of 20% of the collected puparia had emerged as adults by mid-June in 1970, and an average of 42.5% had emerged by mid-October in 1971. On the control ranches, the figures were 35.4% and 37.2%, respectively. Also, on the supervised ranches, 22.5% of the adults emerged by mid-June were parasites, while 57.5% of the adults emerged by mid-October were parasites. On the control ranches, the figures were 12.9% and 62.8%, respectively.

A higher percent parasitization of all fly species on supervised ranches was also observed (95% significance). The *Muscidifurax* species appeared to be most responsible for parasitization up to this date, with no evidence of *Tachinaephagus zealandicus*, which is now known to be active only during winter (see table). In comparison, samples from supervised and control ranches in mid-October show that there was no apparent effect of the parasite releases, since the relative abundance of parasitic species did not change significantly. Final checks of parasitization on the respective ranches in the winter and spring of 1972 were unfortunately precluded by the imposition of a temporary quarantine against manure removal during an outbreak of Newcastle disease.

### Predator and scavenger activity

Judging by their abundance and cohabitation with prey, predatory species that were most responsible for the destruction of immature flies during the study were the histerids, *Carcinops pumilio* Erichson and *Gnathoncus nanus* Scriba; the staphylinid, *Philonthus sordidus* Gravenhorst; the dermapteran, *Euborellia annulipes* (Lucas); the anthocorid, *Lyctocoris campestris* (F); and to a lesser extent the uropodid mites, *Fuscuropoda* spp. The latter species also appeared significant in the drying of fresh manure, although the mechanism by which this is accomplished is not yet fully understood. The macrochelid mites, generally regarded as significant in predation of filth flies, were poorly dispersed and did not attain densities great enough to be considered of major importance in predation when compared to the other predatory species present.

Scavengers were widely distributed, but, compared to predators, occurred at much lower densities. The most abundant species included the dermestid, *Dermestes maculatus* DeGeer; the scarab, *Aphodius lividius* (Olivier); and the tenebrionids, *Alphitobius diaperinus* (Panzer) and *Blapstinus* spp. The presence of these scavengers may have aided in the decomposition of manure, but otherwise their role in fly reduction is not established. Other predatory and scavenger species were encountered, but their densities were extremely low and probably were of no significance.

Periodic random samples revealed a significantly higher (at least double) activity of the above predators on supervised ranches throughout the entire study interval, which in turn is thought to have been partly responsible for the lower fly densities observed on these ranches. The interaction of the predatory complex with parasitic species has been shown in other studies to cause an overall decrease in fly density.

### Conclusions

The stability of the manure habitat is probably one of the most important goals in integrated fly control, whether the manure is located on ranch premises or translocated to remote deposition sites. Relatively stable habitats acquire a diverse biota of beneficial predatory and scavenger species whose impact on flies seems to be proportional to their abundance and distribution. The species involved in predation vary according to geographical, climatic and seasonal differences. Consequently, their respective impact on flies also varies. These complexes can also be expected to change as additional beneficial species are introduced from abroad.

There also appears to be some merit in parasite releases made during springtime, when fly reproduction is favored through lower average density of predators and native parasites. The extent of fly control can be expected to increase as additional natural enemies are introduced from the native ranges of pest flies.

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# *Effect of*

THE DUSKY-VEINED walnut aphid, *Panaphis juglandis* (Goeze), appears in three distinct forms: alate viviparous parthenogenetic females, apterous oviparous females, and alate males. Commonly, only the alate viviparous parthenogenetic female form of this aphid can be found during the spring and summer months. The apterous oviparae and males appear during the fall. This suggests that temperature, day length, or host plant (English walnut) condition influences form.

Preliminary investigations indicate that long day length and high temperatures result in successive generations of alate viviparous parthenogenetic females, while short day length and high temperatures influence the production of males and apterous oviparous females. To further investigate the effects that photoperiod and temperature have on the biology of *P. juglandis*, a series of experiments was conducted at various photoperiod-temperature combinations. Each experiment was carried out in a single growth chamber at temperatures of 25 or 15° C. and photoperiods of 16 or 10 hours. A stock colony on seedling English walnuts was established and maintained in a modified refrigerator growth chamber. Lights in the chamber were operated for 16 hours daily; the temperature was maintained at approximately 25° C. The humidity in the chamber was not controlled, and it varied from 48 to 81% relative humidity. Under these conditions, only parthenogenetic reproduction perpetuated the generations of the stock colony. The parent aphids used in each study were the progeny of a single alate viviparous parthenogenetic female selected from this stock colony. A single parent aphid was placed in a leaf cage on a six-week-old walnut seedling growing in a clay pot, one parent on each of seven seedling trees. The leaf cages used on the leaflets were prepared from clear plastic pill boxes, with the bottoms removed, measuring 4.7 cm square × 1.7 cm deep. A large hole cut in the lids was covered with fine mesh organdy and provided ventilation. Each day that the parent aphid de-

