9	10
mean temperature	25	25	25	25	26	26	26	26	27	
$-4^{o}C$	21	21	21 x ½ = 10.5							
accumulated day-degrees	21	42	52.5							
prelarviposition period	1 day									
mean fecundity during first five days	15.5 $\pm$ 10.31									
mean total fecundity	16.3 $\pm$ 10.31									
mean reproductive period	10 days									
mean length of a generation	127.5 + 52.5 = 180 day-degrees									

TABLE XLVI

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture Man. reared singly on leaves of burdock.

						5.5																						
day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
mean temperature	24	24	24	24	24	24	24	24	24	25	23	23	23	23	25	23	24	25	24	24	24	24	24	24	25	24	24	24
$-4^{o}C$	20	20	20	20	20	20	x ½	= 10																				
accumulated day-degrees	20	40	60	80	100	110																						
prelarviposition period	1 day																											
mean fecundity first five days	31.1 ± 13.35																											
mean total fecundity	65.0 ± 14.44																											
mean reproductive period	25 days																											
mean length of a generation	111 + 110 = 221 day-degrees																											

TABLE XLVII

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture NB-B reared singly on leaves of burdock.

day	1	2	3	4	4.5 5	6	7	8	9	10	11	12	13	14	15	16	17
mean temperature	15	23	23	23	23	24	25	25	24	25	23	23	23	23	25	23	24
$-4^{\circ}C$	21	19	19	19	19 x ½	=	9.5										
accumulated day-degrees	21	40	59	78	87.5												
prelarviposition period	1 day																
mean fecundity first five days	18.1 ± 5.54																
mean total fecundity	273 ± 9.34																
mean reproductive period	16 days																
mean length of a generation	169 + 87.5 = 256.5 day-degrees																

TABLE XLVIII

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture NB-A reared singly on leaves of burdock.

								7.5										
day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
mean temperature	25	23	23	23	23	25	25	25	24	25	23	23	23	23	25	23	24	25
$-4^{o}C$	21	19	19	19	19	21	21	21 x ½ = 10.5										
accumulated day-degrees	21	40	59	78	97	118	139	149.5										
prelarviposition period	1 day																	
mean fecundity first five days	10.9 ± 8.36																	
mean total fecundity	31.3 ± 6.75																	
mean reproductive period	18 days																	
mean length of a generation	149 + 149.5 + 298.5 day-degrees																	

TABLE XLIX

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture NB-A reared singly on leaves of poppy.

			2.5											
day	1	2	3	4	5	6	7	8	9	10	11	12	13	14
mean temperature	23	23	23	23	24	25	25	24	25	23	23	23	25	23
$-4^{o}C$	19	19	$19 \times \frac{1}{2} = 9.5$											
accumulated day-degrees	19	38	$\underline{47.5}$											
prelarviposition period	1 day													
mean fecundity during first five days	14.6 ± 7.45													
mean total fecundity	16.6 ± 9.41													
mean reproductive period	13 days													
mean length of a generation	$149 + 47.5 = \underline{196.5 \text{ day-degrees}}$													

TABLE L

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees," for ten apterous viviparous female aphids from laboratory culture NB-B reared singly on leaves of tuberous dahlia.

		2.5																			
day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
mean temperature	24	25	26	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	24
$-4^{\circ}C$	20	21	$23 \times \frac{1}{2} = 11.5$																		
accumulated day-degrees	20	41	<u>52.5</u>																		
prelarviposition period	1 day																				
mean fecundity first five days	23.4 ± 27.14																				
mean total fecundity	27.6 ± 18.58																				
mean reproductive period	19 days																				
mean length of a generation	169 + 52.5 + <u>221.5 day-degrees</u>																				

TABLE LI

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture BC Wild reared singly on leaves of green garden beans.

2

day	1	2	3	4	5	6	7	8
mean temperature	25	25	25	25	25	24	24	26
-4^{o}C	21	21						
accumulated day-degrees	21	42						
prelarviposition period	1 day							
mean fecundity first five days	6.6							
mean total fecundity	6.6							
mean reproductive period	5 days $\pm$ 2.51							
mean length of a generation	149 + 42 = 191 day-degrees							

TABLE LII

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture NB-A reared singly on leaves of green garden beans.

day	1	2	3	3.5 4	5	6	7	8
mean temperature	24	24	24	24	24	24	25	25
$-4^{o}C$	20	20	20	20 x ½ = 10				
accumulated day-degrees	20	40	60	70				
prelarviposition period	1 day							
mean fecundity first five days	6.6 ± 4.42							
mean total fecundity	7.0 ± 5.25							
mean reproductive period	7 days							
mean length of a generation	149 + 70 = 219 day-degrees							

TABLE LIII

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period, and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture NB-A reared singly on leaves of yellow garden beans.

day	1	2	3	3.5 4	5	6	7
mean temperature	25	25	25	25	24	24	26
$-4^{\circ}C$	21	21	21	21 x ½ = 10.5			
accumulated day-degrees	21	42	63	73.5			
prelarviposition period	1 day						
mean fecundity during first five days	13.8 ± 15.31						
mean total fecundity	13.8 ± 15.31						
mean reproductive period	5 days						
mean length of a generation	149 + 73.5 = 222.5 day-degrees						

TABLE LIV

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period, and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture BC Lab reared singly on leaves of yellow garden beans.

				3.5		
day	1	2	3	4	5	6
mean temperature	25	25	25	25	24	24
$-4^{\circ}C$	21	21	21	$21 \times \frac{1}{2} = 10.5$		
accumulated day-degrees	21	42	63	73.5		
prelarviposition period	1 day					
mean fecundity during first five days	14.6 ± 18.64					
mean total fecundity	14.8					
mean reproductive period	5 days					
mean length of a generation	149 + 73.5 = 222.5 day-degrees					

TABLE LV

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture NB-A reared singly on leaves of scarlet runner bean.

					4.5			
day	1	2	3	4	5	6	7	8
mean temperature	25	26	24	24	24	24	24	25
$-4^{o}C$	21	22	20	20	20 x ½ = 10			
accumulated day-degrees	21	43	63	73	83			
prelarviposition period	1 day							
mean fecundity during first five days	9.5 ± 7.65							
mean total fecundity	15.2 ± 8.98							
mean reproductive period	7 days							
mean length of a generation	149 + 83 = 232 day-degrees							

TABLE LVI

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture BC Lab reared singly on leaves of scarlet runner bean.

day	1	2	3	4	4.5 5	6	7	8
mean temperature	25	26	24	24	24	24	24	25
$-4^{O}C$	21	22	20	20	20 x ½ = 10			
accumulated day-degrees	21	42	63	73	83			
prelarviposition period	1 day							
mean fecundity during first five days	10.5 ± 4.42							
mean total fecundity	15.3 ± 9.07							
mean reproductive period	7 days							
mean length of a generation	149 + 83 = 232 day-degrees							

TABLE LVII

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture NB-A reared singly on leaves of kidney bean.

		2.5				
day	1	2	3	4	5	6
mean temperature	25	25	25	25	25	25
$-4^{o}C$	21	21	$21 \times \frac{1}{2} = 10.5$			
accumulated day-degrees	21	42	52.5			
prelarviposition period	1 day					
mean fecundity during first five days	18.5 ± 19.09					
mean total fecundity	18.5					
mean reproductive period	3 days					
mean length of a generation	149 + 52.5 = 201.5 day-degrees					

TABLE LVIII

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period, and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture BC Lab reared singly on leaves of lima bean.

day	1	2	2.5 3	4	5	6	7	8	9	10
mean temperature	27	27	22	22	22	23	23	23	23	25
$-4^{o}C$	23	23	18 x ½ = 9							
accumulated day-degrees	23	46	55							
prelarviposition period	1 day									
mean fecundity during first five days	7.3 ± 4.37									
mean total fecundity	8.0 ± 4.92									
mean reproductive period	10 days									
mean length of a generation	149 + 55 = 204 day-degrees									

TABLE LIX

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture NB-A reared singly on leaves of lima bean.

day	1	2	3	4	4.5 5	6	7
mean temperature	27	27	22	22	22	23	23
$-4^{o}C$	23	23	18	18	18 x ½ = 9		
accumulated day-degrees	23	46	64	82	<u>91</u>		
prelarviposition period	1 day						
mean fecundity during first five days	6.5 $\pm$ 8.67						
mean total fecundity	11.4 $\pm$ 11.93						
mean reproductive period	6 days						
mean length of a generation	149 + 91 = <u>240 day-degrees</u>						

TABLE LX

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from culture BC Lab reared singly on leaves of garden pea.

