COMPARISON OF SOME LIFE HISTORY PARAMETERS BETWEEN ALATE AND APTEROUS FORMS OF TURNIP APHID (HOMOPTERA: APHIDIDAE) ON CABBAGE UNDER CONSTANT TEMPERATURES

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ABSTRACT

Development, longevity, survivorship and fecundity of the alate and apterous forms of the turnip aphid, *Lipaphis erysimi* (Kaltenbach), were studied on cabbage under constant temperatures in the laboratory. The developmental durations for alate nymphs were 15.8, 9.5, 8.0 and 5.4 d at 15, 20, 25 and 30°C, respectively, and those for apterous nymphs were 13.9, 6.8, 6.1 and 5.0 d. Alate nymphs developed 1.9-3.0 d longer at 15, 20 and 25°C than the apterous nymphs, but the developmental durations between the alate and apterous forms were not significantly different at 30°C. The longevities of alate adults were 12.6, 17.7, 17.6, and 17.2 d at 15, 20, 25, and 30°C, respectively, compared with 25.3, 21.3, 17.5 and 11.7 d, respectively, for apterous aphids under the corresponding temperature regimes. Fecundity was also significantly less for alate adults than for apterous adults. Alate adults produced an average of 7.9, 37.9, 39.0, and 11.9 nymphs in their lifespan at 15, 20, 25 and 30°C, respectively, compared with 52.5, 90.8, 83, and 29.7 nymphs per apterous adult at the same temperature regimes.

Key Words: *Lipaphis erysimi*, turnip aphid, alate aphid, apterous aphid, development, reproduction, cabbage, vegetable

RESÚMEN

Bajo temperaturas constantes en lanratorio, se estudió el desarrollo, la longevidad, la supervivencia y la fecundidad en col de las formas alada y áptera del áfido del nabo *Lipaphis erysimi* (Kaltenbach). El tiempo de desarrollo en ninfas aladas fue de 15.8, 9.5, 8.0 y 5.4 dias a 15, 20, 25 y 30°C respectivamente, mientras que en ninfas ápteras fue de 13.9, 6.8, 6.1 y 5.0 dias. Las ninfas aladas se desarrolaron de 1.9-3.0 dias más rápido a 15, 20 y 25°C que las ninfas ápteras, pero el tiempo de desarrollo entre las formas alada y áptera no fue significativamente diferente a 30°C. La longevidad de los adultos alados fue de 12.6, 17.7, 17.6 y 17.2 dias a 15, 20, 25 y 30°C respectivamente, comparada con 25.3, 21.3, 17.5 y 11.7 dias para los áfidos ápteros bajo los régimenes correspondientes de temperatura. La fecundidad también fue perceptiblemente menor para los adultos alados que para los adultos áptreos. Los adultos alados producen un promedio de 7.9, 37.9, 39.0 y 11.9 ninfas en su lapso de vida a 15, 20, 25 y 30°C respectivamente, comaparado con 52.5, 90.8, 83.0 y 29.7 ninfas por adulto áptero bajo el mismo régimen de temperaturas.

The turnip aphid, *Lipaphis erysimi* (Kaltenbach), is a worldwide pest on *Brassica* crops (Begum 1995; Liu et al. 1997; Prasad 1988; Yue & Liu 2000). The biology of apterous *L. erysimi* on several *Brassica* vegetables were well documented (Ahlawat & Chenulu 1982, Amjad and Peters 1992; Chander & Phadke 1994; Castle et al. 1992; Prasad & Phadke 1984; Edelson et al. 1993; Setokuchi & Muma 1993; Singh et al. 1983; Singh & Sachan 1995). The nymphs and adults suck the sap from leaves, young shoots, inflorescence and young pods, resulting in chlorophyll reduction or even plant death. Additionally, alate *L. erysimi* can transmit some important plant virus diseases, such as sugar cane mosaic virus, cucumber mosaic virus and bean yellow mosaic potyvirus (Ahlawat & Chenulu 1982; Castle et al. 1992).

