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COLOR AND LIGHT INTENSITY PREFERENCES OF FOUR SPECIES OF ALATE CEREAL APHIDS

BY

DONALD A. DICKMANN

A thesis submitted
in partial fulfillment of the requirements for the
degree Doctor of Philosophy, Major in
Entomology, South Dakota
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1974

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COLOR AND LIGHT INTENSITY PREFERENCES OF FOUR

SPECIES OF ALATE CEREAL APHIDS

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_____ _____

Thesis Advisor Date

Head, Entomology-Zoology Department Date

COLOR AND LIGHT INTENSITY PREFERENCES OF FOUR SPECIES OF ALATE CEREAL APHIDS

Abstract

DONALD A. DICKMANN

Under the supervision of Dr. Robert W. Kieckhefer

Color and light intensity preferences of 4 species of alate cereal aphids, the English grain aphid, Macrosiphum avenae (Fab.); oat bird-cherry aphid, Rhopalosiphum padi (L.); corn leaf aphid, R. maidis (Fitch); greenbug, Schizaphis graminum (Rondani); were tested under controlled conditions. No significant differences in color response were found between post-teneral (flight-active) and flight-exhausted alates of any species. Macrosiphum avenae, R. maidis, and S. graminum showed a distinct preference for yellow; R. padi usually preferred green. Alates of all species preferred high light intensities to low within the range tested (350-3500 ft-c). Preferred colors (yellow and green) were more important than light intensity in attracting the alates. All species chose yellow light over daylight of equal or greater intensity; all chose green light over equal or greater intensity. Nonpreferred colors (red and blue) were usually inferior to the total visible spectrum of greater intensity in attracting aphids. Confinement under yellow light significantly increased survival, reproduction, and rate of development whereas confinement under green, red, and blue lights resulted in decreased survival (50-80% mortality), reproduction, and rate of development of all species. Attempts

to condition responses of cereal aphids to color, by rearing or confining them under various colors, were unsuccessful.

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INTRODUCTION

Cereal aphids spend most of their lives in close contact with foliage (wheat, barley, corn, sorghum). Except during molting and periods of flight, as in the case of the alate, they are constantly feeding on a specific host plant to sustain their rapid rate of growth and reproduction.

Recent reviews by certain investigators have presented a change in outlook toward the theory of insect migration. Kennedy and Booth (1963a, 1963b, 1964) noted that migrations usually occur post-tenerally (immediately after wings are formed) but prereproductively. Settling responses are inhibited before flight occurs and totally inhibited when flight starts. Johnson (1957, 1958, 1959) stated that mass migratory flights are made primarily by newly molted adults; this flight is the adults' first flight. Flights of from 30 min to 8 hr or longer are frequently required to satisfy the flight "drive" after which the wing muscles autolyze and aphids settle down to feed and reproduce.

Aphids have been referred to as "little stupid bags of sap." This is not true since these tiny, fragile creatures appear to be well equipped to cope with their environment. There is a sufficient amount of data published to indicate that aphids are able to discriminate between dietary components as well as varying degrees of light intensity or color.

The objectives of this study were:

1. To determine color preferences of post-teneral (flight-active) and flight-exhausted alate cereal aphids (4 species) with the expectation of contributing to a better understanding of the mechanisms of cereal aphid migration and selection of host plants.
2. To determine whether aphid responses to specific colors could be used as an aid in rearing cereal aphids, particularly on artificial diets. Specific colors may stimulate aggregation and feeding through artificial membranes. Understanding of color responses may help in explaining differential feeding on plant extracts of various colors. Alate aphid responses to color may prove to be quite different from apterae where certain colors have been shown to play a major role in stimulation of feeding (and therefore improved survival and reproduction) on artificial diets under membranes.
3. To determine whether color responses of alate cereal aphids may aid in explaining the epidemiology of barley yellow dwarf virus (BYDV) in the field. Barley yellow dwarf disease (BYD) usually causes a distinct yellowing or reddening of the leaves of affected plants. Alate cereal aphids are vectors of BYDV so that differential attraction of aphids to disease-discolored plants may

increase the incidence of BYD.

4. To contribute to an understanding of the usefulness of colored traps to sample populations of air-borne aphids. Changing responses with physiologic state or species may alter interpretation of trap catches. The color of host plant upon which the aphid matured may also influence color response.
5. To obtain a clearer knowledge of aphid responses to varying degrees of light intensity where percent transmittance would be comparable to, greater than, or less than a primary color being tested. The nature of light intensity and its relationship, or interaction, with color may influence different feeding behavior responses.

LITERATURE REVIEW

A number of studies have been conducted in regard to the responses of homopterous insects to light and to color. Some laboratory experiments have included work on wave length composition, intensity of the light source, and orientation of flight movement.

Cody (1941) observed that the pea aphid, Illinoia pisi (Kaltenbach), had a decided preference for garden pea varieties of a dark green color over a light green or yellow-green color. Muller (1964) investigated the responses of aphids to various colored lettuce plants and reported that the yellow and yellow-green varieties attracted more aphids than the whitish-green or reddish-brown varieties. It was demonstrated by Moericke (1952) that in nature, certain species of winged potato aphids were attracted to yellow surfaces. Kennedy, et al. (1961) and Moericke (1962) discussed the interruption of flight of aphids over yellow surfaces.

Some investigators have employed various ways to either attract or repel populations of insects. Kelsheimer (1932) observed leafhopper responses to colored electric light bulbs and reported that ivory and green bulbs were more attractive than tan, brown, red, or blue. Moore (1937) reported on the reactions of aphids to colored insecticides and found Myzus persicae (Sulzer) was attracted to potato plants sprayed with a Bordeaux mixture. He attributed this to the increased intensity of light reflected from the sprayed surfaces. His studies indicated that light intensity might be the primary factor involved in attracting aphids to sprayed surfaces. He also

found that the use of dyed dusts caused a reduction in the amount of light reflected from the treated surfaces which accounted for a reduced aphid infestation of certain plants. Red and black dusts proved to be the most effective, having significantly less aphids per plant than those with white or green dust.

Eastop (1955) demonstrated that sunlight improved yellow pan catches of grass feeding species of aphids as compared with a suction trap on an hourly basis. Moericke (1955) noted that the catch of some homopterous insects in yellow or green traps was reduced when these traps were displayed against a white background. Wilde (1961) experimented with color preferences (by the use of colored sticky traps) of some homoptera and thysanoptera in British Columbia and found the preferred color to be yellow.

Coon and Rinick (1962) found that the English grain aphid and the greenbug were not collected on yellow baffled traps whereas the apple grain aphid, Rhopalosiphum fitchi (Sanderson), and the corn leaf aphid, R. maidis (Fitch), were attracted. These men noted that since English grain aphids were abundant throughout the cereal growing season, the yellow traps appeared to be inefficient as collection devices for this species.

According to Pospisil (1963), Myzus persicae (Sulzer) alates were attracted to yellow or green light much more so than to other colors. He also stated that this reaction did not change during the life span of the winged aphids.

Cartier and Auclair (1964) studied color preferences of the pea aphid, Acyrthosiphon pisum (Harris), confined on a chemically-defined diet and found an increased rate of survival and development when the diets were backlighted with orange or yellow but a decreased rate of survival and development when the diets were backlighted with blue or white. These 2 investigators also carried out a "no choice" experiment with groups of pea aphids confined to specific containers and colors. The results showed almost total survival on yellow and orange light, total mortality on blue, and low survival on white, red, or green light.

Cartier (1966) noted that the pea aphid, A. pisum (Harris), and the potato aphid, Macrosiphum euphorbiae (Thomas), showed a definite preference for yellow and/or orange light over blue, green, and red light. Nymphs and both apterous and alate adults showed similar patterns of responses. His work also indicated that aphids have greater affinity for certain wave lengths and by rearing them under continuous light of preferred wave lengths and colors produced the best growth responses. It was found that blue, green, and red radiations produced growth responses about as poorly as those obtained in total darkness. Orange radiations were found to favor better growth in comparison with white light of high or low intensities, or with darkness.

Schwarz (1965) demonstrated seasonal fluctuations in the behavior responses of Toxoptera citricida (Kirkaldy) using artificial plants with leaves of green or yellow aluminum foil covered with an adhesive

and found that there was a preference for yellow but more marked in spring than in autumn.

Johnson et al. (1967) used reflective materials (aluminum foil and white polyethylene strips) as soil mulches to repel dispersing alate aphids and thus reduce the spread of cucumber mosaic virus (CMV) in gladiolus plantings. Black polyethylene strips proved to be the least effective in repelling aphids and reducing the spread of CMV. Reduction in the spread of CMV in the gladiolus planting appeared to be proportional to the effectiveness of the material being used as a repellent of aphids. According to Adlerz and Everett (1968), aluminum soil and white polyethylene mulches also repelled aphids and, thus, controlled the spread of watermelon mosaic virus (WMV).

Kring (1966, 1967) reported the color preferences of the cabbage aphid, Brevicoryne brassicae (L.); the green peach aphid, Myzus persicae (Sulzer); and the garden nasturtium aphid, Aphis sp. on colored cards in flight chambers under controlled conditions. He found that very few of the aphids alighted on the white walls of the chamber. Some of the colors and tints tested were as intense as yellow, and yet yellow cards were the most attractive for these 3 species of aphids. When some of the aphids attempted to fly, their flight patterns were aimless.

The behavioral response of the bean aphid, Aphis fabae Scopoli, a yellow-sensitive species, to yellow and other colored fluorescent lamps was observed in a flight chamber by Kring (1969). He reported

that the yellow and red lamps reduced aphid activity and blacklight increased activity. These effects on aphid behavior seemed to be related to both UV and visible energy emitted by the various colored lamps. Kring also stated that the reduced flight activity observed under the yellow lamp would indicate that the response to yellow reflective surfaces and yellow lamps may be the same, which is inhibition of flight activity.

Wensler (1962) believed that once the aphids arrive on a yellow surface, further muscular movement is arrested. This is particularly true of flight movement, but it seems true also of leg movement.

MATERIALS AND METHODS

Preferences of four species of alate cereal aphids were tested for color, light intensity, and combination of color and light intensity. Tests were also conducted to condition responses of aphids to color. The 4 species were:

English grain aphid, Macrosiphum avenae (Fab.);

oat bird-cherry aphid, Rhopalosiphum padi (L.);

corn leaf aphid, R. maidis (Fitch); and

greenbug, Schizaphis graminum (Rondani).

Winged aphids of these species were produced in controlled environmental chambers operating at 23½C with a 16-hr photophase at a light intensity of 3000 ft-c supplied by fluorescent and incandescent bulbs. The aphids were crowded on caged barley (Blanco®) plants causing physical contact between individuals under a high population density which has been reported to be the primary factor in the production of alate forms in aphid colonies (Paschke 1959, Toba and Paschke 1967, Lees 1967, and Sutherland 1969).

A temperature of 23½C was selected for the rearing and preference studies of all 4 species of alates. Daniels (1967) reported that this temperature was optimum for greenbug reproduction.

Color preference chambers and varying light intensity chambers were built by covering a cylindrical half-pint waxed container (4.5 cm ht. X 8.5 cm diam) with a plastic petri dish cover in which 4 holes had been drilled to fasten plastic tubing (2.5 cm ht. X 2 cm diam). These pieces of plastic tubing were glued flush with the

inner surface of the petri dish cover so that the aphids could move freely to and from any of 4 turrets (Fig. 1).

The top of the preference chamber assembly consisted of a glass petri dish cover divided into quadrants by cardboard partitions. Kodak® Wratten filters were mounted against the inner top of the glass petri dish cover and aligned with the turrets. Cardboard partitions excluded all but incident light (Fig. 2).

Kodak Wratten color filters, which represented discreet fractions of the visible spectrum and transmitted varying percentages of light, were selected as follows: numbers 15 (yellow), 75.5%; 29 (red), 11.0%; 49B (blue), 0.11%; and 53 (green), 8.1%. Kodak Wratten neutral density filters, with varying degrees of light intensity, were also used in these studies as follows: numbers 0.10 (80%); 0.30 (50%); 0.60 (25%); 1.00 (10%); 3.00 (0.10%); and 4.00 (0.01%). Figure 3 shows the spectral transmittance of all filters (Eastman Kodak Co., 1965). Spectral transmittance ("quality") is virtually the same for all levels of light intensity, but the amount ("quantity") of light passed through would vary with the filter being used. In the spectral transmittance for color, we find variance in "quality" as well as in "quantity."

Spectrophotometric tests of new filters and those that had been used for 1 month did not differ, thus proving that they were relatively stable with no deterioration after exposure to light.

Auclair and Cartier (1963), Cartier (1966), Mittler and Dadd (1962, 1963a, 1963b, 1964, 1965a, 1965b, 1965c), and Kieckhefer and

Derr (1967) have developed techniques for rearing aphids on chemically-defined diets. These diets have been proven to support survival and reproduction for extended periods of time. The aphid diet reported by Kieckhefer and Derr (1967) (Table 1) was used for all tests conducted in this study.

Parafilm feeding sachets (Mittler and Dadd 1964) were placed over each turret (Fig. 4, 5, and 6).

Alate cereal aphids (100) were placed in each (Fig. 7) of 4 preference chambers (4 replicates) where they were allowed free choice of turrets.

This study consisted of:

I. Color Preferences of Flight-active Alates.

Recently molted alates of the 4 test species were allowed free choice of the 4 principal colors in the preference chambers.

II. Color Preferences of Flight-exhausted Alates.

Alates were allowed to fly until their flight "drive" was exhausted, as indicated by settling, feeding, and reproducing on host plants. These flight-exhausted alates were placed in preference chambers and their choice of colors compared with choices made by flight-active alates of the same species.

III. Varying Light Intensity Preferences of Alates.

Alates were allowed free choice of 4 levels of light intensity (comparable to percent transmittance of the 4 principal colors), numbers 0.10 (80%), 0.60 (25%), 1.00 (10%), and 3.00 (0.10%) in the preference chambers (refer to table of IV).

IV. Combination of a Color and Varying Light Intensity Preferences of Alates.

Alates were allowed free choice of a color and/or 3 degrees of light intensity where percent transmittance was comparable to, greater than, or less than the color being tested. Each of the 4 colors, with an array of light intensity filters, was arranged as follows:

Color filter		Neutral density filter	
No.	Transmittance (%)	No.	Transmittance (%)
15 yellow	75.5	0.10	80.0
		.00	100.0
		.30	50.0
29 red	11.0	1.00	10.0
		.60	25.0
		3.00	0.10
49B blue	0.11	3.00	.10
		1.00	10.0
		4.00	.01
53 green	8.1	1.00	10.0
		.60	25.0
		3.00	.10

V. Conditioning of Color Preferences of Alates.

Last instar nymphs were reared to maturity in conditioning chambers (Fig. 8 and 9) under each of the 4 principal colors and then placed into preference chambers where their subsequent color choices were noted.

The number of alates and nymphs (of all 4 species) on the feeding sachets under the various filters was tabulated every 24 hr over

a 5-day period. (Typical distributions of English grain aphid alates, under the various filter combinations, are shown in Fig. 10, 11, 12, and 13.) Feeding sachets containing the artificial diet were replaced at 24-hr intervals. However, each day before the sachets could be changed, the aphids were dislodged from the undersurface of the sachets by a vigorous tapping of the entire preference chamber.

All data were compared statistically using analysis of variance and Duncan's new multiple range test.

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RESULTS AND DISCUSSION

Color Preferences of Flight-active Alates

Color preferences were well defined with respect to all 4 species of post-teneral (flight-active) cereal aphids. Alates of English grain aphid, corn leaf aphid, and greenbug chose yellow over the other colors tested (Tables 2, 4, and 5). Green, which attracted the next largest number of English grain aphids and greenbugs, was in most instances statistically distinguishable from red and blue. The results of tests on corn leaf aphids indicated that green, red, and blue were not significantly different from one another. The fourth species, oat bird-cherry aphids, chose green over the primary colors (Table 3). Yellow, second to green in attractiveness for oat bird-cherry aphids, was found to be significantly more attractive than red or blue.