				4.5				
day	1	2	3	4	5	6	7	8
mean temperature	25	26	24	24	24	24	25	25
$-4^{o}C$	21	22	20	20	20 x ½ = 10			
accumulated day-degrees	21	43	63	83	93			
prelarviposition period	1 day							
mean fecundity during first five days	6.7 ± 7.70							
mean total fecundity	10.0 ± 8.21							
mean reproductive period	7 days							
mean length of a generation	149 + 93 = 242 day-degrees							

TABLE LXI

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period, and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture NB-A reared singly on leaves of garden pea.

					4.5			
day	1	2	3	4	5	6	7	8
mean temperature	25	26	24	24	24	24	25	25
$-4^{o}C$	21	22	20	20	$20 \times \frac{1}{2} = 10$			
accumulated day-degrees	21	43	63	83	93			
prelarviposition period	1 day							
mean fecundity during first five days	6.9 ± 5.46							
mean total fecundity	9.0 ± 5.50							
mean reproductive period	7 days							
mean length of a generation	149 + 93 = 242 day-degrees							

TABLE LXII

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees," for ten apterous viviparous female aphids from laboratory culture Man. reared singly on leaves of potato - Netted Gem.

day	1	2	3	3.5 4	5	6	7	8	9	10	11	12	13
mean temperature	24	24	24	24	24	25	24	24	25	25	25	25	25
$-4^{o}C$	20	20	20	20 x ½ = 10									
accumulated day-degrees	20	40	60	70									
prelarviposition period	1 day												
mean fecundity during first five days	16.2 ± 16.78												
mean total fecundity	22.4 ± 13.17												
mean reproductive period	11 days												
mean length of a generation	111 + 70 + 181 day-degrees												

TABLE LXIII

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture P-E reared singly on leaves of potato - Netted Gem.

				3.5			
day	1	2	3	4	5	6	7
mean temperature	27	27	27	23	22	23	23
$-4^{o}C$	23	23	23	19 x ½ = 9.5			
accumulated day-degrees	23	46	59	68.5			
prelarviposition period	1-2 days						
mean fecundity during first five days	11.2 ± 8.18						
mean total fecundity	11.2						
mean reproductive period	5 days						
mean length of a generation	129 + 68.5 = 197.5 day-degrees						

TABLE LXIV

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees," for ten apterous viviparous female aphids from laboratory culture Man. reared singly on leaves of potato - Pontiac.

							6.5						
day	1	2	3	4	5	6	7	8	9	10	11	12	13
mean temperature	24	24	24	25	25	25	25	26	27	22	22	22	22
$-4^{o}C$	20	20	20	21	21	21	$21 \times \frac{1}{2} = 10.5$						
accumulated day-degrees	20	40	60	81	101	122	132.5						
prelarviposition period	1 day												
mean fecundity during first five days	14.1 ± 22.92												
mean total fecundity	29.3 ± 16.10												
mean reproductive period	13 days												
mean length of a generation	111 + 132.5 = 143.5 day-degrees												

TABLE LXV

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees," for ten apterous viviparous female aphids from laboratory culture P-E reared singly on leaves of potato - Pontiac.

			2.5			
day	1	2	3	4	5	6
mean temperature	25	25	25	24	25	23
$-4^{o}C$	21	21	$21 \times \frac{1}{2} = 10.5$			
accumulated day-degrees	21	42	52.5			
prelarviposition period	2 days					
mean fecundity during first five days	10.4 ± 9.49					
mean total fecundity	10.4 ± 9.49					
mean reproductive period	4 days					
mean length of a generation	129 + 52.5 + 181.5 day-degrees					

TABLE LXVI

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees," for ten apterous viviparous female aphids from laboratory culture NB-A reared singly on leaves of Swiss chard.

day	1	2	2.5 3	4	5
mean temperature	24	24	24	24	24
$-4^{o}C$	20	20	20 x ½ = 10		
accumulated day-degrees	20	40	<u>50</u>		
prelarviposition period	1-2 days				
mean fecundity during first five days	13.7 ± 21				
mean total fecundity	13.7 ± 21				
mean reproductive period	4 days				
mean length of a generation	149 + 50 = <u>199 day-degrees</u>				

TABLE LXVII

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture NB-A reared singly on leaves of beet.

				3.5			
day	1	2	3		4	5	6
mean temperature	23	24	24		24	24	24
$-4^{o}C$	19	20	20		20 x ½ = 10		
accumulated day-degrees	19	39	59		<u>69</u>		
prelarviposition period	1-2 days						
mean fecundity first five days	12.5 ± 17.36						
mean total fecundity	12.5 ± 17.36						
mean reproductive period	5 days						
mean length of a generation	149 + 69 = <u>218 day-degrees</u>						

TABLE LXVIII

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" for ten apterous viviparous female aphids from laboratory culture NB-A reared singly on leaves of spinach.

						6.5		
day	1	2	3	4	5	6	7	8
mean temperature	24	24	23	24	23	24	24	23
$-4^{o}C$	20	20	19	20	19	20 x ½ = 10		
accumulated day-degrees	20	40	59	79	98	108		
prelarviposition period	1-2 days							
mean fecundity first 5 days	9.2 $\pm$ 9.31							
mean total fecundity	10.4 $\pm$ 8.02							
mean reproductive period	6 days							
mean length of a generation	149 + 108 = 257 day-degrees							

TABLE LXIX

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" of ten apterous viviparous females of six cultures of aphids reared singly in the laboratory on leaves of the spindle tree.

	Man.	NB-B	P-E	BC Lab	BC Wild	NB-A
prelarviposition period (days)	1	1	1	1	1	1
mean fecundity during first five days of adult life	16.2	15.9	19.0	10.2	14.1	11.1
mean total fecundity	17.0	23.7	25.8	34.0	36.1	31.5
mean reproductive period (days)	6	12	16	15	20	13
mean length of a generation in day-degrees	186	202.5	182	283.5	283.5	283.5

TABLE LXX

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" of ten apterous viviparous females of three cultures of aphids reared singly in the laboratory on leaves of miscellaneous host plants

	Man. mockorange	Man. viburnum	Man. burdock	Man. netted gem	Man. Pontiac	NB-B burdock	NB-B tuberous dahlia	P-E netted gem	P-E Pontiac
prelarviposition period (days)	1	1	1	1	1	1	1	1-2	2
mean fecundity during first five days of adult life	18.9	15.5	31.1	16.2	14.1	18.1	23.4	11.2	10.4
mean total fecundity	18.9	16.3	65.0	22.4	29.3	27.3	27.6	11.2	10.4
mean reproductive period (days)	5	10	25	11	13	16	19	5	4
mean length of a generation in day-degrees	181	180	221	181	143.5	256.5	221.5	197.5	181.5

TABLE LXXI

Prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of a generation in "day-degrees" of ten apterous viviparous females of three cultures of aphids reared singly in the laboratory on leaves of miscellaneous host plants.

	BC Lab yellow garden bean	BC Lab scarlet runner bean	BC Lab lima bean	BC Lab garden pea	BC Wild green garden bean	NB-A burdock	NB-A poppy	NB-A green garden bean	NB-A yellow garden bean	NB-A scarlet runner bean	NB-A kidney bean	NB-A lima bean	NB-A garden pea	NB-A Swiss chard	NB-A beet	NB-A spinach
prelarviposition period (days)	1	1	1	1	1	1	1	1	1	1	1	1	1	1–2	1–2	1–2
mean fecundity during first five days of adult life	14.6	10.5	7.3	6.7	6.6	10.9	14.6	6.6	13.8	9.5	18.5	6.5	6.9	13.7	12.5	9.2
mean total fecundity	14.8	15.3	8.0	10	6.6	31.3	16.6	7.0	13.8	15.2	18.5	11.4	9.0	13.7	12.5	10.4
mean reproductive period (days)	5	7	10	7	5	18	13	7	5	7	3	6	7	4	5	6
mean length of a generation in day-degrees	222.5	232	204	242	191	298.5	196.5	219	222.5	232	201.5	240	242	199	218	257

Tables XXXVIII to LXVIII inclusive show the prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, mean reproductive period and mean length of generation in day-degrees for 31 miscellaneous tests in the laboratory of the various cultures on several summer hosts, including spindle tree, mockorange and highbush cranberry. In general, these are continuations of development and fecundity of successful colonization attempts of the tests from the plants shown in Table II. Not all hosts were tested with all six aphid cultures, and in many instances the cultures did not colonize (Table II). No attempt was made by the author of this thesis to determine why some kinds of hosts were accepted or rejected by the several aphid cultures. This would have involved several years of long and difficult studies in the areas of research known as "host plant selection by phytophagous insects" or "insect resistance in crop plants."

