Results

Life-cycle of C. foeniculus

C. foeniculus developed through four instar stages; the first, third and fourth instars taking about 1.6 days while the second instar took 1.37 days (Table 1). The developmental period of the aphid, from birth to the last moult, averaged 6.19 days for the apterae. For alates, however, observations made showed that the fourth instar stage was much longer (average 2.7 days) and the developmental period ranged between 7.7 and 8.6 days.

Table 1: Duration of instar stages of the carrot aphid *Chomaphis (dysaphis) foeniculus* on carrots.

Nymphal instar stages	Duration of instar stages (days) Means ± S.E.	Range
First Instar	1.63 ± 0.07	1.50 - 1.75
Second Instar	1.37 ± 0.07	1.25 - 1.46
Third Instar	1.61 ± 0.12	1.42 - 1.46
Fourth Instar	1.60 ± 0.15	1.42 - 2.00
Developmental period	6.19 ± 0.17	5.75 - 6.51

Fecundity and reproduction

Data on fecundity showed that nymphal production by *C. foeniculus* started within one day of the last nymphal moult, and extended for five to six days only (Fig. 1). Fecundity was low, with each mother aphid producing an average of 17.1 nymphs (range 11 - 25).

Nymphal production occurred during the day and at night, with significantly ($P \leq 0.05$) more nymphs (up to 56.2%) being produced during the afternoon period than during the morning (maximum 35.5%) or night (maximum 38.8%) periods (Table 2). Although variation in prevalent weather conditions did not have significant direct effects on nymphal production, significant ($P \leq 0.05$) interaction between weather conditions and diurnal reproduction rhythm was observed. Cloudy and rainy conditions in the mornings lowered nymphal production during the morning period (Table 2) and altered the diurnal reproduction pattern (Fig. 2).

Population build-up

The development of *C. foeniculus* populations on carrots was moderate for both infestation levels of one and four aphids per plant (Fig. 3). After 20 days, an average of 109.5 and 278.6 aphids per plant were recorded for the two initial levels of infestation, respectively. A higher rate of population build-up (5.5 progeny/ aphid/ day) was observed for the lower infestation level than for the higher infestation level (3.5 progeny /aphid/plant).

Table 2. The relationship of nymphal production of *Chomaphis foeniculus* to morning (M) and afternoon (A) weather conditions and period of reproduction.

Diurnal weather conditions	Period of Reproduction: Morning (0600-1200 h)	Afternoon (1200-1800 h)	Night (1800-0600 h)
Bright Day	35.5a 1	34.9b 1	29.5ab 1
Dull Day	21.6b 2	56.4a 1	21.6b 1
Dull M/Bright A	16.2b 3	53.2a 1	38.8a 2
Bright M/Dull A	21.9b 2	50.0a 1	30.9ab 2

a, b, 1,2,3,: means followed by the same letters in each column and same number in each row are not significantly different at $P \leq 0.05$.

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Aspects of the Biology of the Carrot Aphid *Chomaphis (dysaphis) foeniculus* Theobald (Homoptera: Aphididae) in Uganda

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Abstract

Laboratory and cage studies were conducted to assess the life-cycle and reproduction of the carrot aphid *Chomaphis (Dysaphis) foeniculus* Theobald (Homoptera: Aphididae) on carrots *(Daucus carota L.).* There were four instar stages, with a total developmental period of 6.3 days (range 6.1-7.2 days). Reproduction occurred in the first six days of adult life, and each female aphid produced an average of 17.1 nymphs (range 11-25). Significantly more nymphs ($P \leq 0.05$) were produced during the afternoon than the morning hours or night, and nymphal production was suppressed in cloudy overcast conditions. Because of the short developmental period and rapid reproduction after maturity, there was a relatively high rate of population build-up.

Key words: Carrot aphid, *Chomaphis (Dysaphis) foeniculus,* biology, developmental period, reproduction, nymphs.