The life history parameters, such as development, longevity, survivorship and fecundity of the alate form of *L. erysimi* were not well documented, and these biological characteristics and parameters are essential for effective aphid management (Halbert et al. 1981). In this paper, we report the effects of four different constant temperature regimes on development, survivorship, longevity and fecundity of both the alate and apterous forms of *L. erysimi* on cabbage in the laboratory.

MATERIAL AND METHODS

Host Plants

Cabbage, *Brassica oleracea* var. *capitata* L. (Grand Slam Hybrid), was seeded in styrofoam germination trays with 5 seeds per cell (2.5 by 2.5 by 7.5 cm) in a greenhouse. Seedlings were thinned when the plants were 2.5-cm high leaving one healthy plant per cell. These seedlings were transplanted individually to plastic pots (15 cm in diam.) when they were ≈8-cm high with 5-6 leaves. Some of these seedlings were maintained in the greenhouse, and others were maintained in an insectary for feeding the aphid colony.

Development, Survivorship, Longevity and Fecundity

The aphid colony has been maintained on cabbage in a greenhouse for >1 year. Both alate and apterous adult aphids were collected from the greenhouse colony, and were transferred onto potted cabbage plants in an air-controlled insectary at 25 ± 2°C and 55-60% relative humidity (RH) under a photoperiod of 12:12 (L:D) h. Detached cabbage leaves were used to rear *L. erysimi* in all experiments. Clear plastic petri dishes (12.5 cm by 1.2 cm) were used as aphid rearing arenas. Eight layers of paper tissues were put on the bottom of the petri dishes, and the paper tissues were saturated with water for sufficient moisture. A cabbage leaf disk (≈8.0 cm in diam) with the adaxial surface facing up was placed on the water-saturated paper tissue in each petri dish. At the time of the experiment, neonate nymphs (<24 h old 1st instars) were collected from the laboratory colony using a small camel hair brush (#000) and placed into each rearing arena. Thirty to 40 aphids were used for each treatment. Four constant temperatures, 15, 20, 25, and 30°C, were maintained in growth chambers (Percival, Boone, IA) with a photoperiod of 14:10 (L:D) h and 50-75% RH. Development, molting, survival and number of newborn nymphs were recorded daily until the females died. Newborn nymphs were removed after the daily recording until the death of the adult. Leaf disks were replaced at the first sign of deterioration, normally at 4-5 d intervals.

Data Analysis

Aphids were excluded from the data set if they died within 24 h or they were never observed feeding. Developmental duration, longevity and reproduction of both alate and apterous *L. erysimi* under the four constant temperatures were analyzed using a two-way analysis of variance (ANOVA) (temperatures × aphid forms), and the means were separated using the least significant difference (LSD) test at P = 0.05 upon a significant F-test (SAS Institute 1996).

RESULTS AND DISCUSSION

Nymph Development

Temperature significantly affected the development for both alate and apterous nymphs (Fig. 1).

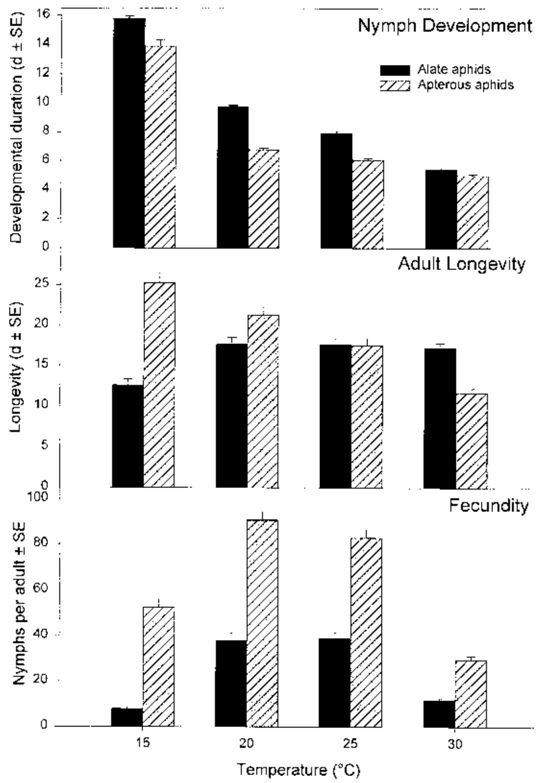

Fig. 1. Development, longevity and fecundity of both alate and apterous alate *Lipaphis erysimi* on cabbage under four constant temperatures in the laboratory.