These 21 tests are summarized in Tables LXIX, LXX, and LXXI. Table LXIX shows the parameters measured for the successful colonization of the European spindle tree (Euonymus europaeus) by all six cultures. It must be noted that although this is the normal winter host of Aphid fabae, on which the sexuparae and sexuales gather, in the tests reported here the spindle tree was acting as a summer host, colonized by apterous viviparous females.

If the data of the group of three called the true Aphis *fabae* (BC Lab, BC Wild and NB-A) are examined in Table LXIX we see that they are reasonably homogenous in both development and reproductive capacity. And they differ collectively from any of the other three cultures Man. NB-B and P-E, which differ to some extent among themselves. Mean fecundity during the first five days is less, but mean total fecundity more, in the true *Aphis fabae* group than in the "non *Aphis fabae* group."

If we compare the results in Table LXIX with those in Table XIV, laboratory tests, it is interesting to note that mean fecundity for the first five days of adult life and total mean fecundity, of the culture Man. on nasturtium are both very much greater than the corresponding counts on the spindle tree; i.e., 31.6 *vs* 16.2 and 76.7 *vs* 17.0. If you compare BC Lab, BC Wild and NB-A (the true *Aphis fabae* group) from Table LXIX with corresponding data from the same cultures on faba bean (Table XIV), mean fecundity for the first five days of adult life is similar between spindle tree and faba bean and mean total fecundity only about one-third more on the average on the spindle tree, compared with the data from faba bean. These observations indicate that the three cultures of the "true *Aphis fabae* group" are more adapted between the spindle tree and faba bean, than is the culture Man. between the spindle tree and nasturtium.

In Table LXX are listed the same parameters as those measured and reported in Table LXIX, for those of the cultures of the "non Aphis fabae group" acceptances on mockorange, Viburnum sp., burdock, potato (Netted Gem), potato (Pontiac), and tuberous dahlia, summarized from the appropriate Tables between XXXVIII and LXVIII. The data in Table LXX demonstrate again the variability among the three cultures Man., NB-B and P-E, and the different growth, development and reproduction that takes place on the different summer host plants. The culture Man. was originally collected in Manitoba on burdock, and in Table LXX we see that it has better development and fecundity on burdock than on any of the other hosts shown. The culture Man. on burdock (Table LXX) is also very similar to the measurements shown in Table XIV for aphids of the culture Man. in laboratory tests on nasturtium.

Table LXXI lists the same measurements and findings for aphids of the so-called "true Aphis fabae" groups as were shown in Tables LXIX and LXX, but on those acceptances which occurred on the host plants yellow garden bean, scarlet runner bean, lima bean, green garden bean, kidney bean, garden pea, burdock, poppy, Swiss chard, beet and spinach. In general, where development took place, and offspring were produced, mean fecundity for the first five days, and total fecundity, were less than for most of those shown in Table LXX of the "non-Aphis fabae group," and comparable with the measurements shown for faba bean, laboratory tests, in Table XIV.

Production of Sexual Forms

On 19 September 1978 two cages were set up in the courtyard of the Animal Science Building. One contained culture Man. on nasturtium, and a pot with a small plant of *Viburnum opulus*. In the other cage was culture BC Wild on faba bean and a pot with a small plant of *Euonymus europaeus*. Fall migrants (sexuparae) soon appeared on each of the winter host plants. On 16 October 1978 oviparae were found on the *Viburnum opulus*, and more on 23 October 1978 and 6 November 1978. No oviparae were found on *Euonymus europaeus* until 6 November 1978. Apparently the "introduced," "true *Aphis fabae*" is about two weeks later than the Manitoba species in responding to those factors such as photoperiod and decreasing temperatures, which bring about the appearance of the forms sexuparae and sexuales. Leaves on the small *Viburnum opulus* had begun to drop by October 6th, but by that time some eggs had been deposited on the bark of the twigs, and around leaf buds. On November 6th leaves were still present on the *Euonymus europaeus* (which is not a winter-hardy shrub in Manitoba, and not a native plant) and the oviparae just beginning oviposition.

CHAPTER V

RESULTS AND DISCUSSION OF CONVENTIONAL TAXONOMY, STATISTICS AND RATIOS

Conventional taxonomy is the term used when measurements and counts are made of anatomical features on museum specimens. The conventional taxonomist looks for similarities and differences. When differences are found, a judgement must be made as to whether they are sufficiently important to denote species differentiation, or whether they are merely normal "within species" variations. Conventional taxonomy is only one of the tools of the biosystematist.

In Chapter III the anatomical features, or as they are more commonly called, the characters, used in aphid taxonomy were outlined. In general, they are measurements of antennal segments, cornicles, cauda, and counts of secondary sensoria on antennal segment III, and counts of setae on various body areas. Tables LXXII to LXXXVII show the results of measurements and counts made in a study of similarities and differences between the six laboratory cultures, both apterous and alate, cleared and mounted on glass microscope slides. Ten aphids were measured for each, and the Tables show the range, the calculated mean, and the 95% confidence interval. The first three cultures in each Table are from the "nasturtium" colonies, and the remaining three from the "faba bean" colonies. There were no differences apparent in total body length of apterae or alatae, length of cauda, number of hairs on cauda, length of cornicles, length of antennal segments III, IV, V, base of VI and unguis of VI, length of setae on antennal segment III, number of secondary sensoria on antennal segments III, IV and V, length of hind tibiae and length of hind tarsal segment II. In some of the Tables (LXXII to LXXXVII) the means appeared to show significant differences, but an examination of the range in every case showed that these were only measurements of normal variations within species. None of these characters could be used in a key to demonstrate species differences from measurements or counts.

The only measurement which offered a significant variation in measurement was length of rostral IV + V. In both apterae and alatae rostral IV + V lengths were greater in those specimens from the nasturtium groups than in those from the "faba bean" group (Table LXXXV).

Cottier (1953, p. 52) stated, "Statements showing actual variations in length of antennal segments, cornicles, and cauda are of limited importance. It is much more useful to know the variation in the relative proportions which antennal segments bear to one another and to cornicles and cauda." Tables LXXXVIII to CII show my attempts to use this method to show differences between mounted specimens from the six laboratory cultures. Frequency distributions are shown of the measurements of ten specimens, and calculations for the values for $\frac{\text{highest ratio}}{\text{lowest ratio}}$, both for apterae and for alatae

TABLE LXXII

Comparisons among range, mean and 95% confidence interval of body length measurements* of ten apterous and alate viviparous female aphids from each of the six laboratory cultures.

	Man.	NB-B	P-E	BC Wild	BC Lab	NB-A
APTERAE						
range	1.62-1.93	1.65-2.02	1.67-1.94	1.49-1.92	1.45-1.67	1.36-2.20
$\bar{x}$	1.78	1.71	1.79	1.66	1.58	1.62
95% confidence interval	0.07	0.09	0.08	0.09	0.08	0.17
ALATAE						
range	1.70-2.40	2.02-2.28	1.76-2.11	1.49-1.76	1.93-2.28	1.20-1.84
$\bar{x}$	2.18	2.15	1.92	1.60	2.17	1.73
95% confidence interval	0.12	0.06	0.08	0.06	0.10	0.08

* measurements are in mm.

TABLE LXXIII

Comparisons among range, mean and 95% confidence interval of cauda length measurements* of ten apterous and alate viviparous female aphids from each of the six laboratory cultures.