Color Preferences of Flight-exhausted Alates

The flight-exhausted alates (so-named because wing muscles had autolyzed, and aphids were feeding and reproducing on the host plants) of all 4 species showed definite color preferences. English grain aphids, corn leaf aphids, and greenbugs preferred yellow over the other colors (Tables 6, 8, and 9). The treatment means for yellow, green, and red were significantly different from one another for the English grain aphid and greenbug; red and blue had means in common. Greenbugs (Table 9) had no members on red at any time and chose blue only at one time period - after 24 hr had elapsed. Corn leaf

aphid color preferences were such that in 2 instances (at 24 hr and 120 hr) they were found to be almost equally distributed on green, red, and blue (Table 8). Green was the primary preference of oat bird-cherry aphids with the means for yellow being significantly different from red and blue (Table 7).

Figures 14, 15, 16, and 17 indicate that there were no great differences in color responses between the flight-active and flight-exhausted members of any of the 4 species of aphids. English grain aphids, corn leaf aphids, and greenbugs chose yellow; whereas, oat bird-cherry aphids showed a preference for green over the primary colors.

Varying Light Intensity Preferences of Alates

All 4 species of cereal aphid alates showed a preference for the highest light intensity (neutral density filter, Kodak 0.10). Not only were they attracted to the highest light intensity, but they responded to a gradient in respect to the other 3 neutral density filters (Kodak 0.60, 1.00, 3.00) with lesser degrees of light intensity (Fig. 18 and 19). The English grain aphid (Table 10) and the greenbug (Table 13) displayed a great preference for the highest light intensity; responses to the other 3 neutral density filters (with lesser degrees of light intensity) were in most cases statistically indistinguishable.

Oat bird-cherry aphid (Table 11) and corn leaf aphid (Table 12) responses to the various light intensities were not as clearly defined. In some instances, the alates of either species were distributed almost equally under the lesser (darker) light intensity filters.

There were no survivors of oat bird-cherry aphids under any of the neutral density filters after 120 hr had elapsed.

Color and Varying Light Intensity Preferences of Alates

Yellow was far more important than varying degrees of light intensity in influencing the choices of all 4 species of aphids; yellow was chosen over daylight of equal or greater intensity of light (Fig. 20 and 21). English grain aphids (Table 14) and corn leaf aphids (Table 16) were attracted primarily to yellow with their preferences for varying light intensities not being significantly different from each other. Oat bird-cherry aphids (Table 15) and greenbugs (Table 17) also chose yellow, but treatment means for the varying intensities of light were usually statistically distinguishable.

After yellow light, green proved to be the choice of all 4 species of cereal aphids; alates chose green over equal or greater intensity of light (Fig. 22 and 23). Members of the English grain aphid, oat bird-cherry aphid, and corn leaf aphid (Tables 18, 19, and 20) showed a rather equal distribution under the varying degrees of light intensity. It should be noted that the greenbug (Table 21) displayed little or no preference for any light but almost always chose green.

Alates of all 4 species of aphids preferred the light intensity of neutral density filter 0.60 (25% transmittance) over red (11% tranmittance) (Tables 22, 23, 24, and 25). At first glance, this might seem to be the logical effect (preference for greater transmittance over lesser transmittance) until we refer to green (with

8.1% transmittance or less than that for red at 11% transmittance) which was preferred over the varying light intensities including the neutral density filter of 0.60 (25% transmittance). The neutral density filter 1.00 (10% transmittance), comparable to the 11% transmittance of the red filter, was usually inferior to red in respect to attracting the cereal aphids. The light intensity of neutral density filter 3.00 (0.10% transmittance) attracted the least number of alates for this series of tests.

Blue (0.11% transmittance) was found to be inferior to the neutral density filter 1.00 (10.0% transmittance) in attracting all 4 species of alates (Tables 26, 27, 28, and 29). Close inspection of the data shows that the blue filter (0.11% transmittance) did, on several occasions, attract more aphids than the comparable neutral density filter 3.00 (0.10% transmittance). Blue, with its array of light intensity filters, was not conducive to survival or reproduction of cereal aphids. The tests with English grain aphids, oat bird-cherry aphids, and corn leaf aphids revealed a high mortality rate with no aphids present under any of the filters after 120 hr had elapsed. Only greenbugs responded and showed signs of life after the 5-day testing period.

Conditioning with Color and Color Preferences of Alates

Late instar nymphs of all 4 species were reared to maturity within conditioning chambers under each of the 4 test colors. The results were quite dramatic and showed extreme differences in regard to survival, rate of development, and reproduction.

When reared under the yellow filter, 80-95% of the aphids survived and developed to the alate stage within a period of 48 hr. These alates were then removed from the conditioning chambers and placed within color preference chambers where their subsequent color choices were noted. The alates of all 4 species (conditioned with yellow) showed a preference for yellow. This was to be expected since yellow had been the preferred color of 3 species of alates in most of the other tests that were conducted. Green, red, and blue were almost always statistically indistinguishable for the English grain aphid (Table 30). Green, which ranked second in response for corn leaf aphids (Table 32) and greenbugs (Table 33), was in most cases significantly more attractive than red and blue; red and blue were statistically indistinguishable. Oat bird-cherry aphids (Table 31) chose yellow over green but the treatment means for these 2 colors, in most instances, were not significantly different from each other. Red and blue were also statistically indistinguishable for oat bird-cherry aphids in this 5-day test.

Late instar nymphs of all 4 species, reared to maturity within conditioning chambers under green, red, or blue filters, did not fare as well as those that were reared under yellow filters. Approximately 50% of the aphids survived and developed to the alate stage within a period of 48 hr. Confinement of aphids under these colors for a period of 72 hr resulted in 80-100% mortality. Therefore, I placed 800-1000 late instar nymphs within a greater number of conditioning chambers to insure an adequate number of alates to be placed

within the color preference chambers where their subsequent color choices could be observed and recorded.

The aphids that had been conditioned with the green filter chose yellow over the other test colors. The responses of the English grain aphid (Table 34) indicated a rather equal distribution under green, red, and blue filters. Oat bird-cherry aphids (Table 35) and greenbugs (Table 37) chose yellow but the means for yellow were usually not significantly different from that of green. There were very few, but similar, responses to red and blue filters by the oat bird-cherry aphid and the greenbug. The response of corn leaf aphids (Table 36) to green was statistically different from the response to yellow, red, or blue; the treatment means of red and blue were not significantly different from each other.

The aphids that had been conditioned with the red filter usually preferred yellow over the other colors tested. English grain aphid (Table 38) responses indicated that the treatment means for green, red, and blue were not significantly different from one another. Corn leaf aphids (Table 40) and greenbugs (Table 41) did show significant differences in the means for green as opposed to the means for red and blue. Oat bird-cherry aphids (conditioned with red) showed a slight preference for green; the means for green and yellow were statistically indistinguishable (Table 39). There were few, but similar, responses to red and blue filters by the oat bird-cherry aphids.

The aphids that had been conditioned with a blue filter usually chose yellow over the other test colors (Tables 42, 44 and 45). Green, ranking second in attraction for 3 of the species, was statistically more attractive than red or blue; red and blue were not significantly different from one another. Oat bird-cherry aphids, conditioned with blue, (Table 43) showed a slight preference for green, but this response was not significantly different from the response to yellow. Very few of the oat bird-cherry aphids were attracted to the red or blue filters.

Although my studies dealt primarily with alates, choices and numbers of nymphs on the feeding sachets under the various filters were also recorded. In most instances, it was found that the color or light intensity preferences of the nymphs were comparable to the choices of the corresponding alates. The number of nymphs tended to increase each day especially for the English grain aphid and the greenbug. Oat bird-cherry aphid and corn leaf aphid nymphs were not as prevalent on the feeding sachets and would tend to remain at a rather low number or decrease in number over a 5-day testing period. In almost all of the tests conducted for alates and nymphs, the F value was significant at the 1 or 5% level.

The English grain aphid proved to be the most hardy of the 4 species studied. All tests showed that survival and reproduction were successfully sustained on artificial diet during the 5-day testing periods. For oat bird-cherry aphids, the pattern of life tended to be just the opposite: a greater proportion of the alates

and nymphs did not feed on the artificial diet under any of the various filters that were used. The alates of oat bird-cherry aphid always appeared to be very active at the bottom of the test chamber during the first 24-48 hr. A few would fly up into 1 of the turrets under 1 of the filters. This was then usually followed by a rapid decline in the population for this species.

A temperature of 23°C for optimum rearing of greenbug, as proposed by Daniels (1967), proved to be satisfactory for all rearing procedures and preference studies conducted in this laboratory.

SUMMARY

Four species of alate cereal aphids (English grain aphid, oat bird-cherry aphid, corn leaf aphid, greenbug) were reared in controlled environmental chambers operating at 23°C with a 16-hr photophase at a light intensity of 3000 ft-c supplied by fluorescent and incandescent bulbs. The aphids were crowded on caged barley (Blanco) plants to stimulate production of alate forms. These alate aphids were tested in specially designed chambers for color preference, light intensity preference, a combination of color-light intensity preference, and color conditioning.

Kodak Wratten color filters (yellow, green, red, and blue) that transmit varying percentages of light were selected to represent discreet fractions of the visible spectrum. Kodak Wratten neutral density filters, with varying degrees of light intensity, were also used in these studies.

Feeding sachets supported survival and reproduction of aphids over 5-day test periods. Feeding sachets were changed each day. The number of alates and nymphs on feeding sachets under the various filters were recorded each day.

No great differences in color responses were evident between flight-active (post-teneral) and flight-exhausted alates of any species. English grain aphids, corn leaf aphids, and greenbugs showed a preference for yellow; oat bird-cherry aphids usually chose green.

Alates of all species showed a preference for the highest light intensity and responded to a gradient in respect to the other lesser degrees of light intensity within the range tested.

Yellow was far more important than varying degrees of light intensity; all species of alates chose yellow over daylight of equal or greater intensity of light. All species of alates preferred green over equal or greater intensity of light. Red and blue were usually inferior to the total visible spectrum of greater intensity in attracting the cereal aphids.

Late-instar nymphs, when reared to maturity under yellow light, had a significantly high rate of survival, reproduction, and development. When reared to maturity under green, red, or blue light, the nymphs had a lower rate of survival, reproduction, and development. Confinement of cereal aphids under green, red, or blue light for 72 hr resulted in high mortality.

Alates of all species, when placed in color preference chambers after being conditioned under yellow, green, red, or blue light, usually chose yellow over the other test colors. However, oat bird-cherry aphids preferred green in several instances.

Usually both nymphs and alates of a species preferred the same colors or light intensities. Numbers of nymphs tended to increase each day for the English grain aphid and the greenbug but decrease each day for the oat bird-cherry aphid and the corn leaf aphid. The English grain aphid proved to be the most hardy species, whereas the oat bird-cherry aphid appeared to be the "weakest" species in

respect to feeding, survival, and reproduction during testing periods.

Almost all tests conducted and processed by statistical analysis of variance were found to be significant at the 1 or 5% level.

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APPENDIX

Fig. 1.--Preference chamber with turrets.

Fig. 2.--Preference chamber, turrets, partitions, and color filter assembly.

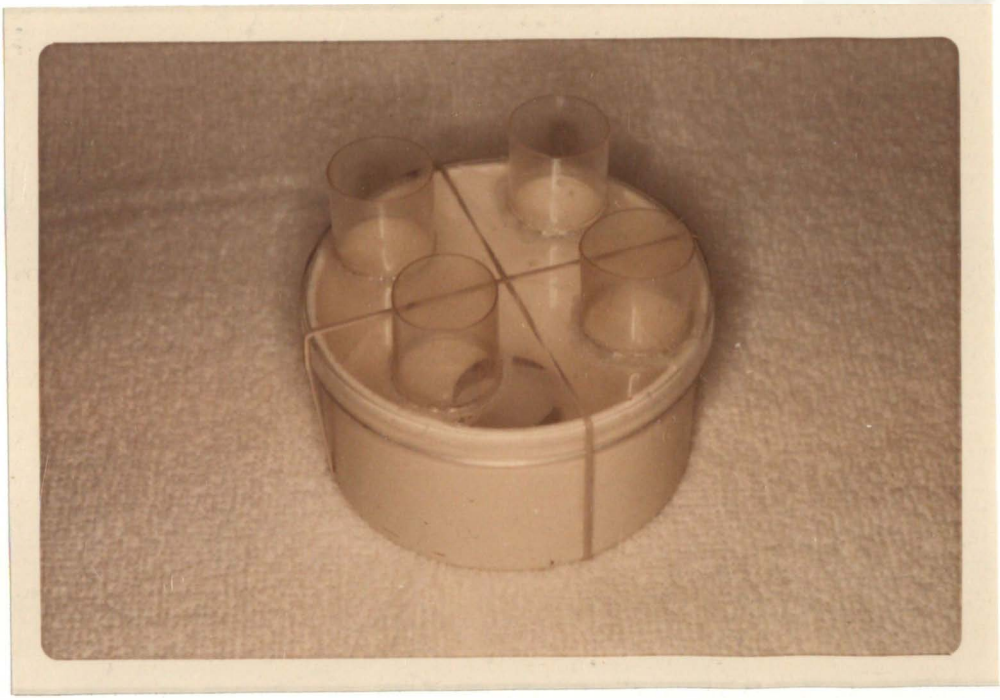
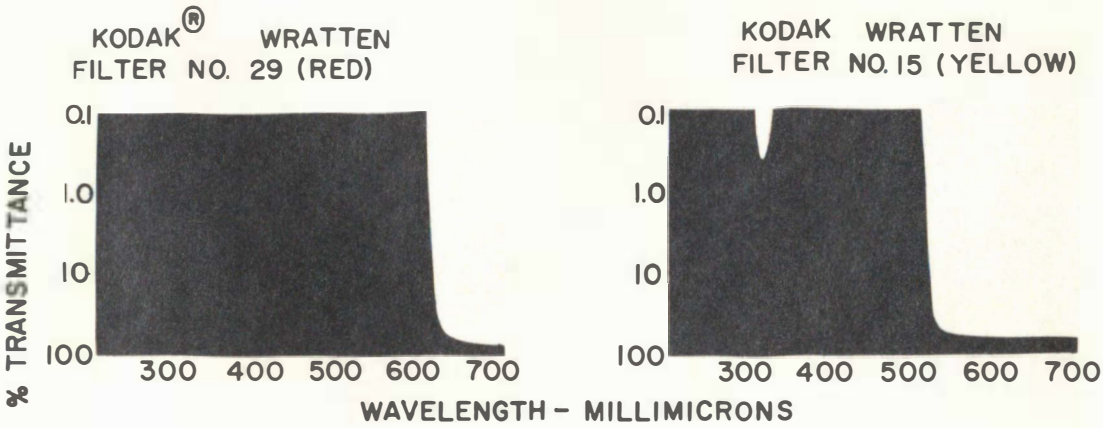


Fig. 3.--Spectral transmittance of Kodak® Wratten filters.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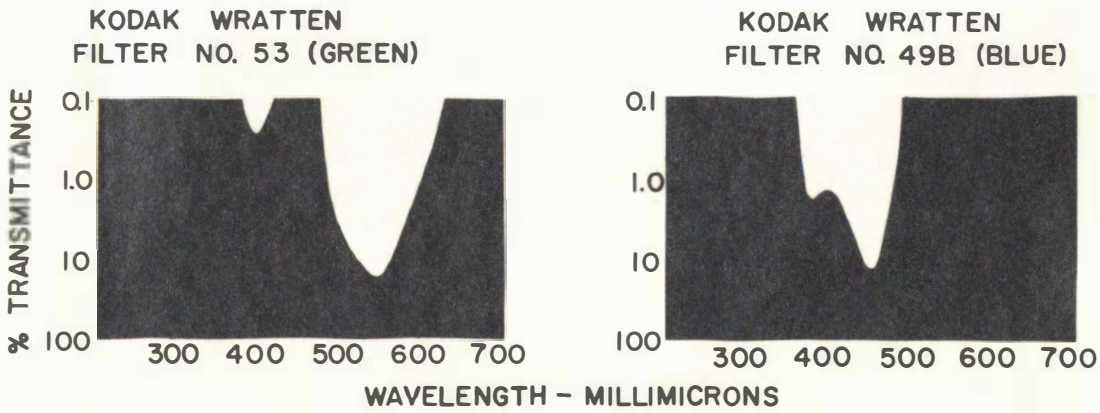
FILTER NO. 29 (RED)
KODAK WRATTEN
FILTER NO. 15 (YELLOW)
% TRANSMITTANCE
0.1
1.0
10
100
300 400 500 600 700
WAVELENGTH - MILLIMICRONS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FILTER NO. 53 (GREEN)
KODAK WRATTEN
FILTER NO. 49B (BLUE)
% TRANSMITTANCE
0.1
1.0
10
100
300 400 500 600 700
WAVELENGTH - MILLIMICRONS