At the four temperatures, alate nymphs developed significantly faster at higher temperatures than at lower temperatures (F = 18.6; df = 3, 102; P = 0.0001). The developmental duration was shortest at 30°C (5.4 d), followed by at 25°C (8.0 d), at 20°C (9.5 d), and the longest at 15°C (15.8 d). Similarly, apterous nymphs also developed faster at higher temperatures than at lower temperatures (F = 9.3; df = 3, 101; P = 0.0002). The developmental duration was shortest at 30°C (5.0 d), followed by at 25°C (6.1 d), at 20°C (6.8 d), and the longest at 15°C (13.9 d). Alate nymphs developed significantly longer than apterous nymphs at 15, 20 and 25°C (F = 11.2- 23.14; df = 1, 102; P = 0.0025-0.0001). Those under 30°C did not show significant differences in developmental durations (F = 1.13; df = 1, 102; P = 0.5741).

Survivorship and Longevity

All nymphs in both alate and apterous forms survived to adulthood (Figs. 1 and 2). The longevities of both alate and apterous adults were significantly affected by temperature. The longevity of alate adults was significantly shorter at 15°C than those at the other three temperatures (F = 7.13; df = 3, 104; P = 0.0471). In contrast, the lon-

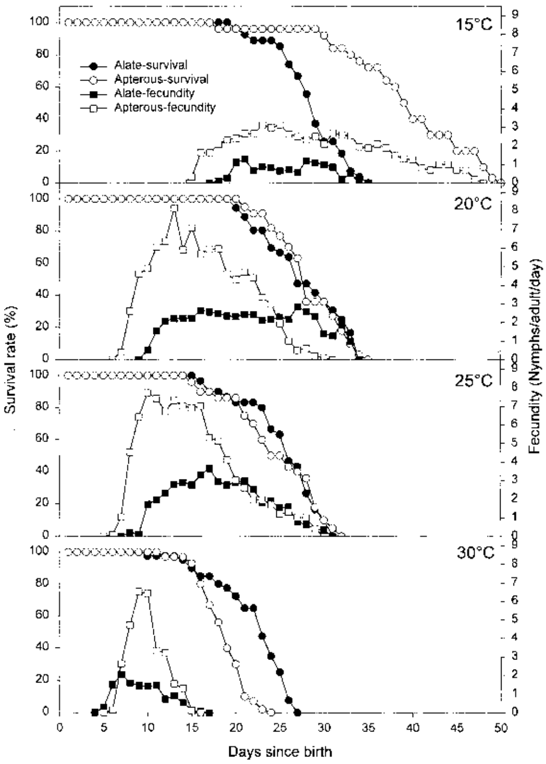

Fig. 2. Survival rates and natality of both alate and apterous *Lipaphis erysimi* on cabbage at different temperatures in the laboratory.

gevities of apterous adults declined as the temperatures increased from 15°C to 30°C. The longest longevity (25.3 d) was obtained at 15°C, followed by 21.3 d at 20°C, 17.5 d at 25°C, and the shortest, 11.7 d at 30°C. Between the two forms, alate adults lived a significantly shorter period than apterous adults (F = 9.87-12.23; df = 1, 102; P = 0.0012-0.0001) at 15, 20 and 30°C except for those at 25°C (F = 0.97; df = 1, 102; P = 0.8754). The largest difference in longevity between the two forms was found at 15°C at which the apterous adults lived ≈2-fold longer than that of alate adults (25.3 d vs. 12.6 d respectively). At 20°C, the apterous adults lived 3.6 d longer than the alate adults. The longevities of both forms were almost the same at 25°C. In contrast, the apterous adults lived 5.5 d shorter than the alate adults (17.2 d vs. 11.7 d) at 30°C.