	Man.	NB-B	P-E	BC Wild	BC Lab	NB-A
			APTERAE			
range	0.16-0.18	0.12-0.17	0.14-0.17	0.13-0.19	0.12-0.17	0.12-0.18
$\bar{x}$	0.16	0.15	0.16	0.16	0.14	0.14
95% confidence interval	0.001	0.001	0.001	0.001	0.001	0.001
			ALATAE			
range	0.15-0.21	0.09-0.17	0.12-0.17	0.11-0.12	0.10-0.17	0.08-0.12
$\bar{x}$	0.17	0.14	0.14	0.11	0.12	0.11
95% confidence interval	0.001	0.001	0.001	0.001	0.001	0.001

* measurements are in mm.

TABLE LXXIV

Comparisons among range, mean and 95% confidence interval of cauda hair numbers from ten apterous and alate viviparous female aphids from each of the six laboratory cultures.

	Man.	NB-B	P-E	BC Wild	BC Lab.	NB-A
			APTERAE			
range	12-16	10-18	11-16	8-14	6-13	2-11
$\bar{x}$	13.7	14.8	12.8	10.4	10.4	8.4
95% confidence interval	2.89	1.66	2.18	1.17	1.46	1.63
			ALATAE			
range	14-18	14-22	12-18	7-12	8-14	8-14
$\bar{x}$	15.6	16.7	14.9	10.2	11.4	11.4
95% confidence interval	0.72	1.48	1.14	0.91	1.37	1.37

TABLE LXXV

Comparisons among range, mean and 95% confidence interval of cornicle length measurements* of ten apterous and alate viviparous female aphids from each of the six laboratory cultures.

	Man.	NB-B	P-E	BC Wild	BC Lab.	NB-A
APTERAE						
range	0.22-0.33	0.19-0.24	0.19-0.31	0.17-0.42	0.15-0.24	0.19-0.40
$\bar{x}$	0.27	0.21	0.25	0.25	0.21	0.25
95% confidence interval	0.01	0.01	0.01	0.01	0.01	0.01
ALATAE						
range	0.19-0.24	0.24-0.28	0.21-0.26	0.10-0.18	0.14-0.21	0.15-0.21
$\bar{x}$	0.20	0.27	0.23	0.14	0.17	0.18
95% confidence interval	0.001	0.001	0.001	0.001	0.001	0.001

* measurements are in mm.

TABLE LXXVI

Comparisons among range, mean and 95% confidence interval of antennal segment III measurements* of ten apterous and alate viviparous female aphids from each of the six laboratory cultures.

	Man.	NB-B	P-E	BC Wild	BC Lab.	NB-A
			APTERAE			
range	0.24-0.31	0.24-0.31	0.22-0.31	0.19-0.15	0.19-0.29	0.22-0.36
$\bar{x}$	0.27	0.27	0.27	0.25	0.23	0.26
95% confidence interval	0.01	0.01	0.01	0.03	0.01	0.03
			ALATAE			
range	0.35-0.40	0.33-0.35	0.31-0.35	0.23-0.31	0.33-0.40	0.26-0.32
$\bar{x}$	0.37	0.34	0.33	0.26	0.35	0.29
95% confidence interval	0.01	0.01	0.01	0.01	0.01	0.01

* measurements are in mm.

TABLE LXXVII

Comparisons among range, mean and 95% confidence interval of antennal segment IV measurements* of ten apterous and alate viviparous female aphids from each of the six laboratory cultures.

	Man.	NB-B	P-E	BC Wild	BC Lab.	NB-A
			APTERAE			
range	0.16-0.22	0.16-0.22	0.16-0.22	0.12-0.26	0.12-0.17	0.12-0.24
$\bar{x}$	0.18	0.18	0.18	0.17	0.14	0.16
95% confidence interval	0.01	0.01	0.01	0.02	0.01	0.02
			ALATAE			
range	0.24-0.28	0.24-0.28	0.21-0.24	0.12-0.26	0.19-0.22	0.15-0.23
$\bar{x}$	0.26	0.26	0.22	0.16	0.20	0.18
95% confidence interval	0.01	0.01	0.01	0.01	0.01	0.01

* measurements are in mm.

TABLE LXXVIII

Comparisons among range, mean and 95% confidence interval of antennal segment V measurements* of ten apterous and alate viviparous female aphids from each of the six laboratory culture.

	Man.	NB-B	P-E	BC Wild	BC Lab.	NB-A
			APTERAE			
range	0.14-0.22	0.14-0.20	0.16-0.24	0.14-0.22	0.11-0.17	0.12-0.22
$\bar{x}$	0.17	0.17	0.18	0.16	0.14	0.15
95% confidence interval	0.01	0.01	0.01	0.01	0.01	0.01
			ALATAE			
range	0.22-0.28	0.22-0.31	0.21-0.24	0.12-0.17	0.19-0.24	0.15-0.21
$\bar{x}$	0.24	0.24	0.22	0.14	0.20	0.18
95% confidence interval	0.01	0.01	0.01	0.01	0.01	0.01

* measurements are in mm.

TABLE LXXIX

Comparisons among range, mean and 95% confidence interval of antennal segment VI (base) measurements* of ten apterous and alate viviparous female aphids from each of the six laboratory cultures.

	Man.	NB-B	P-E	BC Wild	BC Lab.	NB-A
APTERAE						
range	0.09-0.11	0.09-0.19	0.08-0.10	0.08-0.10	0.07-0.10	0.08-0.10
$\bar{x}$	0.10	0.09	0.09	0.09	0.08	0.09
95% confidence interval	0.001	0.001	0.001	0.001	0.001	0.001
ALATAE						
range	0.12-0.15	0.10-0.15	0.10-0.12	0.07-0.09	0.10-0.12	0.08-0.10
$\bar{x}$	0.13	0.12	0.10	0.08	0.10	0.09
95% confidence interval	0.001	0.001	0.001	0.001	0.001	0.001

* measurements are in mm.

TABLE LXXX

Comparisons among range, mean and 95% confidence interval of antennal segment VI (unguis) measurements* of ten apterous and alate viviparous female aphids from each of the six laboratory cultures.

	Man.	NB-B	P-E	BC Wild	BC Lab.	NB-A
			APTERAE			
range	0.31-0.40	0.31-0.40	0.28-0.38	0.28-0.38	0.28-0.33	0.24-0.38
$\bar{x}$	0.34	0.34	0.32	0.30	0.30	0.30
95% confidence interval	0.01	0.01	0.02	0.01	0.01	0.02
			ALATAE			
range	0.34-0.38	0.37-0.42	0.35-0.42	0.24-0.29	0.38-0.42	0.28-0.35
$\bar{x}$	0.36	0.38	0.38	0.27	0.40	0.31
95% confidence interval	0.01	0.01	0.01	0.01	0.01	0.01

* measurements are in mm.

TABLE LXXXI

Comparisons among range, mean and 95% confidence interval of antennal III hair length measurements* of ten apterous and alate viviparous female aphids from each of the six laboratory cultures.

	Man.	NB-B	P-E	BC Wild	BC Lab.	NB-A
			APTERAE			
range	0.03-0.04	0.03	0.03	0.03	0.03	0.03
$\bar{x}$	0.03	0.03	0.03	0.03	0.03	0.03
95% confidence interval	0.001	0.001	0.001	0.001	0.001	0.001
			ALATAE			
range	0.02-0.04	0.03	0.03	0.03	0.03	0.03
$\bar{x}$	0.03	0.03	0.03	0.03	0.03	0.03
95% confidence interval	0.001	0.001	0.001	0.001	0.001	0.001

* measurements are in mm.

TABLE LXXXII

Comparisons among range, mean and 95% confidence interval of the number of secondary sensoria on antennal segment III of ten alate viviparous female aphids from each of the six laboratory cultures.

	Man.	NB-B	P-E	BC Wild	BC Lab.	NB-A
			ALATAE			
range	16-23	13-19	13-17	13-18	10-13	13-20
$\bar{x}$	18.6	14.4	14.4	14.5	11.0	13.3
95% confidence interval	1.70	1.55	1.30	0.86	1.17	1.11

TABLE LXXXIII

Comparisons among range, mean and 95% confidence interval of the number of secondary sensoria on antennal segment IV of ten alate viviparous female aphids from each of the six laboratory cultures.

	Man.	NB-B	P-E	BC Wild	BC Lab	NB-A
			ALATAE			
range	2-4	1-2	1-5	1-5	1-2	1-4
$\bar{x}$	3.25	1.30	2.10	2.8	1.3	2.00
95% confidence interval	0.71	0.29	0.84	0.88	0.29	1.16

TABLE LXXXIV

Comparisons among range, mean and 95% confidence interval of the number of secondary sensoria on antennal segment V of ten alate viviparous female aphids from each of the six laboratory cultures.