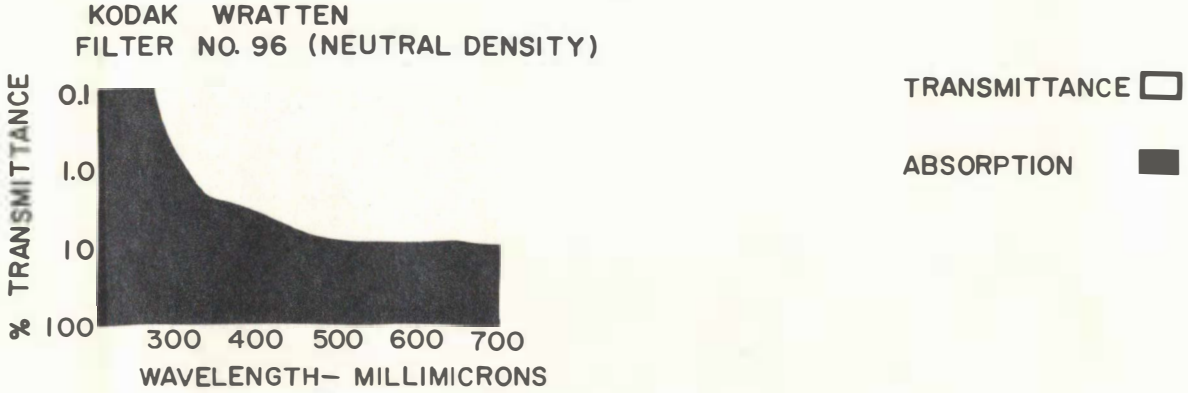
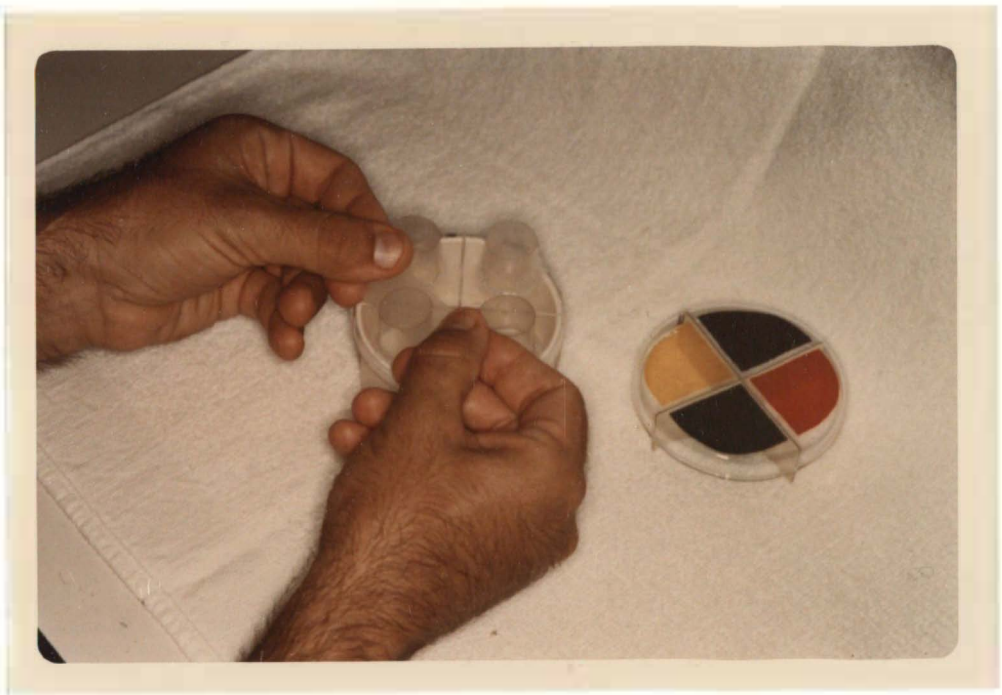

KODAK WRATTEN
FILTER NO. 96 (NEUTRAL DENSITY)
% TRANSMITTANCE
0.1
1.0
10
100
300 400 500 600 700
WAVELENGTH- MILLIMICRONS
TRANSMITTANCE
ABSORPTION

Fig. 4.--Application of first Parafilm® membrane over each turret.

Fig. 5.--Application of liquid diet on each Parafilm® membrane.



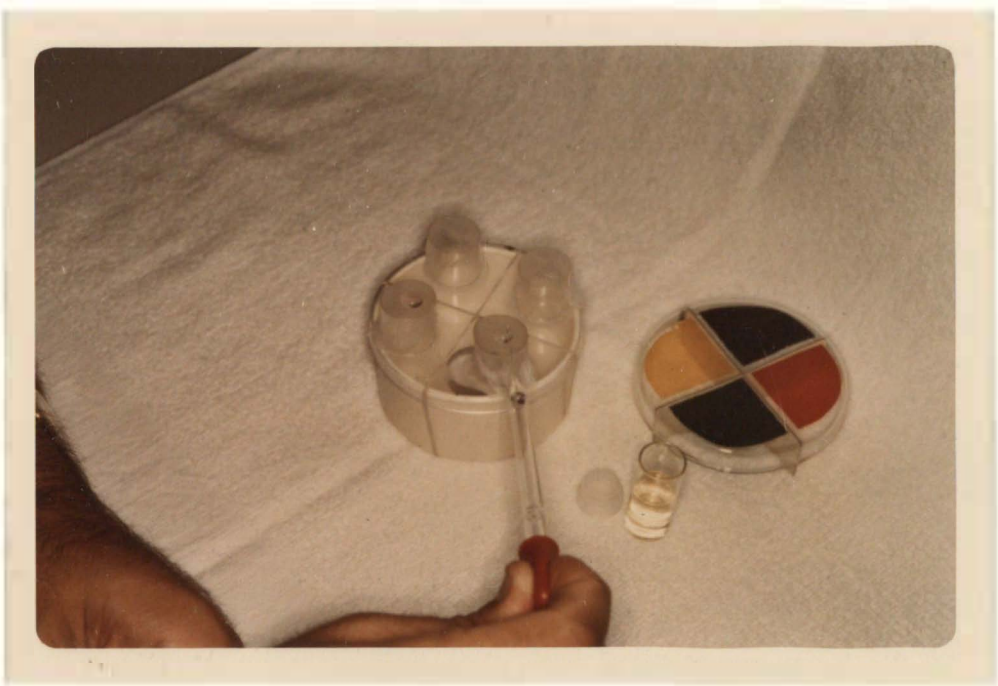
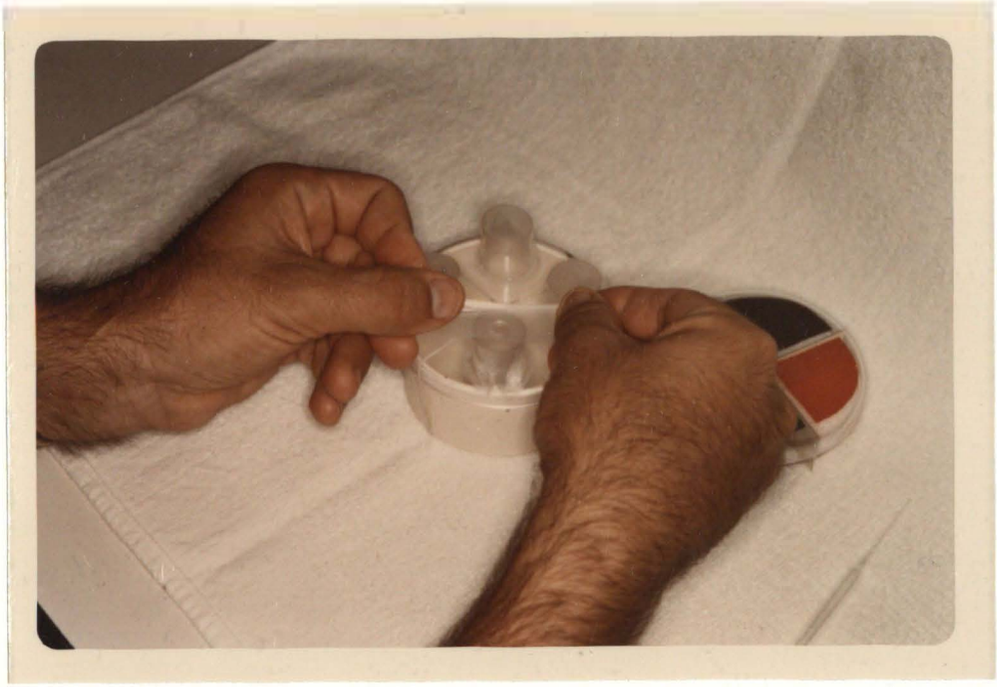


Fig. 6.--Application of second Parafilm® membrane to form sachet over each turret.

Fig. 7.--One complete preference chamber assembly.



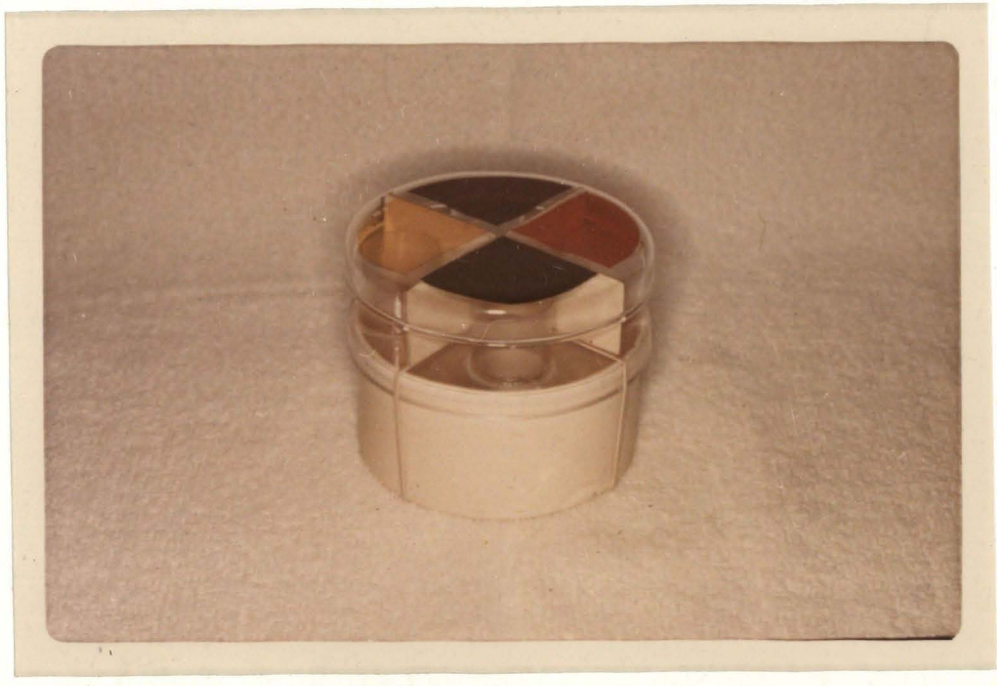
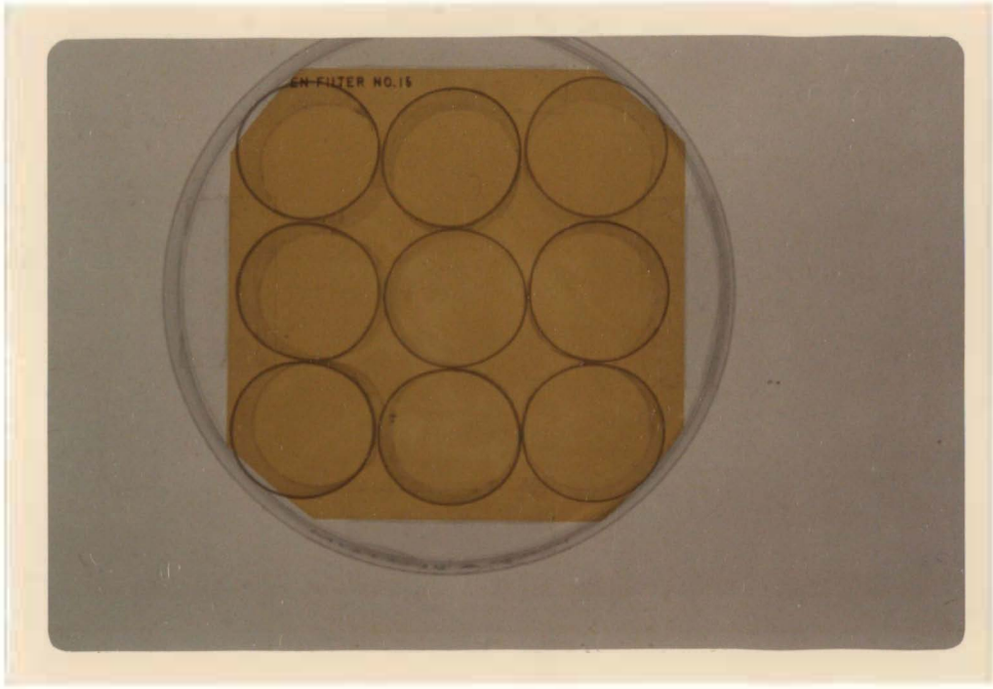


Fig. 8.--One complete (yellow) conditioning chamber assembly (top view).

Fig. 9.--One complete (red) conditioning chamber assembly (top view).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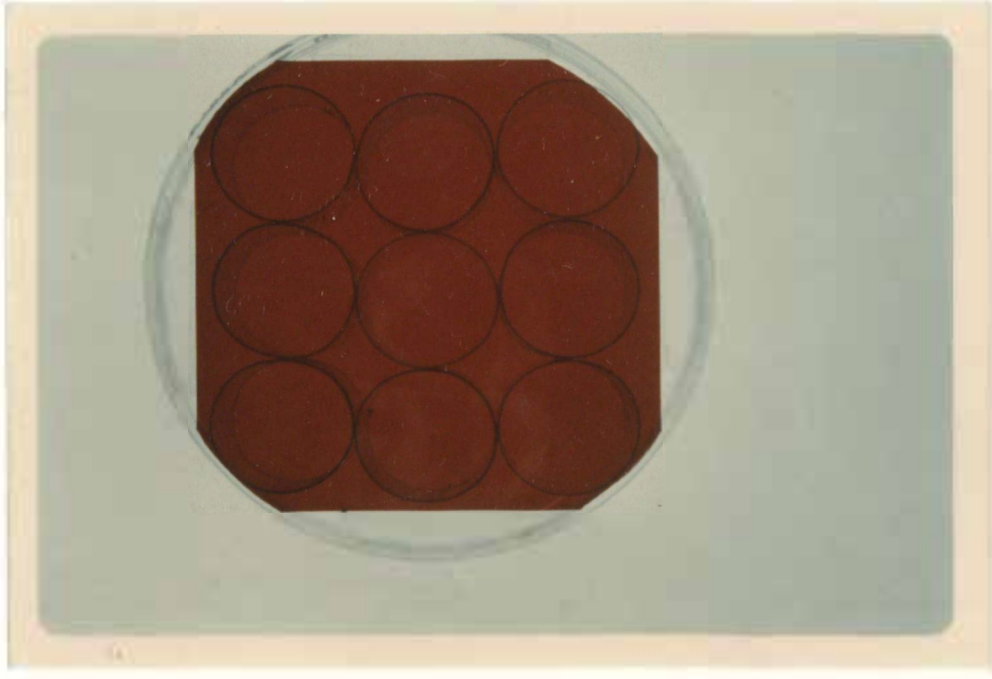
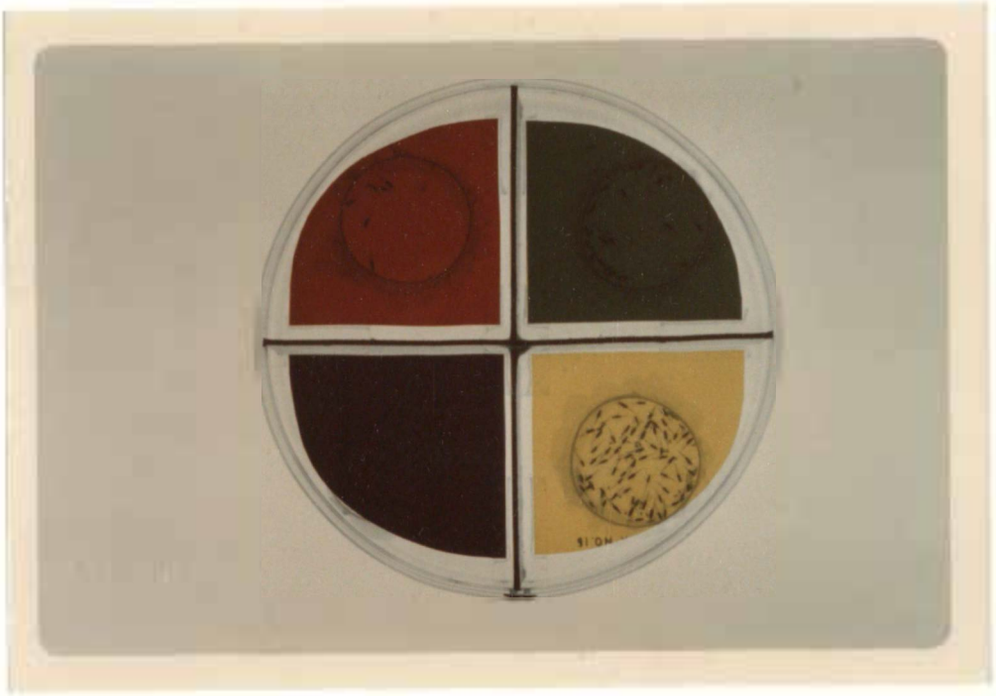


Fig. 10.--Color preference chamber (top view) showing distribution of alates - English grain aphid.