# *environment on reproduction in dusky-veined walnut aphids*

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posited offspring it was moved to an adjacent leaf cage on the same plant. In this way neither parent nor offspring experienced crowding, a phenomenon which some researchers claim has increased alate production in some aphids. The classification of the progeny was often carried out at the fourth instar, when the type of reproductive system and the presence or absence of wing buds sufficed to distinguish the forms.

Only one form, the alate viviparous parthenogenetic female, was produced under the 16-hour condition irrespective of temperature. The stock colony, also maintained under a 16-hour photoperiod, produced only alate viviparous females over a three-year period, whether the aphids were crowded on the leaflets or not. Evidently long day length completely suppressed any tendency for the production of sexuals.

Sexuals were produced during the 10-hour photoperiod condition. However, a high temperature partially blocked the short day effect, resulting in the production of both alate viviparous females and and apterous oviparous females. A similar occurrence with *Megoura viciae* Buckton has been described at a 12-hour photoperiod and 20° C.

Short days and a temperature of 15° C. completely inhibited the production of viviparae. Under these conditions, alate males appeared for the first time. Since no males were produced under the higher temperature or longer photoperiod tested, it appears that both short days and low temperatures are required for the production of male aphids of this species.

The graph shows the percentages of the parents producing the various forms or combinations of forms. Whether the temperature was high or low, all of the parents produced viviparous offspring under long day conditions. When the day length was shortened, about 15% of the parents continued to produce only viviparae at 25° C. and none produced viviparae at 15° C. Under the short day length and low temperature condition, about 25% of the parents produced only oviparae, while the remainder produced a mixture of oviparae and males. The males comprised about 15% of the total progeny of those females which produced males.

Experiments were also conducted to investigate whether host plant condition might influence form determination. Since the production of oviparae under natural conditions is confined to the fall of the year, it would seem likely that the development of this form might be favored by changes in the plant phloem sap. To test this assumption, 16-week-old seedling walnut trees growing in clay pots were held in total darkness for four-, three-, two-, and one-week periods to stress them and thereby change their nutritional value. Two plants were subjected to each time interval.

When the dark treatment was completed, each plant was covered with a large cage and placed in a growth chamber held at 25° C. and a 12-hour photoperiod. These temperature and photoperiod conditions were selected because they were close to the conditions under which parent aphids produced oviparous offspring. A single young viviparous female selected from the stock colony was placed on each plant and allowed to deposit offspring for 24 hours. These individuals were then removed, along with all but five of the offspring. These five larvae were allowed to develop, mature, and produce offspring under the experimental conditions. The offspring produced were removed daily as they became adults. Their sex and form were recorded.

The two plants held in darkness for four weeks were in such poor condition that they had lost all of their foliage. The parent aphids colonized the stems, but they all died before reaching maturity and consequently no offspring were deposited under this condition. All offspring produced under the remaining three conditions resulted in alate viviparae, and those produced on plants held in darkness for three weeks clearly showed that the food supply was impoverished. The mean weight of 82 individuals was only 1.2 ± 0.3 mg on plants held in darkness for three weeks, compared with 1.5 ± 0.2 mg on plants held in darkness for only one week. In addition, the total number of offspring deposited was fewer on plants held in darkness for the longer periods of time. No oviparous females or males were produced under any of these experimental conditions.

These laboratory findings help explain why the sexual forms of this aphid appear only in the fall when day length decreases and temperatures begin to drop. Initially, a few sexual females appear along with the parthenogenetic females. As the season progresses and temperatures continue to get cooler, the production of the parthenogenetic females is inhibited and male aphids then appear along with the sexual females.

Poor host plant condition does not appear to counteract the effects of long day length, which it may sometimes do in relation to the induction of diapause in some insects.

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INFLUENCE OF PHOTOPERIOD AND TEMPERATURE ON FORM DETERMINATION OF PROGENY OF VIVIPAROUS PARTHENOGENETIC FEMALES OF P. JUGLANDIS.