	Man.	NB-B	P-E	BC Wild	BC Lab.	NB-A
			ALATAE			
range	1-3	1	1	1-2	1-2	1-2
$\bar{x}$	1.30	0.10	0.10	1.50	1.50	1.50
95% confidence interval	0.001	0.001	0.001	0.001	0.001	0.001

TABLE LXXXV

Comparisons among range, mean and 95% confidence interval of rostral IV + V measurements* of ten apterous and alate viviparous female aphids from each of the six laboratory cultures.

	Man.	NB-B	P-E	BC Wild	BC Lab.	NB-A
			APTERAE			
range	0.14	0.14	0.14	0.10	0.10-0.12	0.10-0.12
$\bar{x}$	0.14	0.14	0.14	0.10	0.11	0.11
95% confidence interval	0.001	0.001	0.001	0.001	0.001	0.001
			ALATAE			
range	0.13-0.14	0.12-0.14	0.12-0.14	0.10	0.10-0.12	0.10-0.12
$\bar{x}$	0.13	0.12	0.12	0.10	0.11	0.11
95% confidence interval	0.001	0.001	0.001	0.001	0.001	0.001

* measurements are in mm.

TABLE LXXXVI

Comparisons among range, mean and 95% confidence interval of the length* of the hind tibia of ten apterous and alate viviparous female aphids from each of the six laboratory cultures.

	Man.	NB-B	P-E	BC Wild	BC Lab.	NB-A
			APTERAE			
range	0.88-1.14	0.79-0.88	0.84-1.05	0.79-1.20	0.70-0.96	0.70-1.19
$\bar{x}$	0.99	0.85	0.90	0.89	0.82	0.84
95% confidence interval	0.04	0.01	0.04	0.08	0.05	0.30
			ALATAE			
range	1.12-1.18	1.14-1.03	1.00-1.10	0.79-0.92	1.01-1.32	0.79-1.05
$\bar{x}$	1.16	1.18	1.10	0.83	1.10	0.92
95% confidence interval	0.01	0.01	0.08	0.03	0.06	0.05

* measurements are in mm.

TABLE LXXXVII

Comparisons among range, mean and 95% confidence interval of hind tarsal II measurements* of ten apterous and alate viviparous female aphids from each of the six laboratory cultures.

	Man.	NB-B	P-E	BC Wild	BC Lab.	NB-A
			APTERAE			
range	0.10-0.16	0.10	0.10	0.09-0.10	0.09-0.10	0.10-0.12
$\bar{x}$	0.11	0.10	0.10	0.09	0.09	0.10
95% confidence interval	0.01	0.01	0.01	0.01	0.01	0.01
			ALATAE			
range	0.10-0.13	0.10-0.12	0.10	0.10	0.10-0.14	0.10
$\bar{x}$	0.12	0.11	0.10	0.10	0.12	0.10
95% confidence interval	0.01	0.01	0.01	0.01	0.01	0.01

* measurements are in mm.

TABLE LXXXVIII

Frequency distributions of the ratios of $\frac{\text{length of antennal segment IV}}{\text{length of antennal segment III}}$ for ten apterous viviparous female aphids from each of the six laboratory cultures.

	Man.		NB-B		P-E		BC Wild		BC Lab.		NB-A	
	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.
	0.62–0.64	2	0.57–0.59	2	0.62–0.64	4	0.59–0.61	2	0.48–0.50	2	0.54–0.60	2
	0.65–0.67	12	0.60–0.62	4	0.65–0.67	4	0.62–0.64	6	0.51–0.53	4	0.61–0.67	8
	0.68–0.70	0	0.63–0.65	2	0.68–0.70	4	0.65–0.67	2	0.54–0.56	2	0.68–0.74	4
	0.71–0.73	3	0.66–0.68	4	0.71–0.73	6	0.68–0.70	6	0.57–0.59	6	0.75–0.81	0
	0.74–0.76	3	0.69–0.71	4	0.74–0.76	2	0.71–0.73	2	0.60–0.62	0	0.82–0.88	2
			0.72–0.74	4			0.74–0.76	2	0.63–0.65	2	0.89–0.95	2
									0.66–0.68	4		
Totals		20		20		20		20		20		20
Values for $\frac{\text{highest ratio}}{\text{lowest ratio}}$	1.22		1.29		1.22		1.28		1.41		1.75	

TABLE LXXXIX

Frequency distributions of the ratios of $\frac{\text{length of segment V}}{\text{length of segment III}}$ for ten apterous viviparous female aphids from each of the six laboratory cultures.

	Man.		NB-B		P-E		BC Wild		BC Lab.		NB-A	
	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.
	0.62–0.64	4	0.53–0.55	2	0.59–0.61	2	0.53–0.55	2	0.51–0.53	2	0.54–0.56	4
	0.65–0.67	2	0.56–0.58	2	0.62–0.64	0	0.56–0.58	2	0.54–0.56	0	0.57–0.59	4
	0.68–0.70	2	0.59–0.61	2	0.65–0.67	6	0.59–0.61	2	0.57–0.59	2	0.60–0.62	2
	0.71–0.73	10	0.62–0.64	4	0.68–0.70	6	0.62–0.64	2	0.60–0.62	6	0.63–0.65	6
			0.65–0.67	4	0.71–0.73	2	0.65–0.62	4	0.63–0.65	2	0.66–0.68	2
			0.68–0.70	4	0.74–0.76	4	0.68–0.70	4	0.66–0.68	6	0.69–0.71	2
			0.71–0.73	2			0.71–0.73	2	0.69–0.71	2		
							0.74–0.76	2				
Totals		20		20		20		20		20		20
Values for $\frac{\text{highest ratio}}{\text{lowest ratio}}$	1.17		1.37		1.28		1.45		1.39		1.31	

TABLE XC

Frequency distributions of the ratios of $\frac{\text{length of base antennal segment VI}}{\text{length of base segment III}}$ for ten apterous viviparous female aphids from each of the six laboratory cultures.

	Man.		NB-B		P-E		BC Wild		BC Lab.		NB-A	
	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.
	0.34–0.36	10	0.31–0.33	2	0.28–0.30	4	0.28–0.30	4	0.33–0.37	2	0.28–0.31	4
	0.37–0.39	2	0.34–0.36	10	0.31–0.33	4	0.31–0.33	6	0.38–0.42	0	0.32–0.35	0
	0.40–0.42	4	0.37–0.39	2	0.34–0.36	6	0.34–0.36	4	0.43–0.47	0	0.36–0.39	8
	0.43–0.45	2	0.40–0.42	4	0.37–0.39	2	0.37–0.39	2	0.48–0.52	4	0.40–0.43	4
	0.46–0.48	0	0.43–0.45	2	0.40–0.42	4	0.40–0.42	2	0.53–0.57	10	0.44–0.47	2
	0.49–0.51	2					0.43–0.45	2	0.58–0.62	0	0.48–0.51	0
									0.63–0.67	4	0.52–0.55	2
Totals		20		20		20		20		20		20
Values for highest ratio / lowest ratio	1.5		1.45		1.50		1.60		2.03		1.96	

TABLE XCI

Frequency distributions of the ratios of $\frac{\text{length of unguis segment VI}}{\text{length of segment III}}$ for ten apterous viviparous female aphids from each of the six laboratory cultures.

	Man.		NB-B		P-E		BC Wild		BC Lab.		NB-A	
	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.
	0.73-0.75	6	0.75-0.77	4	0.74-0.77	8	0.67-0.69	2	0.68-0.71	4	0.76-0.78	8
	0.76-0.78	4	0.78-0.80	4	0.78-0.81	2	0.70-0.72	2	0.72-0.75	2	0.79-0.81	2
	0.79-0.81	4	0.81-0.83	4	0.82-0.85	0	0.73-0.75	2	0.76-0.79	4	0.82-0.84	2
	0.82-0.84	4	0.84-0.86	4	0.86-0.89	2	0.76-0.78	2	0.80-0.83	4	0.85-0.87	2
	0.85-0.87	0	0.87-0.89	2	0.90-0.93	8	0.79-0.81	4	0.84-0.87	0	0.88-0.90	0
	0.88-0.90	0	0.90-0.92	0			0.82-0.84	0	0.88-0.91	2	0.91-0.93	2
	0.91-0.93	2	0.93-0.95	2			0.85-0.87	6	0.92-0.95	4	0.94-0.96	4
							0.88-0.90	0				
							0.91-0.93	2				
Totals		20		20		20		20		20		20
Values for $\frac{\text{highest ratio}}{\text{lowest ratio}}$	1.27		1.26		1.25		1.38		1.39		1.26	

TABLE XCII

Frequency distributions of the ratios of $\frac{\text{length of segment IV}}{\text{length of segment III}}$ for ten alate viviparous female aphids from each of the six laboratory cultures.