Fig. 11.--Varying light intensity preference chamber (top view) showing distribution of alates - English grain aphid.



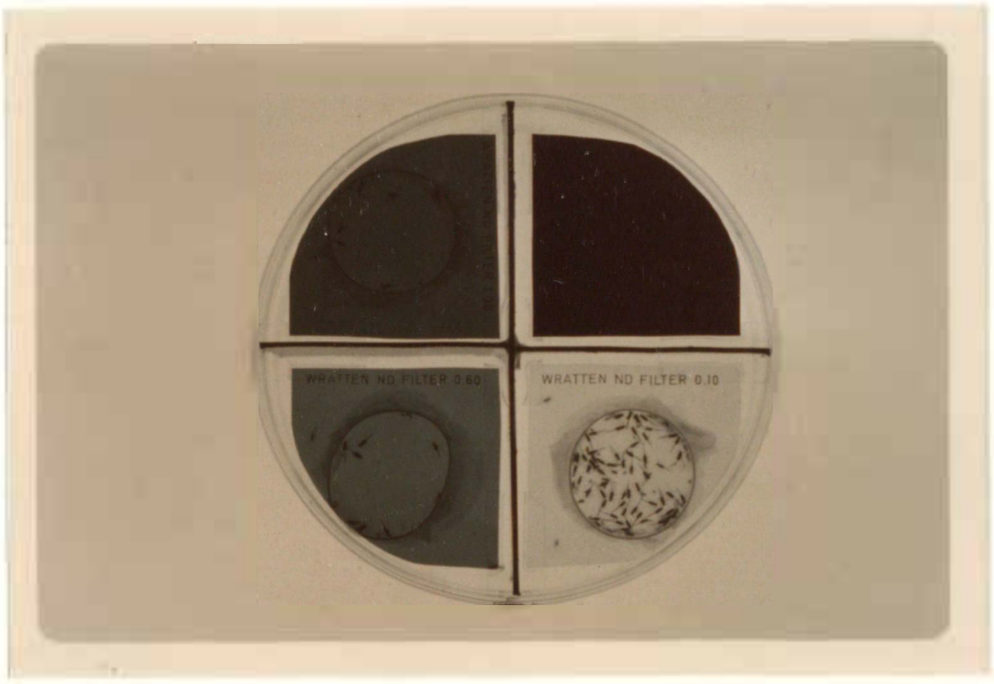
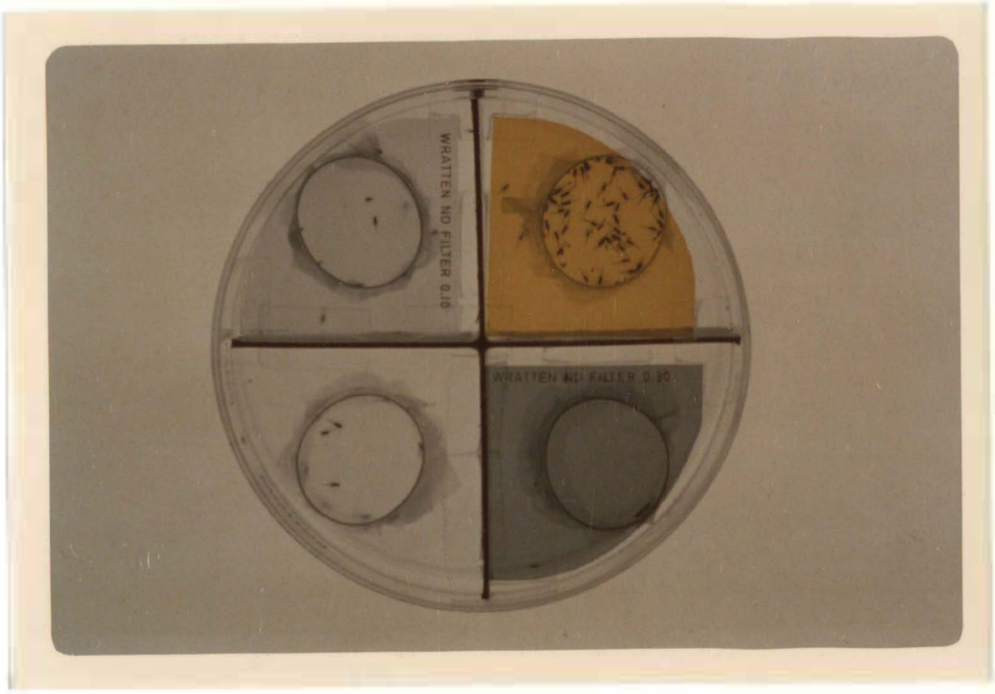

WRATTEN ND FILTER 0.60
WRATTEN ND FILTER 0.10

Fig. 12.--Color (yellow) and varying light intensity preference chamber (top view) showing distribution of alates - English grain aphid.

Fig. 13.--Color (green) and varying light intensity preference chamber (top view) showing distribution of alates - English grain aphid.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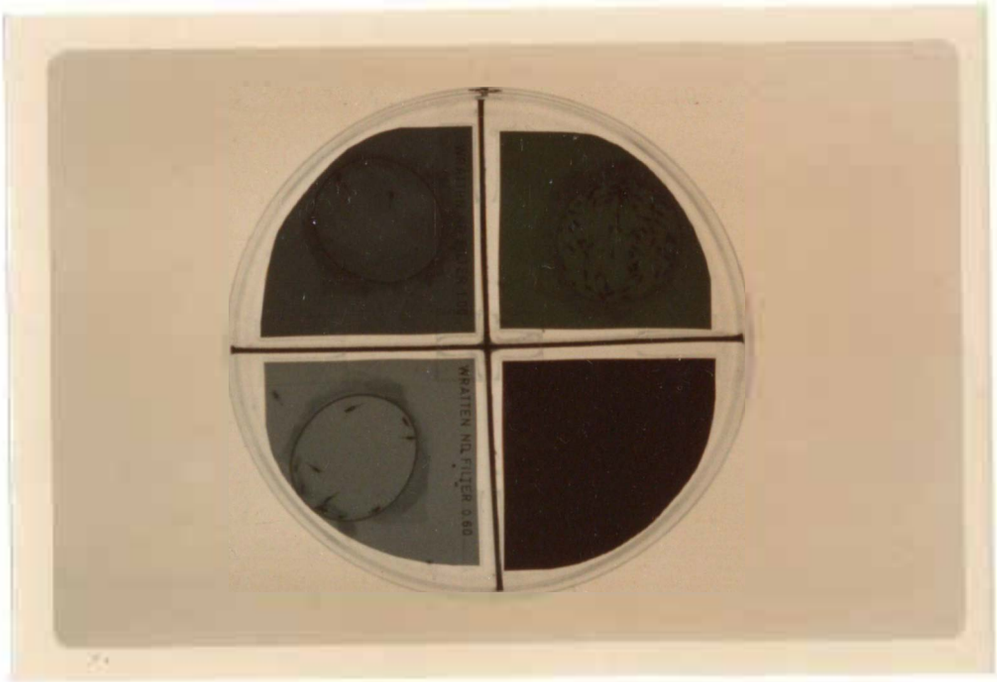
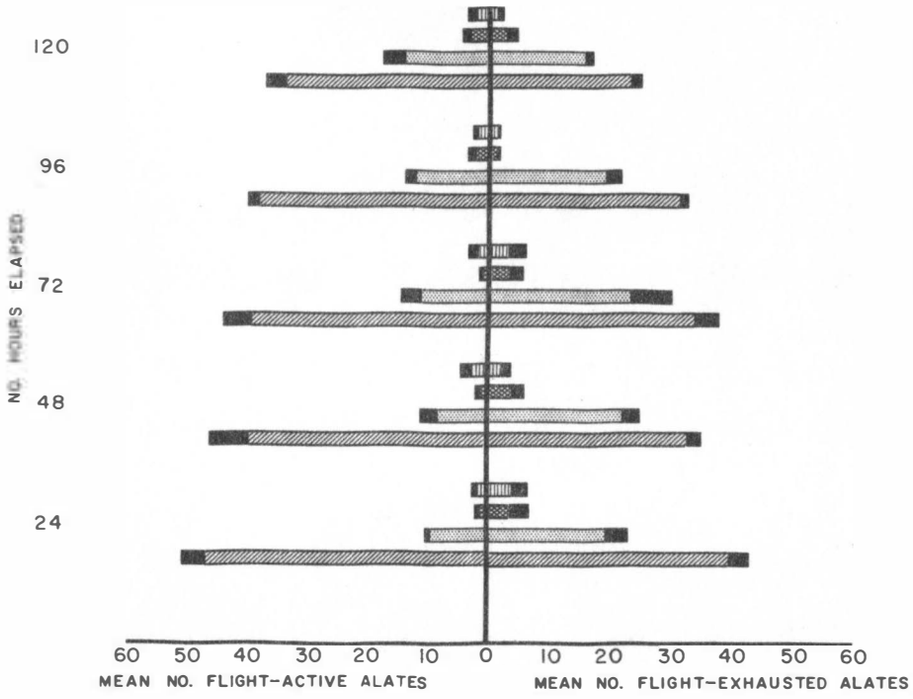

WRATTEN ND FILTER 0.60

Fig. 14.--Comparison of color preferences of flight-active and flight-exhausted alates of English grain aphid.

Fig. 15.--Comparison of color preferences of flight-active and flight-exhausted alates of oat bird-cherry aphid.

ENGLISH GRAIN APHID



OAT BIRD-CHERRY APHID

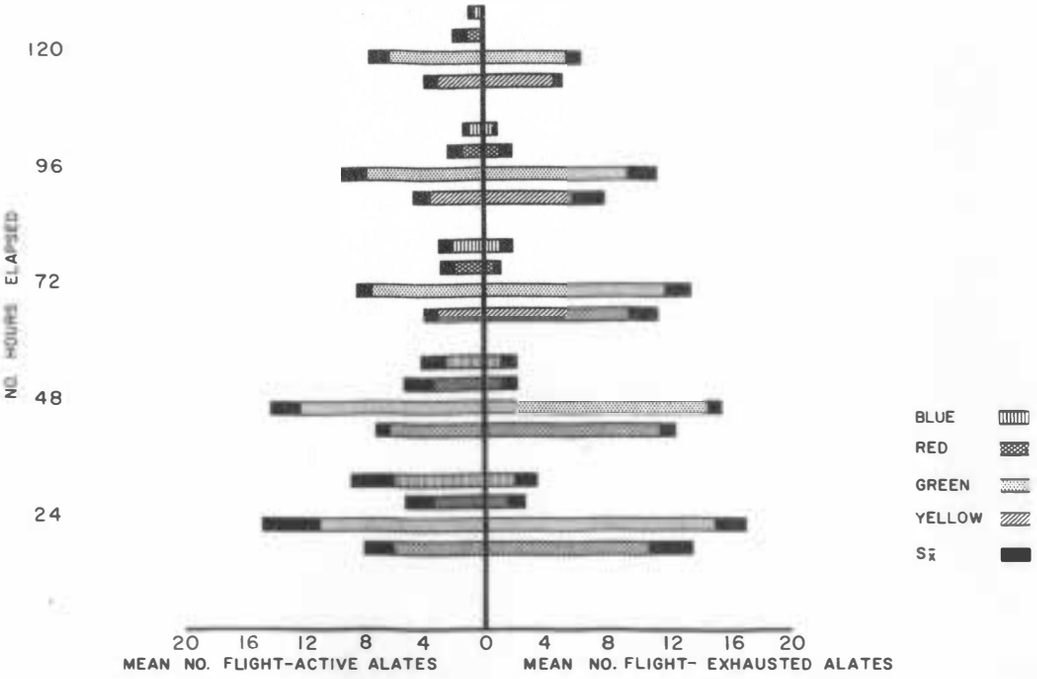
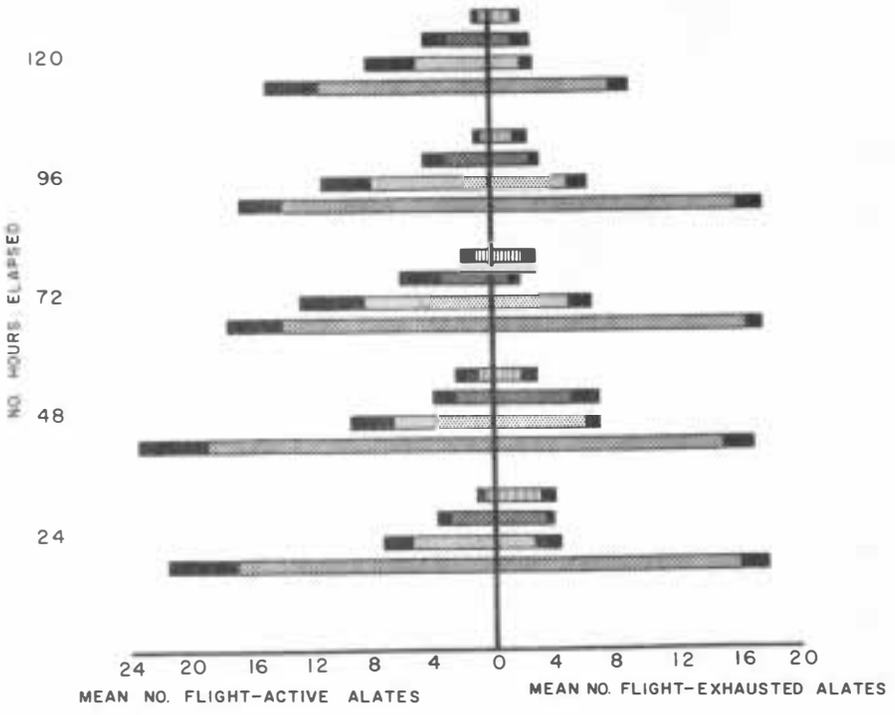


Fig. 16.--Comparison of color preferences of flight-active and flight-exhausted alates of corn leaf aphid.

Fig. 17.--Comparison of color preferences of flight-active and flight-exhausted alates of greenbug.