Similar effects were also reported by DeLoach (1974) and Liu (1991). Aphid development and reproduction typically increase from zero at a low temperature threshold, reach a maximum at the most favorable temperature, then decrease rapidly to zero at a lethal threshold. Like other aphids in general, *L. erysimi* reared at temperatures above the upper or below the lower thresholds develop more slowly than those under the most favorable conditions. The nymphs developed fastest at 30°C, and slightly slower at 25 and 20°C. DeLoach (1974) found that *L. erysimi* on turnip could continue to reproduce at 30°C, but failed to do so at 35°C. Similarly, Liu (1991) found the most favorable temperature for *L. erysimi* was 26°C. At 8.3 and 35°C, few nymphs developed to adults, but none produced any offspring. At 11.3 and 32.8°C, few adults successfully reproduced. Therefore, the lower and upper threshold temperature for *L. erysimi* should be higher than 8°C and lower than 33°C, with the most favorable temperature between 25 and 27°C. DeLoach (1974) also reported great mortality for some young *L. erysimi* nymphs because these young nymphs failed to become well-established on the new host plants after having been transferred from the original host plants.

Fecundity

Temperature played a significant role for aphid reproduction (Figs. 1 and 2). Alate adults produced the most nymphs at 25°C (39.0 nymphs/adult) and 20°C (37.9 nymphs/adult), followed by these (11.9 nymphs/adult) at 30°C, and the fewest at 15°C (7.9 nymphs/adult). Apterous adults produced most nymphs at 20°C (90.8 nymphs/adult), followed by 83.0 nymphs/adult at 25°C, 52.5 nymphs/adult at 15°C, and the fewest, 29.7 nymphs/adult at 30°C. Between the two forms, apterous adults produced 6.6-, 2.4-, 2.1- and 2.5-fold more nymphs per adult than alate adults of the corresponding temperature.

Both alate and apterous adults started to produce nymphs 1 or 2 d after the last molting, so the adults from last molting to the first reproduction were only 1-2 d old (Fig. 2). Both fecundity and reproductive period varied at the four temperature regimes. Generally, the alate aphids had lower daily reproductive rates and shorter period of reproduction than the apterous forms at the same temperature. At 15°C, reproductive periods lasted 12 d at 15°C, compared with 24 d at 20 and 25°C, respectively, and only 11 d at 30°C. Daily fecundity at the peak reproduction period was 3-4 nymphs at 20 and 25°C, <2 nymphs at 30°C and 15°C.

The reproductive periods of apterous lasted 34 d at 15°C, compared with 24 d at 20°C, 25 d at 25°C, and only 11 d at 30°C. An aphid could produce 8-9 nymphs per d at the peak reproduction period at 20 and 25°C, 6-7 nymphs at 30°C, and 2-3 nymphs at 15°C.

Our results clearly indicate that many biological parameters, including nymph development, adult longevity and fecundity differed between alate and apterous forms. Similar results were reported by Takaoka (1973) who reviewed that longer nymph period, longer adult longevity and lower fecundity of alate virginoparae were found in many species of aphids compared to those of their apterous form. Information from this study will aid in predicting the population dynamics of *L. erysimi* on cole crops in south Texas. The susceptibility to low (<10°C) and high temperature (>35°C) may present a partial explanation for the low field populations of *L. erysimi* in the summer and in the winter months when temperatures are often >30 and <10°C, respectively. Meanwhile, the information on *L. erysimi* obtained under constant temperatures may not be directly applicable for field populations that may be affected by fluctuating temperatures (Liu & Meng, 1990) and other biotic and abiotic factors.

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