	Man.		NB-B		P-E		BC Wild		BC Lab.		NB-A	
	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.
	0.65–0.67	2	0.73–0.75	12	0.63–0.65	4	0.45–0.48	2	0.54–0.56	12	0.55–0.57	4
	0.68–0.70	6	0.76–0.78	4	0.66–0.68	5	0.49–0.52	4	0.57–0.59	2	0.58–0.60	4
	0.71–0.73	8	0.79–0.81	4	0.69–0.71	9	0.53–0.56	4	0.60–0.62	4	0.61–0.63	8
	0.74–0.76	4			0.72–0.74	0	0.57–0.60	6	0.63–0.65	2	0.64–0.66	2
					0.75–0.77	2	0.61–0.64	0			0.67–0.69	0
							0.65–0.68	4			0.70–0.72	2
Totals		20		20		20		20		20		20
Values for $\frac{\text{highest ratio}}{\text{lowest ratio}}$	1.16		1.10		1.22		1.51		1.20		1.30	

TABLE XCIII

Frequency distributions of the ratios of $\frac{\text{length of segment V}}{\text{length of segment III}}$ for ten alate viviparous female aphids from each of the six laboratory cultures.

	Man.		NB-B		P-E		BC Wild		BC Lab.		NB-A	
	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.
	0.61-0.64	6	0.63-0.66	4	0.58-0.61	2	0.50-0.53	4	0.54-0.56	6	0.54-0.56	4
	0.65-0.68	4	0.67-0.70	8	0.62-0.65	8	0.54-0.57	4	0.57-0.59	6	0.57-0.59	4
	0.69-0.72	4	0.71-0.74	8	0.66-0.69	6	0.58-0.61	4	0.60-0.62	4	0.60-0.62	4
	0.73-0.76	4			0.70-0.73	2	0.62-0.65	4	0.63-0.65	0	0.63-0.65	4
	0.77-0.80	0			0.74-0.77	2	0.66-0.69	4	0.66-0.68	4	0.66-0.68	4
	0.81-0.84	0										
	0.85-0.88	0										
	0.89-0.92	0										
	0.93-0.95	2										
Totals		20		20		20		20		20		20
Values for $\frac{\text{highest ratio}}{\text{lowest ratio}}$	1.55		1.17		1.32		1.38		1.25		1.25	

TABLE XCIV

Frequency distributions of the ratios of $\frac{\text{length of base of antennal segment VI}}{\text{length of segment III}}$ for ten alate viviparous female aphids from each of the six laboratory cultures.

	Man. Ratio	No. of Ant.	NB-B Ratio	No. of Ant.	P-E Ratio	No. of Ant.	BC Wild Ratio	No. of Ant.	BC Lab. Ratio	No. of Ant.	NB-A Ratio	No. of Ant.
	0.29-0.31	2	0.29-0.31	4	0.29-0.30	6	0.26-0.28	6	0.25-0.26	2	0.31-0.32	8
	0.32-0.34	2	0.32-0.34	10	0.31-0.32	8	0.29-0.31	6	0.27-0.28	2	0.33-0.34	6
	0.35-0.37	4	0.35-0.37	2	0.33-0.34	4	0.31-0.33	2	0.29-0.30	10	0.35-0.36	6
	0.38-0.40	12	0.38-0.40	0	0.35-0.36	2	0.34-0.36	2	0.31-0.32	2		
			0.41-0.43	4			0.36-0.37	4	0.33-0.34	4		
Totals		20		20		20		20		20		20
Values for $\frac{\text{highest ratio}}{\text{lowest ratio}}$	1.38		1.48		1.24		1.42		1.36		1.16	

TABLE XCV

Frequency distribution of the ratios of $\frac{\text{length of unguis segment VI}}{\text{length of segment III}}$ for ten alate viviparous female aphids from each of the six laboratory cultures.

	Man.		NB-B		P-E		BC Wild		BC Lab.		NB-A	
	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.	Ratio	No. of Ant.
	0.85-0.87	2	1.05-1.08	2	1.06-1.09	6	0.93-0.96	4	0.95-0.98	2	0.90-0.93	2
	0.88-0.90	0	1.09-1.11	8	1.10-1.13	2	0.97-1.00	6	0.99-1.02	0	0.94-0.97	0
	0.91-0.93	0	1.12-1.14	6	1.14-1.17	2	1.01-1.04	2	1.01-1.04	2	0.94-1.01	2
	0.94-0.96	6	1.15-1.17	0	1.18-1.21	2	1.05-1.08	2	1.05-1.08	8	1.02-1.05	0
	0.97-0.99	0	1.18-1.20	2	1.22-1.25	2	1.09-1.12	0	1.09-1.12	0	1.06-1.09	6
	1.00-1.02	10	1.21-1.23	2	1.26-1.29	2	1.13-1.16	4	1.13-1.16	0	1.10-1.13	6
	1.03-1.05	2			1.30-1.33	2	1.17-1.20	2	1.17-1.20	2	1.14-1.17	4
					1.34-1.37	2			1.21-1.24	0		
									1.25-1.28	6		
Totals		20		20		20		20		20		20
Values for highest ratio / lowest ratio	1.23		1.17		1.29		1.29		1.34		1.3	

TABLE XCVI

Frequency distributions of the ratio $\frac{\text{length of cauda}}{\text{length of antennal segment III}}$ in ten apterous viviparous female aphids from each of the six laboratory cultures.

	Man.		NB-B		P-E		BC Wild		BC Lab.		NB-A	
	Ratio	No. of Cauda	Ratio	No. of Cauda	Ratio	No. of Cauda	Ratio	No. of Cauda	Ratio	No. of Cauda	Ratio	No. of Cauda
	0.57-0.60	4	0.42-0.45	1	0.49-0.52	1	0.54-0.57	3	0.54-0.57	4	0.50-0.53	2
	0.61-0.64	4	0.46-0.49	1	0.53-0.56	2	0.58-0.61	1	0.58-0.61	1	0.54-0.57	2
	0.65-0.68	2	0.50-0.53	1	0.57-0.60	3	0.62-0.63	0	0.62-0.65	2	0.58-0.61	2
			0.54-0.57	0	0.61-0.64	2	0.66-0.69	2	0.66-0.69	1	0.62-0.65	2
			0.58-0.61	3	0.65-0.68	1	0.70-0.73	4	0.70-0.73	2	0.66-0.69	2
			0.62-0.65	2	0.69-0.72	1						
			0.66-0.69	2								
Totals		10		10		10		10		10		10
Values for $\frac{\text{highest ratio}}{\text{lowest ratio}}$	1.19		1.64		1.46		1.35		1.35		1.38	

TABLE XCVII

Frequency distributions of the ratio $\frac{\text{length of cauda}}{\text{length of antennal segment III}}$ in ten alate viviparous female aphids from each of the six laboratory cultures.

	Man.		NB-B		P-E		BC Wild		BC Lab.		NB-A	
	Ratio	No. of Cauda	Ratio	No. of Cauda	Ratio	No. of Cauda	Ratio	No. of Cauda	Ratio	No. of Cauda	Ratio	No. of Cauda
	0.42-0.43	2	0.26-0.29	1	0.36-0.38	2	0.35-0.37	1	0.29-0.31	3	0.28-0.30	1
	0.44-0.45	0	0.30-0.33	1	0.39-0.41	2	0.38-0.40	1	0.32-0.34	4	0.31-0.33	0
	0.46-0.47	3	0.34-0.37	0	0.42-0.44	0	0.41-0.43	1	0.35-0.37	0	0.34-0.36	1
	0.50-0.51	0	0.38-0.41	2	0.45-0.47	1	0.44-0.46	2	0.38-0.40	1	0.37-0.39	5
	0.52-0.53	3	0.42-0.45	1	0.48-0.50	1	0.47-0.49	0	0.41-0.43	1	0.40-0.42	3
	0.54-0.54	2	0.46-0.49	2	0.51-0.53	4	0.50-0.52	3				
			0.50-0.53	3			0.53-0.55	2				
Totals		10		10		10		10		10		10
Values for $\frac{\text{highest ratio}}{\text{lowest ratio}}$	1.28		2.03		1.47		1.57		1.48		1.50	

TABLE XCVIII

Frequency distributions of the ratio $\frac{\text{length of cauda}}{\text{mean length of cornicles}}$ in ten apterous viviparous female aphids from each of the six laboratory cultures.