CORN LEAF APHID



GREENBUG

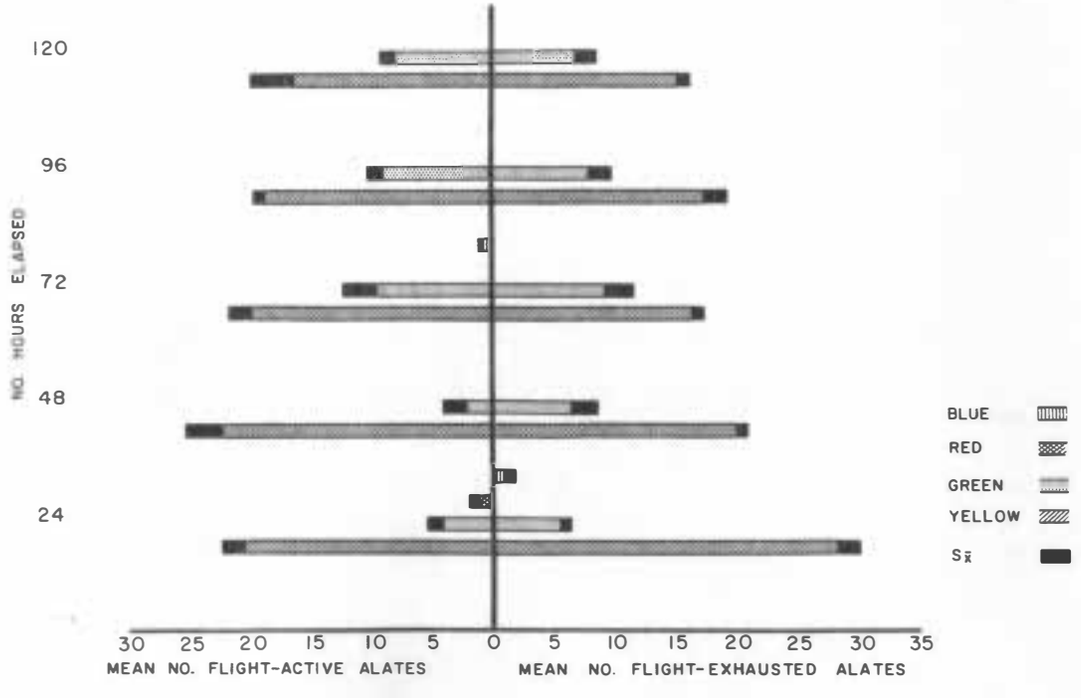


Fig. 18.--Varying light intensity preferences of alates - greenbug and English grain aphid.

Fig. 19.--Varying light intensity preferences of alates - oat bird-cherry aphid and corn leaf aphid.

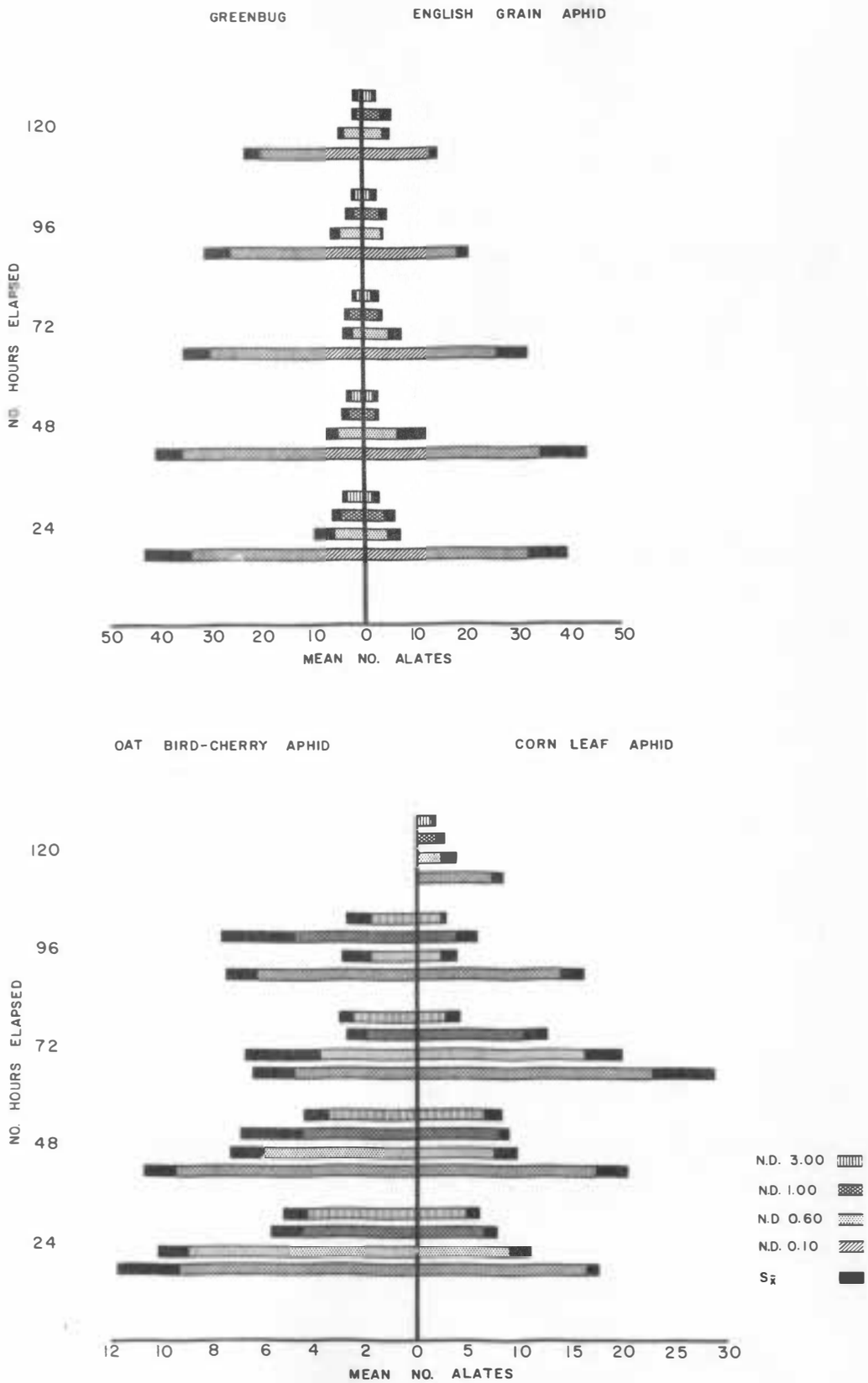
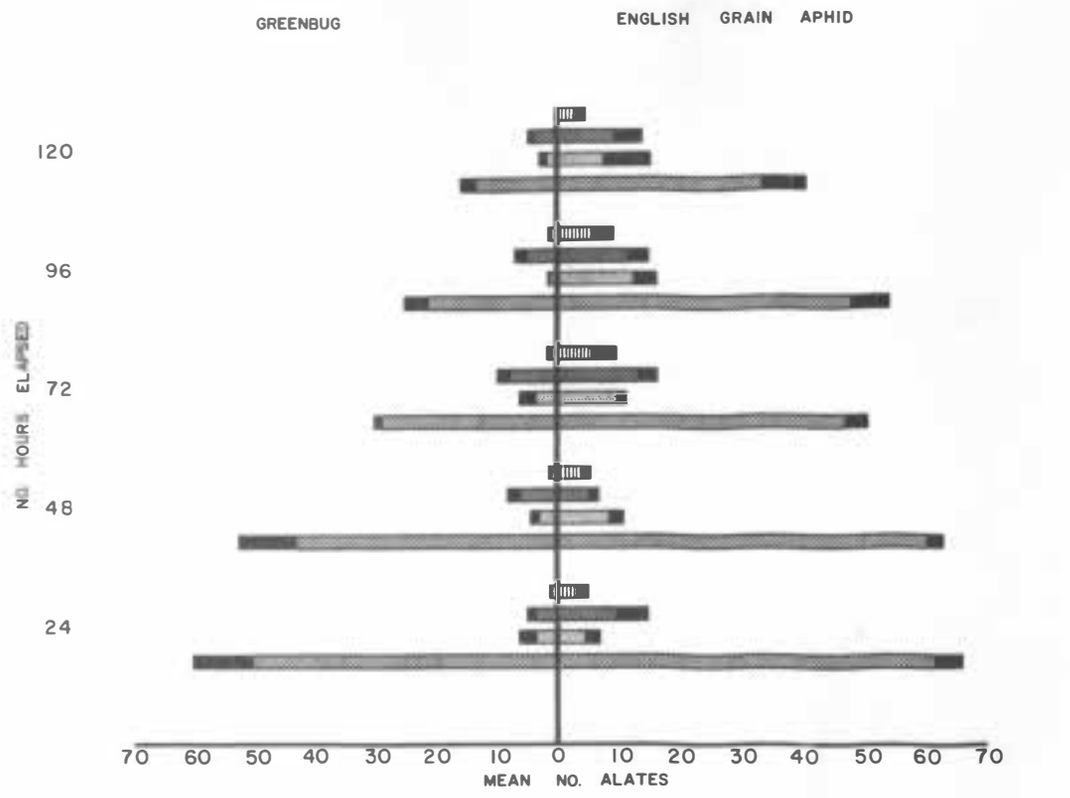

GREENBUG
ENGLISH GRAIN APHID
120
96
72
48
24
NO. HOURS ELAPSED
50 40 30 20 10 0 10 20 30 40 50
MEAN NO. ALATES
OAT BIRD-CHERRY APHID
CORN LEAF APHID
120
96
72
48
24
NO. HOURS ELAPSED
12 10 8 6 4 2 0 5 10 15 20 25 30
MEAN NO. ALATES
N.D. 3.00
N.D. 1.00
N.D 0.60
N.D. 0.10
$S_{\bar{x}}$

Fig. 20.--Color (yellow) and varying light intensity preferences of alates - greenbug and English grain aphid.

Fig. 21.--Color (yellow) and varying light intensity preferences of alates - oat bird-cherry aphid and corn leaf aphid.


GREENBUG
ENGLISH GRAIN APHID
120
96
72
48
24
NO. HOURS ELAPSED
70 60 50 40 30 20 10 0 10 20 30 40 50 60 70
MEAN NO. ALATES

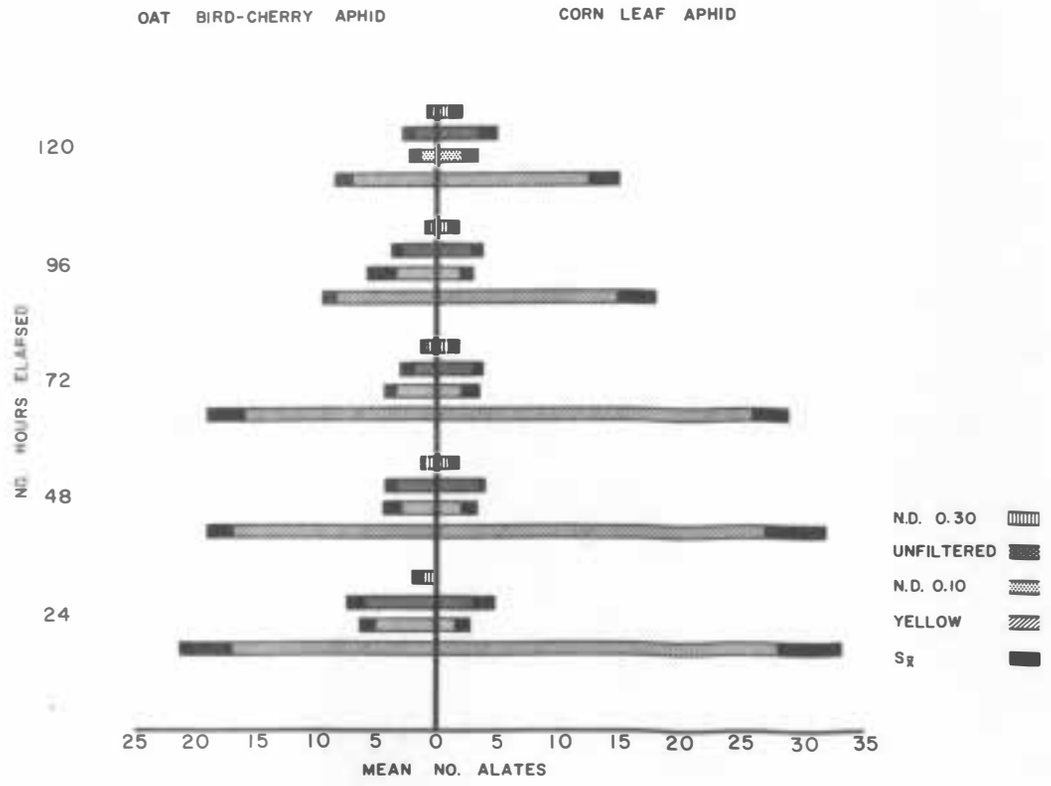

OAT BIRD-CHERRY APHID
CORN LEAF APHID
120
96
72
48
24
NO. HOURS ELAPSED
25 20 15 10 5 0 5 10 15 20 25 30 35
MEAN NO. ALATES
N.D. 0.30
UNFILTERED
N.D. 0.10
YELLOW
$S_{\bar{x}}$

Fig. 22.--Color (green) and varying light intensity preferences of alates - greenbug and English grain aphid.

Fig. 23.--Color (green) and varying light intensity preferences of alates - oat bird-cherry aphid and corn leaf aphid.

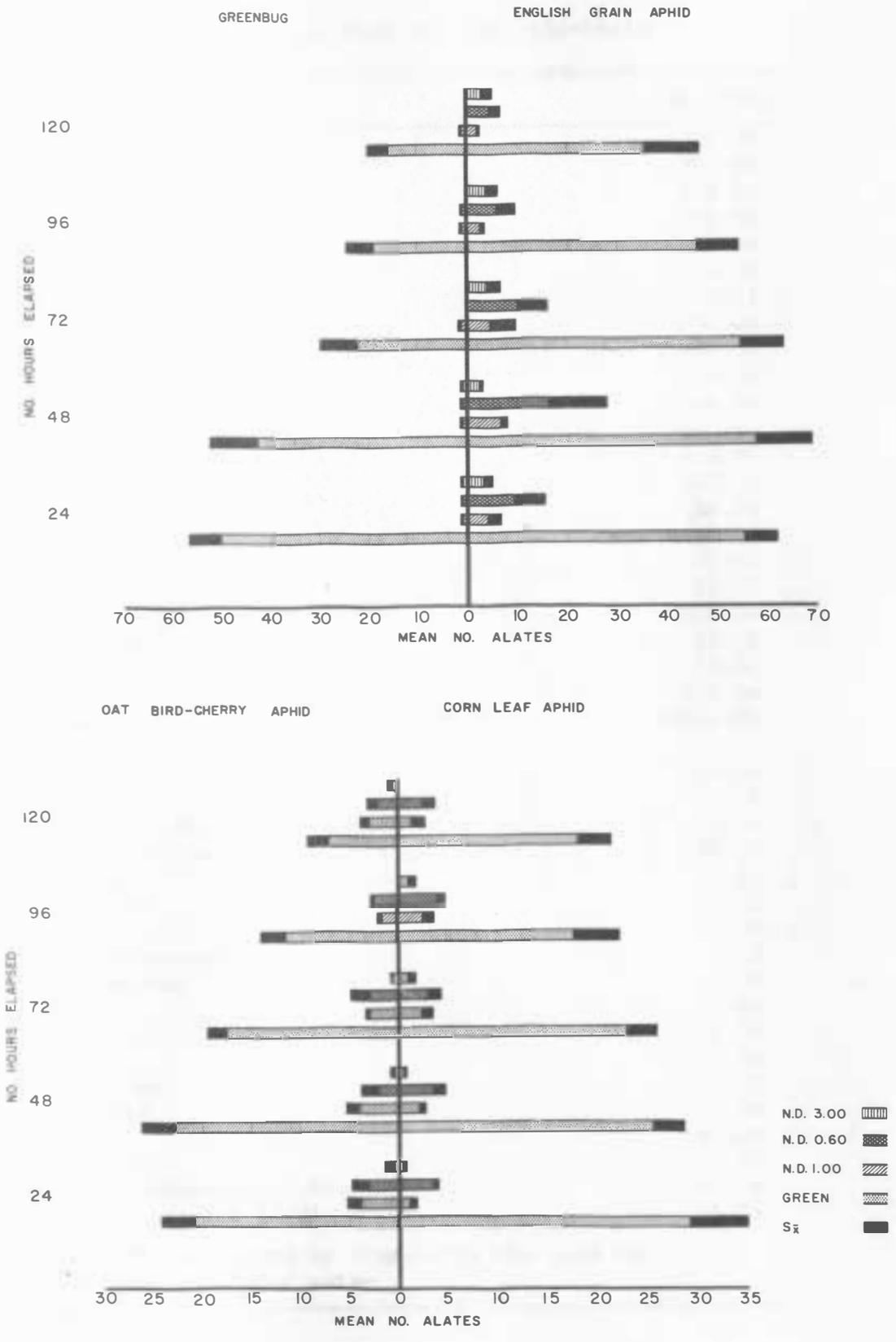

GREENBUG
ENGLISH GRAIN APHID
120
96
72
48
24
NO. HOURS ELAPSED
70 60 50 40 30 20 10 0 10 20 30 40 50 60 70
MEAN NO. ALATES
OAT BIRD-CHERRY APHID
CORN LEAF APHID
120
96
72
48
24
NO. HOURS ELAPSED
30 25 20 15 10 5 0 5 10 15 20 25 30 35
MEAN NO. ALATES
N.D. 3.00
N.D. 0.60
N.D. 1.00
GREEN
$S_{\bar{x}}$

Table 1.--Artificial Diet No. III, Kieckhefer and Derr (1967).