	Man.		NB-B		P-E		BC Wild		BC Lab.		NB-A	
	Ratio	No. of Cauda	Ratio	No. of Cauda	Ratio	No. of Cauda	Ratio	No. of Cauda	Ratio	No. of Cauda	Ratio	No. of Cauda
	0.42-0.45	1	0.56-0.59	2	0.53-0.56	2	0.58-0.61	3	0.49-0.52	1	0.51-0.54	2
	0.46-0.49	0	0.60-0.63	1	0.57-0.60	3	0.62-0.65	0	0.53-0.56	0	0.55-0.58	1
	0.50-0.53	0	0.64-0.67	2	0.61-0.64	2	0.66-0.69	1	0.57-0.60	2	0.59-0.62	1
	0.54-0.57	2	0.68-0.71	1	0.65-0.68	1	0.70-0.73	1	0.61-0.64	0	0.63-0.66	1
	0.58-0.61	3	0.72-0.75	0	0.69-0.73	0	0.74-0.77	1	0.65-0.68	1	0.67-0.70	1
	0.62-0.65	2	0.76-0.79	2	0.74-0.77	2	0.78-0.81	3	0.69-0.72	2	0.71-0.74	1
	0.66-0.69	0	0.80-0.83	1			0.82-0.85	1	0.73-0.75	1	0.75-0.78	1
	0.70-0.73	0	0.84-0.87	1					0.76-0.79	1	0.79-0.82	1
	0.74-0.77	2							0.80-0.83	2	0.83-0.86	1
Totals		10		10		10		10		10		10
Values for $\frac{\text{highest ratio}}{\text{lowest ratio}}$	1.83		1.53		1.45		1.46		1.69		1.68	

TABLE XCIX

Frequency distributions of the ratio $\frac{\text{length of cauda}}{\text{mean length of cornicles}}$ in ten alate viviparous female aphids from each of the six laboratory cultures.

	Man. Ratio	No. of Cauda	NB-B Ratio	No. of Cauda	P-E Ratio	No. of Cauda	BC Wild Ratio	No. of Cauda	BC Lab. Ratio	No. of Cauda	NB-A Ratio	No. of Cauda
	0.71-0.74	1	0.36-0.39	1	0.44-0.47	1	0.42-0.45	1	0.54-0.59	2	0.42-0.46	1
	0.75-0.78	2	0.40-0.43	1	0.48-0.51	0	0.46-0.49	0	0.60-0.65	3	0.47-0.51	0
	0.79-0.82	2	0.44-0.47	0	0.52-0.55	0	0.50-0.53	1	0.66-0.71	3	0.52-0.56	1
	0.83-0.86	2	0.48-0.51	1	0.56-0.59	3	0.54-0.57	2	0.72-0.77	0	0.57-0.61	4
	0.87-0.90	0	0.52-0.55	2	0.60-0.63	3	0.58-0.61	3	0.78-0.83	0	0.62-0.66	2
	0.91-0.94	2	0.56-0.59	0	0.64-0.67	0	0.64-0.67	1	0.84-0.89	1	0.67-0.71	0
	0.95-0.98	0	0.60-0.63	3	0.68-0.71	0	0.68-0.71	1	0.90-0.95	0	0.72-0.76	0
	0.99-1.02	1	0.64-0.67	2	0.72-0.75	1	0.72-0.75	1	0.96-1.01	0	0.77-0.81	2
					0.76-0.79	2			1.02-1.07	1		
Totals		10		10		10		10		10		10
Values for Highest ratio / lowest ratio	1.43		1.86		1.79		1.78		1.98		1.92	

TABLE C

Frequency distributions of the ratio $\frac{\text{cornicle length}}{\text{length of antennal segment III}}$ in ten apterous viviparous female aphids from each of the six laboratory cultures.

	Man.		NB-B		P-E		BC Wild		BC Lab.		NB-B	
	Ratio	No. of Corn.	Ratio	No. of Corn.	Ratio	No. of Corn.	Ratio	No. of Corn.	Ratio	No. of Corn.	Ratio	No. of Corn.
	0.88–0.91	2	0.68–0.71	1	0.83–0.86	6	0.74–0.78	2	0.59–0.64	1	0.73–0.76	1
	0.92–0.95	5	0.72–0.75	1	0.87–0.90	1	0.79–0.83	0	0.65–0.70	2	0.77–0.80	1
	0.96–0.99	5	0.76–0.79	7	0.91–0.94	4	0.84–0.88	4	0.71–0.76	1	0.81–0.84	1
	1.00–1.03	3	0.80–0.83	3	0.95–0.98	4	0.89–0.93	2	0.77–0.82	2	0.85–0.88	1
	1.04–1.07	3	0.94–0.87	4	0.99–1.02	3	0.94–0.98	5	0.83–0.88	1	0.89–0.92	0
	1.08–1.11	0	0.88–0.91	4	1.03–1.06	0	0.99–1.03	2	0.89–0.94	5	0.93–0.96	5
	1.12–1.15	1			1.07–1.10	2	1.04–1.08	2	0.95–1.00	2	0.97–1.00	4
	1.16–1.19	1					1.09–1.14	3	1.01–1.06	4	1.01–1.04	3
									1.07–1.12	2	1.05–1.08	8
											1.09–1.12	1
											1.13–1.16	1
Totals		20		20		20		20		20		20
Values for highest ratio / lowest ratio	1.35		1.33		1.32		1.54		1.89		1.58	

TABLE CI

Frequency distributions of the ratio $\frac{\text{cornicle length}}{\text{length of antennal segment III}}$ in ten alate viviparous female aphids from each of the six laboratory cultures.

	Man.		NB-B		P-E		BC Wild		BC Lab.		NB-B	
	Ratio	No. of Corn.	Ratio	No. of Corn.	Ratio	No. of Corn.	Ratio	No. of Corn.	Ratio	No. of Corn.	Ratio	No. of Corn.
	0.37-0.40	1	0.72-0.75	6	0.55-0.59	2	0.42-0.47	5	0.40-0.43	3	0.54-0.57	4
	0.41-0.44	0	0.76-0.79	4	0.60-0.64	2	0.48-0.53	7	0.44-0.47	0	0.58-0.61	0
	0.45-0.48	0	0.80-0.83	10	0.65-0.69	2	0.54-0.59	5	0.48-0.51	11	0.62-0.65	4
	0.49-0.52	0			0.70-0.74	5	0.60-0.65	1	0.52-0.55	4	0.66-0.69	8
	0.53-0.56	6			0.75-0.79	4	0.66-0.71	1	0.56-0.59	2	0.70-0.73	4
	0.57-0.60	10			0.80-0.84	5	0.72-0.77	1			0.74-0.77	1
	0.61-0.63	3										
Totals		20		20		20		20		20		20
Values for highest ratio / lowest ratio	1.70		1.15		1.52		1.83		1.47		1.42	

TABLE CII

Frequency distributions of the secondary sensoria on antennal segment III in ten alate viviparous female aphids from each of the six laboratory cultures.

	Man.		NB-B		P-E		BC Wild		BC Lab.		NB-A	
	No. of Sensoria	No. of Ant.	No. of Sensoria	No. of Ant.	No. of Sensoria	No. of Ant.	No. of Sensoria	No. of Ant.	No. of Sensoria	No. of Ant.	No. of Sensoria	No. of Ant.
	21-24	2	23-25	2	25-26	10	18-19	6	26-27	10	22-23	6
	25-28	0	26-28	2	27-28	2	20-21	4	28-29	2	24-25	2
	29-32	4	29-30	4	29-30	2	22-23	6	30-31	0	26-27	4
	33-36	4	31-33	8	30-32	6	24-25	0	32-33	4	28-29	2
	37-40	4	34-36	4			26-27	4	34-35	4	30-31	2
	41-43	6									32-33	4
Totals	721	20	606	20	562	20	432	20	522	20	536	20

There are no ratios in any of those compared in any of the Tables LXXXVIII to CII which could be used to differentiate between any of the six laboratory cultures. All variations could be those which occur within the limits of one species.

Measurements of Sexual Forms

Six oviparae (culture BC Wild) from *Euonymus europaeus* and ten oviparae (culture Man.) from *Viburnum opulus*, from the cages in the courtyard of the Animal Science Building, as outlined at the end of Chapter IV, were measured as described in Chapter III. There were no significant differences between the measurements of the forms from the two cultures, of body length, cauda length, number of hairs on cauda, cornicle length, length of longest hairs on antennal segment III, length of hind tibia, length of hind tarsal II, number of setae on rostral IV + V or number of setae on abdominal segment VIII dorsally.

There were differences between the oviparae as shown in the following measurements:

	Oviparae of culture Man.	Oviparae of culture BC Wild
Length of unguis	Range 0.16 - 0.24 mm mean 0.193 mm	Range 0.14 - 0.15 mm mean 0.143 mm
Total length of antennae	Range 0.57 - 0.77 mm mean 0.685 mm	Range 0.53 - 0.62 mm mean 0.568 mm
Length of rostral IV + V	Range 0.09 - 0.10 mm mean 0.098 mm	Range 0.08 mm mean 0.08 mm

In measurements of males, unguis of antennal segment VI of specimens from culture Man. was also longer than that of males of culture BC Wild, 0.38 - 0.43 mm in the former and 0.27 - 0.31 in the latter. Length of rostral IV + V was greater in males of culture Man. (0.14 mm) than in the males of culture BC Wild (0.10 mm).

In all the measurements made of "characters" on the alate and apterous forms of the six cultures, no definite differences could be found which could be considered as of specific rank, except in the measurement of the length of rostral segment IV + V.

But our success in obtaining males and oviparae resulted in two more forms which could be measured, and here there are important "character" differences at the species level, as follows:

1. Specimens of both males and oviparae from the "nasturtium" group have a longer unguis than those from the "faba bean group."

2. Total length of antennae of both males and oviparae from the "nasturtium" group is greater than in those from the "faba bean group."

3. Length of rostral IV + V is greater in both males and oviparae of the "nasturtium group" than in those from the "faba bean group." It is interesting to note that this character difference was also observed in the measurements made on alate and apterous viviparous females (Table LXXXV).

On the basis of the three measurement differences noted above, and on the host plant behavioural and physiological differences, one can say with confidence that the three cultures from the "nasturtium" group represent a species distinct from the "faba bean group," or the true *Aphis fabae* species. It is considered also that the species from the culture Man., NB-B, and P-E is an undescribed *Aphis* new species.

CHAPTER VI

SUMMARY AND CONCLUSIONS

A species of aphid which has been collected over several years in Manitoba on various wild and cultivated plants has been considered to be the well known economic pest named *Aphis fabae* Scopoli. Color of both live and mounted specimens, and conventional measurements of mounted specimens, were identical to those of *A. fabae* specimens from Europe.

In Europe, *A.fabae* feeds and thrives on faba beans and other beans, and also other plants. However, live aphids from Manitoba could not be induced to feed on faba bean, *Vicia faba* L. This anomaly resulted in the present study to determine if the species from Manitoba is (a) merely a biotype or physiological race of *A.fabae*, or (b) a subspecies of *A.fabae*, or (c) a species distinct and separate from *A. fabae*.

A biosystematic approach was used to solve the problem, involving use of the scanning electron microscope, examination of chromosomes, physiological and ethological studies, and conventional taxonomy (measurements and counts of cleared, whole mounts on glass microscope slides).

Live cultures of what were presumed to be *A.fabae* were obtained from British Columbia and from New Brunswick. The Manitoba species lived and thrived on garden nasturtium, *Tropaeolum majus* L. Two of the cultures obtained from New

Brunswick, fed and reproduced on nasturtium in the laboratory, but would not live on faba bean. It was assumed that they were the same species as that collected in Manitoba. Another culture from New Brunswick, and two cultures from British Columbia lived and thrived on faba bean, but not on nasturtium plants. There were therefore six cultures of live aphids available for the studies, three which would live on nasturtium and not on faba bean, and three (apparently the true A. fabae), which would live on faba bean but not on nasturtium.

No differences could be found between the six cultures when they were examined under the scanning electron microscope.

No differences were found when size, shape and numbers of chromosomes of specimens from the six cultures were examined.

Some or all of the six cultures were tested for their acceptance of 22 different plants, including nasturtium and faba bean. The list of plants is given in Table I, and the acceptance or rejection of the plants by the aphids is shown in Table II. The three cultures mentioned above consistently accepted nasturtium and did not live on faba bean, nor would they feed on other beans, such as green beans, yellow beans, scarlet runner beans, kidney beans or Lima beans. The other three cultures consistently accepted faba bean and would not live on nasturtium. Only two host plants were accepted by all six cultures, the spindle tree, Euonymus europaeus L. and the burdock, Arctium minus.

In Tables III - XIV are shown measurements of the various cultures on either nasturtium or faba bean in either field or laboratory tests, of nymphal development time, prelarviposition period, mean fecundity during first five days of adult life, mean total fecundity, and physiological development time in day-degrees, for both alate and apterous viviparous forms. No consistent differences could be found which could be species differences.

In Tables XV - XXVI are shown measurements of the various cultures on either nasturtium or faba bean in either field or laboratory tests, of days of adult life, mean length of adult life, mean fecundity per aphid, mean reproductive period and mean length of a generation in day-degrees, for both alate and apterous viviparous forms. No consistent differences could be found which could be species differences.

In Tables XXVII - XXXVII are shown measurements of the various cultures on several species or cultivars of plants in field tests, of the same parameters measured in Tables XV - XXVI, for both alate and apterous viviparous forms. No consistent differences could be found which could be species differences.

In Tables XXXVIII - LXXI are shown measurements of the various cultures on several species or cultivars of plants, in laboratory tests, of the same parameters measured in Tables III - XIV, for both alate and apterous viviparous forms. No consistent differences could be found which could be species differences.

In Chapter V are shown measurements made of cleared, mounted specimens, both winged and wingless forms, all six cultures of aphids, of total body length, cauda length, number of hairs on cauda, length of cornicle, length of antennal segments III, IV, V, base of VI and unguis of VI, length of longest setae on antennal segment III, length of rostral IV + V, length of hind tibia and length of hind tarsal segment II. There were no significant differences between any of the six cultures, except that rostral IV + V was longer in those aphids feeding on nasturtium than in those feeding on faba bean.

Also in Chapter V are measurements of ratios, mostly various segments compared with antennal segment III. None of the measurements using ratios showed differences which could be those between different species.

In September of 1978 an attempt was made to obtain the sexual forms of two of the cultures. In one cage outdoors were aphids on nasturtium, and a small potted plant of *Viburnum opulus*, and in another cage were aphids on faba bean, and a small potted plant of *Euonymus europaeus*. It was assumed that photoperiod and decreasing temperatures would induce aphids (sexuparae) to move from the summer host (the herbaceous plant) to the winter host (the woody plant), where sexual forms would be produced, to lay the overwintering eggs. Males and oviparae were thus obtained.

Conventional measurements were made of mounted specimens on slides, of males and oviparae. Rostral IV + V, length of unguis, and total length of antennae were longer in both males and oviparae of the aphids from *Viburnum opulus* than in those from *Euonymus europaeus*.

The following observations indicate that those aphids which live on nasturtium (the Manitoba species) are a different species from those which live on faba bean:

1. Host preferences; the Manitoba species lives on nasturtium and dies on faba bean. The "true" *Aphis fabae* lives on faba bean and not on nasturtium.

2. The sexual forms of the Manitoba species appeared two weeks earlier on their winter host than those of *Aphis fabae*.

3. Rostral IV + V is longer in alate and apterous viviparous forms, males and oviparae, of the Manitoba species.

4. Length of unguis and total length of antennae are greater in males and oviparae of the Manitoba species.

It is considered that the Manitoba species is not *Aphis fabae* Scopoli, and that it is probably a new species, presently undescribed.

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