Constituent	mg/100ml
Alanine	50.00
Arginine	200.00
Asparagine	150.00
Aspartic acid	50.00
Cysteine	25.00
Cystine	2.50
Gamma amino butyric acid	0.01
Glutamic acid	100.00
Glutamine	300.00
Glycine	10.00
Histidine	100.00
Isoleucine	100.00
Leucine	100.00
Lysine-HCl	100.00
Methionine	50.00
Phenylalanine	50.00
Proline	50.00
Serine	50.00
Threonine	100.00
Tryptophane	50.00
Tyrosine	10.00
Valine	100.00
Sucrose	20000.00
Cholesterol*	
Ascorbic acid	10.00
Biotin	.20
Calcium pantothenate	2.50
Choline chloride	20.00
Folic acid	.50
Iso-inositol	25.00
Nicotinic acid	5.00
Para-aminobenzoic acid	5.00
Pyridoxine-HCl	1.50
Riboflavin	2.50
Thiamine-HCl	1.50
B_{12}	.20
DL-carnitine	10.00
Lipoic acid	2.00
RNA	50.00
Salt mix #2	2.50
Potassium phosphate (K_3PO_4)	62.00
Magnesium chloride ($MgCl_2$ $6H_2O$)	25.00

*Cholesterol was added by dissolving the diet in cholesterol-saturated water

Table 2.--Color preferences of flight-active alates - English grain aphid.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	47.0±4.2a	9.3±1.0b	1.0±1.2c	1.3±1.3c	**
48	40.0±6.7a	8.3±3.0b	0.8±1.0b	2.5±2.1b	**
72	39.5±4.8a	10.8±3.5b	.5±0.6c	1.5±1.7c	**
96	38.3±2.2a	12.0±2.2b	2.0±1.4c	1.3±1.0c	**
120	34.0±3.7a	13.8±3.9b	3.0±1.4c	2.0±1.4c	**
			Number of nymphs		
24	9.3±2.6a	4.8±3.6ab	.5± .6b	0.5±1.0b	**
48	19.8±8.7a	6.3±5.0b	1.5±1.9b	1.5±1.7b	**
72	36.5±15.1a	7.3±5.0b	2.0±1.8b	1.5±1.3b	**
96	37.3±5.0a	13.0±7.0b	1.5±1.7c	2.0±0.8c	**
120	41.0±3.9a	22.3±4.6b	3.5±2.4c	3.5±1.9c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 3.--Color preferences of flight-active alates - oat bird-cherry aphid.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	6.0±2.2b	11.0±4.2a	3.5±1.9c	5.8±3.4b	*
48	6.3±1.0b	12.3±2.2a	3.3±2.1c	2.5±1.9c	**
72	3.0±0.8b	7.3±1.3a	1.8±1.0c	2.0±1.4c	**
96	3.5±1.3b	7.8±1.7a	1.3±1.3c	0.8±0.5c	**
120	3.0± .8b	6.3±1.5a	0.8±1.0c	.5± .6c	**
			Number of nymphs		
24	1.8± .5a	1.3±0.5b	0c	0c	**
48	2.3±1.7	2.3±2.6	.3±0.5	0	
72	7.3±3.9a	7.3±5.3a	.8± .5b	1.3±1.5b	**
96	4.8±1.5b	14.5±1.3a	.3± .5c	0c	**
120	3.5±1.3b	18.5±5.5a	0b	.8±1.0b	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 4.--Color preferences of flight-active alates - corn leaf aphid.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	16.8±4.6a	5.3±2.1b	2.8±1.0b	0.5±0.6b	**
48	18.8±4.7a	6.5±2.9b	2.3±1.7b	.8±1.5b	**
72	13.8±3.8a	8.3±4.4ab	3.3±2.8b	.8±1.0b	**
96	13.8±3.2a	7.8±3.4b	3.0±1.4b	.3± .5b	**
120	11.3±3.6a	4.8±3.3b	2.8±1.7b	.3± .5b	**
			Number of nymphs		
24	13.0±2.9a	3.3±1.9b	1.0±0.8b	1.5±1.9b	**
48	12.5±2.6a	5.8±2.2b	1.8±1.7b	.5±1.0b	**
72	17.5±4.5a	6.3±1.5b	1.5±1.0b	.3± .5b	**
96	13.8±2.5a	8.0±2.2b	1.8±1.0c	1.0± .8c	**
120	12.3±2.5a	9.3±4.3a	1.5±1.3b	2.5±2.4b	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 5.--Color preferences of flight-active alates - greenbug.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	20.3±2.2a	4.0±1.4b	0.8±1.0c	0c	**
48	22.3±3.1a	2.0±2.2b	0b	0b	**
72	20.0±2.2a	9.5±3.1b	0c	0.3±0.5c	**
96	18.8±1.3a	9.0±1.4b	0c	0c	**
120	16.5±3.7a	8.0±1.4b	0c	0c	**
			Number of nymphs		
24	4.8±3.0a	2.3±1.5b	.3±0.5c	.3± .5c	*
48	33.3±3.6a	3.8±4.1b	0b	.3± .5b	**
72	25.3±6.8a	17.0±4.7b	1.0± .8c	.3± .5c	**
96	29.5±5.4a	15.0±4.1b	0c	0c	**
120	31.8±7.7a	13.3±5.3b	0c	0c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 6.--Color preferences of flight-exhausted alates - English grain aphid.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	39.3±3.4a	19.3±3.8b	3.5±3.5c	3.8±2.9c	**
48	32.5±2.6a	21.8±3.3b	3.8±2.2c	2.0±1.8c	**
72	33.8±4.1a	23.5±7.0b	3.5±2.4c	3.3±2.9c	**
96	31.5±1.3a	19.5±2.6b	0.8±0.5c	1.3±0.5c	**
120	23.5±1.9a	16.0±1.4b	2.8±2.1c	1.3±1.3d	**
			Number of nymphs		
24	8.8±3.9a	6.0±4.9ab	1.3±1.0b	1.0± .8b	**
48	15.0±4.1a	7.8±4.8b	.3± .5c	1.5± .6c	**
72	24.0±7.7a	10.5±4.7b	1.8±1.7c	1.5±1.0c	**
96	40.0±6.7a	14.0±3.9b	.5± .6c	0.0c	**
120	34.0±7.4a	20.5±9.3b	.8± .5c	1.0± .8c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, c, or d in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 7.--Color preferences of flight-exhaused alates - oat bird-cherry aphid.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	10.5±2.9b	15.0±2.4a	1.3±1.3c	1.8±1.7c	**
48	11.5±1.3b	14.5±1.3a	0.8±1.0c	0.8±1.0c	**
72	9.5±2.1b	11.8±1.7a	.5± .6c	.8±1.0c	**
96	5.8±2.4b	9.3±2.1a	1.0± .8c	.3±0.5c	**
120	4.5±0.6b	5.3±1.3a	0c	0c	**
			Number of nymphs		
24	5.8±1.5a	5.5±3.7a	1.0± .8b	1.3± .5b	*
48	12.3±6.4a	13.3±3.8a	.5± .6b	.8±1.0b	**
72	12.8±6.4a	12.5±5.8a	.3± .5b	.3± .5b	**
96	5.8±2.2a	6.8±3.4a	0b	.5±1.0b	**
120	5.5±2.4a	5.8±2.1a	0b	.3± .5b	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 8.--Color preferences of flight-exhausted alates - corn leaf aphid.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	16.0±1.8a	2.5±1.7b	3.3±0.5b	3.0±1.2b	**
48	15.0±2.2a	6.0±0.8b	5.0±1.8c	1.8±1.0d	**
72	16.5±1.3a	5.0±1.6b	1.0± .8d	2.0±0.8c	**
96	16.0±1.8a	5.0±1.4b	2.5± .6c	1.5±1.0d	**
120	7.8±1.3a	2.0± .8b	1.5±1.3b	1.5± .6b	**
			Number of nymphs		
24	2.5±1.3a	0.3± .5b	0.5± .6b	0b	**
48	5.3±1.0a	1.3±1.3b	.5± .6c	0.3± .5c	**
72	8.0±1.8a	5.0±1.4b	1.0±1.2c	0d	**
96	8.3±1.5a	5.0±2.6b	2.3±1.0c	.3± .5d	**
120	12.5±2.6a	5.8±1.3b	1.5±1.3c	.8±1.0c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, c, or d in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value signficant at 5% level; ** at the 1% level.

Table 9.--Color preferences of flight-exhausted alates - greenbug.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	28.0±2.2a	5.5±1.3b	0c	0.8±1.0c	**
48	20.0±1.2a	6.5±2.4b	0c	0c	**
72	16.5±1.3a	9.3±2.6b	0c	0c	**
96	17.5±1.9a	7.8±2.2b	0c	0c	**
120	15.3±1.3a	6.8±1.7b	0c	0c	**
			Number of nymphs		
24	19.5±6.4a	5.5±1.3b	0.3±0.5b	.5±1.0b	**
48	34.5±12.4a	17.5±6.7b	0c	0c	**
72	34.5±5.4a	30.8±13.2a	1.0±1.2b	1.5±1.7b	**
96	54.3±5.2a	33.5±4.4b	.8±1.0c	0c	**
120	56.3±5.0a	34.8±6.0b	1.3±1.9c	0c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 10.--Varying light intensity preferences of alates - English grain aphid.

Time elapsed (hr)	Light intensity of Kodak® Wratten filter[a/] 0.10	0.60	1.0	3.0	Significance[b/]
			Number of alates		
24	31.8±7.5a	4.3±2.6b	3.8±2.2b	1.3±1.5b	**
48	34.3±9.2a	6.3±6.0b	2.0±0.8b	1.8±1.0b	**
72	26.3±6.0a	4.8±2.6b	2.8±1.0b	1.5±1.7b	**
96	18.5±2.4a	3.5±0.6b	3.0±1.8b	1.5±1.3c	**
120	13.3±1.5a	3.8±1.7b	3.3±2.4b	1.8±1.0c	**
			Number of nymphs		
24	4.8±1.3a	2.0±1.4b	0.3± .5c	0.3±0.5c	**
48	11.8±3.4a	3.3±1.5b	.5± .6c	.3± .5c	**
72	8.3±3.5a	3.3±1.5b	.8±1.0b	.8± .5b	**
96	7.0±4.2a	3.8±1.9ab	0b	.3± .5b	**
120	4.8±1.7a	3.8±1.3b	.8±1.0c	0c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 11.--Varying light intensity preferences of alates - oat bird-cherry aphid.

Time elapsed (hr)	Light intensity of Kodak® Wratten filter[a/] 0.10	0.60	1.0	3.0	Significance[b/]
			Number of alates		
24	9.3±2.5a	9.0±1.2a	4.5±1.3b	4.3±1.0b	**
48	9.5±1.3a	6.0±1.4b	4.5±2.6c	3.5±1.0c	**
72	4.8±1.7	3.8±3.0	2.0±0.8	2.5±0.6	
96	6.3±1.3a	1.8±1.3c	4.8±3.0b	1.8±1.0c	**
120	0	0	0	0	
			Number of nymphs		
24	2.5±0.6a	2.3±1.3a	0.3± .5b	0.5± .6b	**
48	2.8±1.0a	2.8±1.0a	1.3±1.3b	1.3± .5b	*
72	4.8±2.9a	3.3±2.2b	.8±1.0c	1.5± .6c	*
96	2.3±1.3a	2.0±0.8a	.3± .5b	.5± .6b	*
120	0	0	0	0	

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 12.--Varying light intensity preferences of alates - corn leaf aphid.

Time elapsed (hr)	Light intensity of Kodak® Wratten filter[a/] 0.10	0.60	1.0	3.0	Significance[b/]
			Number of alates		
24	16.3±1.3a	9.0±2.2b	6.5±1.3c	4.8±1.3d	**
48	17.3±3.1a	7.5±2.4b	8.0±1.2b	6.5±1.9b	**
72	22.8±6.2a	16.3±3.8ab	10.3±2.4b	2.8±1.5b	**
96	14.0±2.4a	2.3±1.7c	3.8±2.2b	2.3±0.5c	**
120	7.3±1.3a	2.3±1.7b	1.8±1.0b	1.3± .5b	**
			Number of nymphs		
24	6.0±3.7a	3.0±1.4ab	0.8±0.5b	0.8±1.0b	*
48	9.3±2.5a	5.0±2.3b	1.0±1.4c	1.0± .8c	**
72	12.8±2.4a	5.8±2.2b	1.5± .6c	1.8±1.0c	**
96	6.8±2.5a	3.3±1.5b	1.0± .8c	1.0± .8c	**
120	2.8±1.5a	1.8±1.3b	.3± .5c	0c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 13.--Varying light intensity preferences of alates - greenbug.

Time elapsed (hr)	Light intensity of Kodak® Wratten filter[a/] 0.10	0.60	1.0	3.0	Significance[b/]
			Number of alates		
24	34.0±9.4a	5.8±4.3b	4.5±2.1b	3.3±1.0b	**
48	35.8±5.4a	5.0±2.8b	2.8±1.7b	2.3±1.3b	**
72	30.3±5.5a	2.0±2.2b	2.5±1.3b	1.3±1.0b	**
96	26.3±5.4a	4.3±2.2b	1.5±1.9b	1.3±1.0b	**
120	20.3±3.4a	3.3±1.5b	0.8±1.0b	0.5±1.0b	**
			Number of nymphs		
24	11.8±2.1a	5.3±2.1b	.5±1.0c	.3±0.5c	**
48	18.0±3.9a	4.5±1.0b	1.3±1.0b	1.0± .8b	**
72	17.5±6.2a	4.3±3.2b	.8±1.5b	.5± .6b	**
96	13.3±3.2a	3.3±1.3b	1.5±1.3c	.5±1.0c	**
120	7.8±3.0a	3.0±1.4b	.8±1.0b	0b	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 14.--Color (yellow) and varying light intensity preferences of alates - English grain aphid.

Time elapsed (hr)	Color or intensity of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	0.10	0	0.30	
			Number of alates		
24	61.3±4.8a	4.5±2.5b	9.5±5.4b	3.0±2.2b	**
48	60.3±2.8a	8.8±2.2b	5.0±1.8b	3.8±1.7b	**
72	47.0±3.9a	9.8±1.7b	13.3±3.3b	5.5±4.4b	**
96	48.0±6.3a	12.5±3.9b	11.5±3.7b	5.8±3.8b	**
120	33.5±7.3a	7.5±7.9b	9.5±4.5b	3.0±1.8b	**
			Number of nymphs		
24	7.5±2.4a	2.5±2.9b	2.0±2.0b	1.3±1.3b	**
48	38.8±5.7a	6.0±3.2b	5.0±1.4b	4.8±3.0b	**
72	41.0±1.6a	14.3±5.0b	16.3±5.7b	11.5±5.0b	**
96	49.8±5.4a	17.8±6.7b	15.8±6.3b	9.3±5.3b	**
120	16.5±4.2a	3.5±1.3b	6.5±2.4b	3.3±2.4b	**

a/ Means ± standard deviations are for 4 replicates. Means with a or b in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 15.--Color (yellow) and varying light intensity preferences of alates - oat bird-cherry aphid.

Time elapsed (hr)	Color or intensity of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	0.10	None	0.30	
			Number of alates		
24	17.0±4.4a	5.0±1.4b	5.8±1.7b	1.0±1.2b	**
48	16.8±2.4a	2.8±1.7b	3.3±1.0b	0.8±0.5c	**
72	16.0±3.2a	3.3±1.0b	1.8±1.3c	.8± .5c	**
96	8.3±1.3a	3.3±2.5b	2.8±1.0b	.5± .6c	**
120	7.0±1.6a	1.3±1.0b	1.8±1.0b	.3± .5c	**
			Number of nymphs		
24	4.5±0.6a	1.5±1.0b	1.3±1.3b	.8±1.0b	**
48	6.0±1.4a	1.8±1.7b	1.5±1.3b	0c	**
72	9.3±1.7a	3.0±0.8b	2.8±1.0b	.5±1.0c	**
96	13.5±3.1a	2.3±1.7b	2.5±1.3b	.5±1.0c	**
120	10.0±3.6a	2.0± .8b	0.8±1.0b	.5± .6b	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 16.--Color (yellow) and varying light intensity preferences of alates - corn leaf aphid.

Time elapsed (hr)	Color or intensity of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	0.10	None	0.30	
			Number of alates		
24	27.8±5.4a	1.5±1.3b	3.0±1.8b	0b	**
48	26.8±5.1a	2.0±1.4b	3.5±0.6b	0.8±1.0b	**
72	25.8±3.0a	2.0±1.6b	3.0± .8b	.8±1.0b	**
96	14.8±3.3a	1.8±1.3b	2.8±1.0b	1.0±0.8b	**
120	12.5±2.6a	2.0±1.4c	3.3±1.7b	1.0±1.2c	**
			Number of nymphs		
24	12.8±2.2a	0.3±0.5c	2.5±1.3b	.3± .5c	**
48	13.3±4.3a	1.8±1.7b	2.8± .5b	.3± .5b	**
72	14.8±4.2a	2.8±1.0b	3.8±1.0b	.8±1.0b	**
96	20.5±4.9a	1.8±2.4b	3.0± .8b	0b	**
120	13.8±4.3a	2.3±1.0b	3.8±1.3b	1.0± .8b	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 17.--Color (yellow) and varying light intensity preferences of alates - greenbug.

Time elapsed (hr)	Color or intensity of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	0.10	None	0.30	
			Number of alates		
24	50.5±9.9a	3.3±3.0b	3.3±1.7b	0.3±0.5b	**
48	43.3±9.8a	2.8±1.7b	6.0±2.4b	.5± .6b	**
72	29.0±1.6a	3.3±3.0c	7.8±2.2b	.5±1.0d	**
96	21.3±4.2a	0.3±0.5b	4.8±2.2b	.5±1.0b	**
120	13.3±2.6a	1.5±1.3c	3.5±1.3b	0d	**
			Number of nymphs		
24	14.3±3.3a	2.5±1.3b	4.3±3.3b	.5± .6b	**
48	23.8±5.1a	2.8±1.7b	5.3±1.7b	1.0± .8b	**
72	33.5±6.9a	.8±1.0b	4.8±2.1b	.8±1.0b	**
96	34.5±4.7a	3.3±1.0b	8.5±3.1b	1.0± .8b	**
120	43.0±8.6a	2.5±1.3b	5.8±2.2b	.5± .6b	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, c, or d in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 18.--Color (green) and varying light intensity preferences of alates - English grain aphid.

Time elapsed (hr)	Color or intensity of Kodak® Wratten filter[a/]				Significance[b/]
	Green	1.00	0.60	3.00	
			Number of alates		
24	55.0±6.8a	4.0±2.9b	9.0±6.5b	3.0±2.2b	**
48	57.5±11.6a	6.5±1.7b	16.0±11.9b	2.3±1.0b	**
72	54.3±9.1a	4.5±5.4b	10.0±6.0b	4.0±2.9b	**
96	46.0±8.3a	2.5±1.3b	5.8±4.1b	3.8±2.6b	**
120	35.3±11.4a	2.0±0.8b	4.5±2.5b	3.0±2.6b	**
			Number of nymphs		
24	10.5±4.2a	0.8± .5b	1.0±0.8b	0.8±1.0b	**
48	30.0±17.0a	4.0±3.6b	11.3±8.3b	1.0±0.8b	**
72	30.5±7.6a	6.5±3.4b	7.5±5.4b	4.5±5.2b	**
96	24.5±17.5a	3.8±2.8b	7.5±6.6ab	1.8±1.7b	*
120	16.0±12.4a	.8±1.0b	5.5±3.7ab	.3± .5b	*

a/ Means ± standard deviations are for 4 replicates. Means with a or b in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 19.--Color (green) and varying light intensity preferences of alates - oat bird-cherry aphid.

Time elapsed (hr)	Color or intensity of Kodak® Wratten filter[a/]				Significance[b/]
	Green	1.00	0.60	3.00	
			Number of alates		
24	20.8±3.5a	3.8±1.5b	3.0±1.8b	0.5±1.0c	**
48	22.8±3.5a	4.0±1.4b	2.0±1.8b	.3±0.5b	**
72	17.5±2.1a	2.8±0.5b	2.8±2.1b	.3± .5c	**
96	11.5±2.6a	1.5± .6b	2.3±0.5b	0c	**
120	7.0±2.3a	2.8±1.0b	2.0±1.2b	.5± .6c	**
			Number of nymphs		
24	3.8±1.3a	0.8±1.0b	0.5± .6b	.3± .5b	**
48	5.8±3.0a	2.0±1.2b	1.8±1.3b	0c	**
72	9.3±1.0a	2.5±1.3b	1.3±1.3c	.5±1.0c	**
96	8.3±1.5a	2.0±1.4b	1.5±1.0b	.5± .6c	**
120	12.5±2.4a	1.3± .5b	1.3±1.5b	.3± .5c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 20.--Color (green) and varying light intensity preferences of alates - corn leaf aphid.

Time elapsed (hr)	Color or intensity of Kodak® Wratten filter[a/]				Significance[b/]
	Green	1.00	0.60	3.00	
			Number of alates		
24	29.0±5.9a	1.0±0.8b	3.5±0.6b	0.3±0.5b	**
48	25.3±3.3a	2.0± .8c	3.5±1.3b	.3± .5d	**
72	22.8±3.1a	2.3±1.3b	3.0±1.4b	.8±1.0c	**
96	17.5±4.7a	2.5±1.3b	4.0± .8b	.8±1.0b	**
120	18.0±3.4a	1.3±1.5b	2.5±1.3b	0b	**
			Number of nymphs		
24	9.0±2.4a	0.3± .5b	1.0± .8b	0b	**
48	17.8±2.5a	.8±1.0c	2.0± .8b	.3± .5c	**
72	21.8±2.2a	1.8±1.7c	3.3±1.3b	0d	**
96	20.8±4.8a	3.3±2.2b	3.3±1.0b	.3± .5b	**
120	19.3±4.3a	2.5±2.1b	3.0±1.8b	.3± .5b	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, c, or d in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 21.--Color (green) and varying light intensity preferences of alates - greenbug.

Time elapsed (hr)	Color or intensity of Kodak® Wratten filter[a/]			Significance[b/]
	Green	1.00	0.60	3.00	
		Number of alates			
24	50.0±6.8a	0.3±0.5b	0.5±0.6b	0.3±0.5b	**
48	42.5±9.9a	.3± .5b	.3± .5b	.3± .5b	**
72	22.0±7.9a	1.0± .8b	0b	0b	**
96	18.8±5.9a	.5± .6b	.3± .5b	0b	**
120	16.0±4.2a	.3± .5b	0b	0b	**
		Number of nymphs			
24	16.8±4.9a	.5± .6b	.8± .5b	.3± .5b	**
48	26.8±15.8a	.8±1.0b	.5± .6b	.8± .5b	**
72	34.0±15.7a	1.0±1.4b	.8±1.0b	.8± .5b	**
96	31.0±15.2a	.5±1.0b	1.0±1.2b	1.5±1.9b	**
120	32.5±19.7a	0b	0b	.3± .5b	**

a/ Means ± standard deviations are for 4 replicates. Means with a or b in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 22.--Color (red) and varying light intensity preferences of alates - English grain aphid.

Time elapsed (hr)	Color or intensity of Kodak® Wratten filter[a/]				Significance[b/]
	Red	1.0	0.60	3.00	
			Number of alates		
24	17.8±5.1ab	10.0±1.4b	21.8±3.8a	5.3±1.3b	**
48	14.5±2.4a	6.5±2.4b	16.5±10.4a	2.0±1.8b	*
72	9.8±2.2	6.5±4.4	11.3±4.3	5.3±3.0	
96	5.0±5.0ab	1.3±0.5b	6.8±3.5a	1.0±0.8b	*
120	1.8±0.5	1.0± .8	3.0±2.9	0.3± .5	
			Number of nymphs		
24	2.5±2.4	0.8± .5	2.5±0.6	1.3±1.3	
48	4.0±3.2	1.3±1.0	4.3±3.3	0	
72	1.5±1.3b	1.0± .8c	2.5±1.7a	0d	*
96	1.0± .8b	.3± .5c	2.0±1.4a	0c	*
120	0	0	0	0	

a/ Means ± standard deviations are for 4 replicates. Means with a, b, c, or d in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 23.--Color (red) and varying light intensity preferences of alates - oat bird-cherry aphid.

Time elapsed (hr)	Color or intensity of Kodak® Wratten filter[a/]				Significance[b/]
	Red	1.00	0.60	3.00	
			Number of alates		
24	6.8±2.4ab	5.3±2.1b	11.3±2.5a	1.0±1.4b	**
48	5.8±2.5ab	3.5±2.6b	10.8±3.0a	0.8±1.0b	**
72	3.5±1.3b	3.5±0.6b	9.8±2.5a	1.0±0.8c	**
96	1.5±1.3c	3.0± .8b	6.0±2.9a	.5± .6c	**
120	1.5±0.6c	2.3±1.0b	3.8±1.7a	.3± .5d	*
			Number of nymphs		
24	1.0±1.2	0.5± .6	2.3±2.1	0	
48	2.3±1.3b	2.0± .8b	3.0±1.8a	0c	*
72	2.8±1.3b	2.0± .8b	4.8±2.2a	.8±1.0c	**
96	1.5±1.3	1.5±1.0	3.0±0.8	1.0±1.4	
120	0.8±1.0	.3± .5	1.8±1.0	.5± .6	

a/ Means ± standard deviations are for 4 replicates. Means with a, b, c, or d in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 24.--Color (red) and varying light intensity preferences of alates - corn leaf aphid.

Time elapsed (hr)	Color or intensity of Kodak® Wratten filter[a/]				Significance[b/]
	Red	1.00	0.60	3.00	
			Number of alates		
24	7.5±2.6bc	5.3±2.1c	12.8±2.2a	2.0±1.4c	**
48	10.3±2.9a	4.3±1.7b	12.8±2.6a	1.0±0.8b	**
72	7.8±3.4ab	4.5±1.0b	9.8±1.3a	0.8±1.0b	**
96	8.0±1.8a	2.3±1.7b	11.5±2.6a	.5±1.0b	**
120	8.0±2.2a	2.0±0.8c	5.0±0.8b	.5± .6d	**
			Number of nymphs		
24	3.8±1.3a	0.5± .6c	2.5±1.7b	.3± .5c	**
48	3.5±1.3b	1.0±1.2c	4.8±1.5a	.3± .5c	**
72	5.3±1.7b	2.0±1.6c	7.0±1.4a	.5± .6d	**
96	8.3±2.5ab	3.0±2.2b	9.8±4.2a	1.0± .8b	**
120	9.0±1.8a	3.0±1.8b	11.0±2.6a	0b	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, c, or d in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 26.--Color (blue) and varying light intensity preferences of alates - English grain aphid.

Time elapsed (hr)	Color or intensity of Kodak® Wratten filter[a/]				Significance[b/]
	Blue	3.00	1.00	4.00	
			Number of alates		
24	9.8±4.1a	5.3±2.1ab	9.8±3.1a	2.8±1.0b	**
48	8.0±3.3a	3.8±1.5ab	10.8±2.9a	0.5±0.6b	**
72	6.5±2.5a	2.8±1.3ab	9.3±4.0a	1.0± .8b	**
96	3.8±1.5a	1.8±0.5b	4.3±1.9a	.5± .6c	*
120	0	0	0	0	
			Number of nymphs		
24	1.0±0.8b	0.8± .5c	2.0±0.8a	0d	**
48	4.8±2.1b	1.3± .5c	6.8±2.9a	.8± .5c	**
72	3.0±1.4	1.5±1.3	3.8±2.5	.5± .6	
96	1.5±1.3	.5±1.0	2.5± .6	.5± .6	
120	0	0	0	0	

a/ Means ± standard deviations are for 4 replicates. Means with a, b, c, or d in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 27.--Color (blue) and varying light intensity preferences of alates - oat bird-cherry aphid.

Time elapsed (hr)	Color or intensity of Kodak® Wratten filter[a/]				Significance[b/]
	Blue	3.00	1.00	4.00	
			Number of alates		
24	2.0±1.6c	7.0±2.9b	13.3±2.8a	1.3±1.5c	**
48	2.3±1.5c	5.8±1.5c	11.8±2.1a	0.5±0.6d	**
72	2.8±1.0b	2.0±1.4b	10.5±2.6a	.3± .5c	**
96	1.8±1.5b	2.0±1.4b	4.3±1.9a	.5± .6c	*
120	0	0	0	0	
			Number of nymphs		
24	0b	0.3±0.5b	3.0±1.4a	0b	**
48	1.0±1.2b	.3± .5c	3.0±1.6a	.3± .5c	**
72	1.8±0.5b	1.5±1.9b	4.0±2.2a	0c	*
96	1.0±1.2	1.0± .8	2.3±1.5	0	
120	0	0	0	0	

a/ Means ± standard deviations are for 4 replicates. Means with a, b, c, or d in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 28.--Color (blue) and varying light intensity preferences of alates - corn leaf aphid.

Time elapsed (hr)	Color or intensity of Kodak® Wratten filter[a/]				Significance[b/]
	Blue	3.00	1.00	4.00	
			Number of alates		
24	5.8±1.5b	6.3±2.8b	16.5±2.6a	0.3±0.5c	**
48	3.0±0.8c	5.0±0.8b	16.0±3.4a	.5± .6d	**
72	1.8± .5c	5.0±1.4b	9.5±2.1a	.5±1.0d	**
96	0.5± .6c	3.0±1.4b	6.3±1.5a	.5± .6c	**
120	0	0	0	0	
			Number of nymphs		
24	0	1.3±1.0b	3.5±0.6a	0c	**
48	.5± .6c	2.0± .8b	4.8±1.5a	0c	**
72	1.0±1.2c	3.0±1.2b	8.3±2.8a	0c	**
96	.5± .6c	2.0± .8b	5.8±1.5a	0c	**
120	0	0.8±1.0b	4.0±1.2a	.3± .5c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, c, or d in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 29.--Color (blue) and varying light intensity preferences of alates - greenbug.

Time elapsed (hr)	Color or intensity of Kodak® Wratten filter[a/]				Significance[b/]
	Blue	3.00	1.00	4.00	
			Number of alates		
24	7.0±2.2b	7.0±2.4b	14.8±3.6a	0.5±0.6c	**
48	5.8±1.5b	4.5±1.3c	11.8±2.8a	1.3±1.0d	**
72	3.0±0.8c	3.8±1.7bc	10.3±2.6a	1.0± .8d	**
96	2.5±1.3c	3.3±1.7bc	7.8±2.2a	0d	**
120	2.5±1.3b	1.8±1.0c	5.0±1.4a	.5± .6d	**
			Number of nymphs		
24	2.3±1.3b	1.3±1.0c	6.3±1.3a	0d	**
48	2.8±1.7c	3.0±1.4bc	6.3±1.0a	1.0±1.2d	**
72	4.0±1.4bc	2.8±1.0c	10.3±3.2a	.3± .5d	**
96	2.3±1.3c	3.8±1.0b	7.8±3.1a	.5±1.0d	**
120	0.8±1.0c	1.3±1.0b	5.0±1.4a	.3± .5c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, c, or d in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 30.--Conditioning with color (yellow) and color preferences of alates - English grain aphid.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	42.0±2.9a	2.3±1.9b	3.5±1.0b	2.5±2.1b	**
48	41.0±5.7a	4.0±1.4b	2.0±1.4b	2.3±2.2b	**
72	36.8±4.3a	6.8±2.8b	3.3±2.2b	0.8±0.5b	**
96	41.0±7.9a	7.0±2.2b	2.5±1.7b	.8±1.0b	**
120	32.5±4.0a	10.5±5.3b	2.8±1.0c	1.8±1.3c	**
			Number of nymphs		
24	10.5±1.3a	4.0±1.2b	0.8±1.0c	.3± .5c	**
48	12.3±2.6a	6.3±2.9b	.5±0.6c	.8±1.0c	**
72	15.8±8.4a	5.3±2.2b	.8±1.0b	0.0b	**
96	38.0±15.0a	7.5±5.1b	.8±1.0b	.5±1.0b	**
120	43.5±7.6a	12.0±10.0b	2.5±1.7c	2.5±2.4c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 31.--Conditioning with color (yellow) and color preferences of alates - oat bird-cherry aphid.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	12.5±1.3a	11.3±2.2a	1.0±1.4b	1.3±1.0b	**
48	12.5±2.1a	9.0±1.4b	2.0±0.8c	1.5±1.3c	**
72	12.0±2.2a	11.3±2.2a	2.0±1.4b	1.0±0.8b	**
96	10.8±1.0a	8.5±1.9b	2.0±1.4c	2.0±1.6c	**
120	10.0±2.2a	8.5±1.3a	1.5±1.3b	1.3±1.0b	**
			Number of nymphs		
24	1.0±0.8	0.5±0.6	0.3± .5	0	
48	4.3±2.6b	5.5±1.3a	.3± .5c	0.3± .5c	**
72	10.8±3.0a	8.5±2.1a	1.5±1.3b	.5±1.0b	**
96	8.5±2.6a	8.8±1.7a	2.3±1.9b	1.8±1.5b	**
120	15.8±2.6a	12.5±2.6a	.3± .5b	.5±1.0b	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 32.--Conditioning with color (yellow) and color preferences of alates - corn leaf aphid.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	20.5±5.4a	10.8±1.9b	2.0±0.8c	1.3±1.0c	**
48	17.8±5.4a	8.8±2.6b	1.3±1.5c	2.0±0.8c	**
72	15.5±4.2a	8.5±3.7b	2.0±1.4c	1.0±1.2c	**
96	11.0±3.7a	6.5±1.7b	1.5±1.3c	1.8±0.5c	**
120	12.0±2.9a	5.0±0.8b	1.5± .6c	1.3±1.5	**
			Number of nymphs		
24	4.5±2.1a	3.0±1.4b	0.8±1.0c	0.8±1.0c	*
48	6.0±1.8a	3.5±1.7b	1.3±1.3c	1.0± .8c	**
72	12.3±2.9a	5.3±1.7bc	1.5± .6c	1.5±1.0c	**
96	13.5±3.1a	6.5±2.6bc	2.5±1.3c	1.8±1.0c	**
120	15.8±3.3a	7.3±3.1b	2.3±1.3c	2.0±0c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 33.--Conditioning with color (yellow) and color preferences of alates - greenbug.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	18.3±2.5a	7.8±2.5b	0.5±0.6c	0.5±0.6c	**
48	17.8±5.1a	3.8±1.3bc	.5±1.0c	.8±1.0c	**
72	18.3±3.0a	5.3±2.1b	.3± .5c	.3± .5c	**
96	17.3±3.3a	3.8±1.3bc	.8±1.5c	.5± .6c	**
120	17.0±3.4a	4.8±1.5b	0c	0c	**
			Number of nymphs		
24	9.0±1.6a	3.5±2.1b	.3± .5c	0c	**
48	21.0±2.6a	7.5±1.9b	1.5± .6c	.8± .5c	**
72	33.8±4.6a	10.8±3.5b	1.0± .8c	.5± .6c	**
96	36.0±4.3a	15.3±5.9b	.5± .6c	1.3±1.0c	**
120	39.0±7.6a	27.8±5.1b	1.3±1.0c	1.3±1.9c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 34.--Conditioning with color (green) and color preferences of alates - English grain aphid.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	39.5±6.2a	5.5±2.6b	1.3±0.5c	1.3±1.0c	**
48	38.3±3.4a	5.5±3.9b	1.8±2.1b	1.5±0.6b	**
72	31.8±4.0a	8.3±3.3b	1.5± .6c	2.3±1.7c	**
96	32.3±6.2a	8.8±3.9b	1.8±1.0b	2.5±2.1b	**
120	28.5±5.6a	8.0±2.2b	1.8±1.0b	2.3±2.1b	**
			Number of nymphs		
24	11.3±2.2a	5.5±1.3b	0.5± .6c	0.3± .5c	**
48	12.0±1.6a	5.8±1.5b	1.8± .5c	.8± .5d	**
72	22.0±6.7a	5.5±2.6b	.8±1.0b	1.0± .8b	**
96	25.3±6.0a	7.8±5.0b	1.0± .0b	.8±1.0b	**
120	31.8±4.5a	9.8±2.2b	2.5±1.3c	1.5±1.9c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, c, or d in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 35.--Conditioning with color (green) and color preferences of alates - oat bird-cherry aphid.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	12.5±3.5a	11.8±1.7a	1.5±1.3b	0.8±1.0b	**
48	11.0±1.8a	9.0±1.8a	2.3±1.5b	.8±1.0b	**
72	9.3±2.2a	9.8±1.7a	1.8±1.0b	1.5±1.3b	**
96	9.0±1.4a	8.5±2.4a	1.8±1.7b	1.3±1.0b	**
120	7.5±2.4a	7.8±1.0a	0.5±0.6b	0b	**
			Number of nymphs		
24	0.5±0.6	0.8±0.5	0	0	
48	2.3±1.3a	2.5±1.3a	.5± .6b	0b	**
72	6.0±1.4b	7.8±3.0a	1.0± .8c	1.8±1.0c	**
96	6.3±2.1a	6.3±1.5a	.3± .5b	1.0±0.8b	**
120	11.3±5.7a	9.5±3.4a	0b	.3± .5b	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 36.--Conditioning with color (green) and color preferences of alates - corn leaf aphid.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	18.3±4.3a	8.5±1.7b	2.3±1.5c	1.5±1.3c	**
48	21.3±5.6a	8.5±2.4b	1.8±1.3c	1.3±1.0c	**
72	16.5±3.4a	6.3±1.9b	1.5±0.6c	1.0±1.2c	**
96	14.5±5.7a	5.0±2.4bc	1.3±1.3c	1.5±1.3c	**
120	10.8±2.4a	3.3±1.5b	1.0±1.2c	1.0±0.8c	**
			Number of nymphs		
24	3.8±0.5a	2.8±1.5b	0.3± .5c	0.3± .5c	**
48	9.8±3.6a	4.0±2.2bc	.8±1.0c	1.3± .5c	**
72	15.3±4.1a	7.3±1.7b	.3± .5c	.5±1.0c	**
96	13.3±4.0a	5.8±3.0bc	1.5± .6c	1.3±1.0c	**
120	14.0±2.8a	6.0±2.2b	1.8±1.5c	1.3±1.0c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 37.--Conditioning with color (green) and color preferences of alates - greenbug.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	23.0±5.2a	7.3±2.5b	0.3±0.5c	0.3±0.5c	**
48	13.5±3.7a	7.0±2.9b	1.0± .8c	.8±1.0c	**
72	12.8±5.6a	9.0±3.9a	.5± .6b	.8±1.0b	**
96	12.8±3.6a	8.3±1.7a	1.0± .8b	.8±1.0b	**
120	11.3±4.4a	9.0±2.2a	.3± .5b	0b	**
			Number of nymphs		
24	4.8±1.7a	2.3±1.5b	.8± .5c	0c	**
48	20.8±6.5a	7.8±3.1bc	1.0± .8c	.8± .5c	**
72	26.8±3.6a	15.8±3.0b	.8±1.0c	.8± .5c	**
96	32.8±4.0a	12.0±4.5b	1.5±1.3c	1.0±0c	**
120	38.8±3.1a	14.8±3.3b	0c	0c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 38.--Conditioning with color (red) and color preferences of alates - English grain aphid.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	43.8±10.0a	11.8±6.3b	3.0±3.6b	2.5±2.4b	**
48	45.3±7.7a	12.3±4.5b	1.0±2.0c	1.5±0.6c	**
72	36.8±10.9a	17.3±7.7b	4.3±2.6b	2.8±1.0b	**
96	26.8±0.4a	15.3±5.7b	4.3±3.8c	2.8±1.5c	**
120	23.0±5.9a	13.5±5.1ab	4.3±2.8b	0.8±1.0b	**
			Number of nymphs		
24	17.5±5.2a	6.0±2.9b	2.0±1.6b	1.5±1.3b	**
48	39.5±2.6a	16.0±4.5b	1.5±1.9c	.8± .5c	**
72	35.5±10.0a	11.5±6.5b	2.3±3.3b	.5± .5b	**
96	41.5±10.0a	16.0±8.8b	4.3±3.9b	.3± .5b	**
120	49.8±5.3a	16.3±5.5b	5.8±4.8c	.5±1.0c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 39.--Conditioning with color (red) and color preferences of alates - oat bird-cherry aphid.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	9.8±1.3a	9.3±1.7a	1.8±1.0b	2.0±1.4b	**
48	7.5±1.7b	11.5±2.6a	1.0±0.8c	1.0±0.8c	**
72	6.8±3.3a	8.3±3.0a	0b	0.5±1.0b	**
96	5.3±1.3a	4.5±1.7a	0.8±1.0b	.3± .5b	**
120	1.3±1.9	1.3±1.5	.5± .6	0	
			Number of nymphs		
24	0.3±0.5	1.8±1.7	.3± .5	.3± .5	
48	2.3±2.1a	2.8±1.3a	.5± .6b	.3± .5b	*
72	2.3±2.6a	2.5±1.7a	.5± .6b	0b	*
96	1.5±1.9	1.8±1.7	.3± .5	0	
120	1.5±1.3	0.8±1.5	.3± .5	0	

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 40.--Conditioning with color (red) and color preferences of alates - corn leaf aphid.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	16.0±4.1a	8.5±3.9b	2.0±1.4c	2.0±0.8c	**
48	15.3±3.4a	7.3±1.9b	1.8±1.0c	1.5± .6c	**
72	15.5±2.5a	7.8±2.8b	1.3±1.0c	0.8± .5c	**
96	10.5±2.4a	6.5±2.6b	0.5±0.6c	1.0± .8c	**
120	10.8±4.3a	4.3±1.9bc	1.3±1.0c	.8± .5c	**
			Number of nymphs		
24	2.5±0.6a	1.0±0.8b	.5± .6c	.3± .5d	**
48	6.5±2.5a	4.0±1.4b	.3± .5c	0c	**
72	14.3±4.8a	6.0±2.9bc	1.5± .6c	1.3±1.0c	**
96	15.3±3.9a	7.3±3.3bc	2.3±1.3c	1.5±1.0c	**
120	18.5±4.0a	8.0±3.2bc	2.3±1.0c	2.0±1.4c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, c, or d in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 41.--Conditioning with color (red) and color preferences of alates - greenbug.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	26.0±2.8a	5.0±1.8b	0.5±1.0c	0.3±0.5c	**
48	20.0±2.9a	5.0±1.8b	.5±0.6c	0c	**
72	18.5±3.8a	6.3±2.5b	0c	.3± .5c	**
96	16.0±3.3a	7.0±1.8b	0c	0c	**
120	15.3±2.5a	4.8±1.7b	0c	0c	**
			Number of nymphs		
24	18.8±1.9a	4.5±1.7b	.5± .6c	.3± .5c	**
48	30.3±4.6a	14.8±3.3b	.5±1.0c	.5±1.0c	**
72	39.3±3.3a	24.5±3.4b	0c	.3± .5c	**
96	58.8±5.9a	25.8±2.6b	.5± .6c	.5± .6c	**
120	59.5±2.6a	27.0±4.7b	1.0±1.4c	.5±1.0c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 42.--Conditioning with color (blue) and color preferences of alates - English grain aphid.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	40.0±2.6a	13.0±2.9b	0.8±1.0c	3.0±2.2c	**
48	33.8±6.1a	12.0±4.8b	5.0±3.6c	4.3±3.5c	**
72	39.0±2.2a	17.5±5.4b	3.3±2.9c	1.5±1.9c	**
96	33.8±2.5a	16.8±1.7b	2.8±1.5c	1.8±1.7d	**
120	32.5±3.9a	14.5±5.8b	3.0±2.2c	3.3±2.1c	**
			Number of nymphs		
24	5.5±2.6a	7.3±4.3a	.8±1.5b	1.3±1.3b	**
48	13.5±3.4a	6.3±3.3b	2.5±3.1b	2.3±2.6b	**
72	24.3±3.9a	11.5±3.7b	1.5±1.7c	0.8±1.0c	**
96	30.8±6.0a	11.5±2.1b	2.5±1.3c	1.5±1.0c	**
120	32.8±6.7a	12.5±3.3b	1.0±1.4c	2.0±2.4c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, c, or d in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 43.--Conditioning with color (blue) and color preferences of alates - oat bird-cherry aphid.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	12.8±2.6a	10.5±2.6a	0.8±1.0b	1.3±1.0b	**
48	9.0±3.2a	10.0±1.4a	1.3±1.0b	1.8±1.0b	**
72	5.5±2.1ab	7.5±3.7a	1.3±1.0b	0.5±0.6b	**
96	3.5±1.3a	3.3±2.8a	.5±0.6b	.5± .6b	*
120	0	0	0	0	
			Number of nymphs		
24	2.3±2.6	2.3±1.3	0	.3± .5	
48	3.0±1.4a	3.3±1.9a	.5± .6b	.3± .5b	*
72	2.5±1.0b	4.0±2.4a	.3± .5c	.8± .1c	*
96	1.8±1.7	0.8±1.0	0	.3± .5	
120	0	0	0	0	

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 44.--Conditioning with color (blue) and color preferences of alates - corn leaf aphid.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	15.3±2.5a	7.8±3.4b	1.5±0.6c	1.8±1.0c	**
48	14.3±3.0a	7.3±3.4b	1.8± .5c	1.0±1.2c	**
72	13.0±2.9a	5.5±2.4bc	1.8±1.0c	1.3±1.5c	**
96	9.5±2.6a	4.8±1.7b	1.0± .8c	0.8±1.0c	**
120	6.3±2.1a	5.3±1.3b	0c	.5±0.6c	**
			Number of nymphs		
24	3.3±2.1a	1.8±0.5b	1.5± .6c	1.8±1.0c	*
48	5.3±1.3a	3.3±1.5b	1.8± .5c	1.0±1.2c	**
72	9.8±2.2a	3.8±1.5b	1.8±1.0c	1.3±1.5c	**
96	12.8±3.9a	5.3±2.6bc	1.0± .8c	.8±1.0c	**
120	7.3±1.7a	2.8± .5b	0c	.5± .6c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.

Table 45.--Conditioning with color (blue) and color preferences of alates - greenbug.

Time elapsed (hr)	Color of Kodak® Wratten filter[a/]				Significance[b/]
	Yellow	Green	Red	Blue	
			Number of alates		
24	19.0±4.8a	7.5±2.4b	1.0±1.4c	1.0±0.8c	**
48	17.8±2.2a	7.0±3.4b	1.0±0.8c	0.3± .5c	**
72	18.3±4.3a	6.3±2.9b	0.3± .5c	.5± .6c	**
96	17.3±6.4a	8.0±3.4b	.5±1.0c	.3± .5c	**
120	15.0±2.9a	7.3±1.3b	1.0± .8c	1.3± .5c	**
			Number of nymphs		
24	7.8±2.9a	2.3±1.3b	0c	.3± .5c	**
48	16.0±3.4a	6.8±2.9b	.3± .5c	.3± .5c	**
72	23.8±3.0a	15.5±2.6b	.5± .6c	1.3±1.0c	**
96	37.8±5.1a	18.8±3.0b	.8±1.0c	.5± .6c	**
120	43.0±6.5a	17.0±4.4b	0c	.5± .6c	**

a/ Means ± standard deviations are for 4 replicates. Means with a, b, or c in common are not significantly different (5%) when compared by Duncan's new multiple range test.

b/ * F value significant at 5% level; ** at the 1% level.