Introduction

The carrot aphid *Chomaphis (Dysaphis) foeniculus* Theobald (Homoptera: Aphididae) was first described from Egypt by Theobald (1923), and has since been recorded from New Zealand, North America, Palestine, Ethiopia, Kenya, Tanzania and Zimbabwe (Bodenheimer and Swirsky, 1958; Eastop, 1958; LePelley, 1959). The aphid has characteristically six antennal segments, and apterae are covered with grey waxy dust. Brachypterae and alatiform intermediates, frequent in the species, differ from normal apterae in the darker pigmentation of the thorax and longer third antennal segment that often bears rhinaria (Eastop, 1958). *C. foeniculus* infests plants in the families Umbelliferae, including carrots *(Daucus carota L.),* Lilliaceae and other related monocotyledons. It feeds below ground level but nymphs are also found on upper foliage attended by ants (Eastop, 1958), and often covered with soil.

Although *C. foeniculus* has hitherto not been reported from Uganda, recent observations at Makerere University Agricultural Research Institute, Kabanyolo (MUARIK), suggest that significant infestation of carrots by the aphid occurs in the country. Given this pest potential (a related species, *C. tulipae* Boyer de F., is a vec-

tor of two tulip viruses), and the fact that the few published reports on the aphid are limited to taxonomic descriptions and brief notes on distribution and host range, the present study was instituted to assess some aspects of its biology when reared on carrots in Uganda.

Materials and Methods

The study was carried out at Makerere University Agricultural Research Institute, Kabanyolo (MUARIK), located 16 km north of Kampala, Uganda, at latitude 0° 28' North, longitude 32° 37' East and an altitude of about 1290 m above sea level. The experiments were set in small cages in a large glasshouse during the rainy season of 1989. Diurnal temperatures in the glasshouse averaged 24.7°C (range 19.3 - 28.6 °C). Seedlings of carrots were transplanted singly in small pots (top diameter 9 cm) and used for the study when about one month old. *C. foeniculus*, initially obtained from field colonies on carrots, were raised on potted carrot plants in the glasshouse to provide test insects.

Life-cycle of C. foeniculus

Ten carrot plants were each infested with four freshly moulted *C. foeniculus* adults and left overnight. In the morning, nymphs found on the plants were removed and adult aphids left to reproduce for 3 hours, between 0900 and 1200h, after which all adult aphids were removed. Nymphs produced were inspected daily at 2-hour intervals, between 0600 and 2000h, and records made of time of moulting and start of reproduction. Instar duration and the developmental period of the aphid were then determined.

Fecundity and reproduction

After the fourth moult, adult aphids from the above study were removed to leave only two per plant, which were then left to reproduce. Nymphs produced each day were counted at 0900 h and removed from the plants. The observations continued until the mother aphids died; the fecundity, duration of nymphal production and the longevity of the aphid were then obtained.

To determine the daily pattern of nymphal production, eight carrot plants were each infested with three freshly moulted apterous *C. foeniculus* adults. Nymphs produced on each plant were counted at 2-h intervals between 0600 and 2200 h, and at 0600 h the next day, and then removed. All aphids on the plants were removed every four days and the plants re-infested with freshly moulted apterae. This observation continued over a period of 30 days.

On the basis of records of weather conditions, the experimental days were categorised as follows:

i) Bright Day (BD)- sunny and dry the whole day,

ii) Dull Day (DD)- cloudy and/or rainy the whole day.

iii) Bright Morning/Dull Afternoon (BM/DA)- sunny and dry between 0600 and 1200 h, and cloudy and/or rainy between 1200 and 1800 h,

iv) Dull Morning/ Bright Afternoon- reverse of situation obtained in (iii).

Four days were randomly selected for each of the above categories, and data on nymphal production subjected to an analysis of variance to determine the relationship between nymphal production, prevalent weather conditions, and the different reproduction periods of morning (0600 - 1200 h), afternoon (1200 - 1800 h) and night (1800 - 0600 h). Diurnal pattern of nymphal production under the different weather conditions were also analyzed, and the means compared using Duncan's multiple range tests and plotted (Duncan, 1955).

Population build-up

Six weeks old carrot plants were infested with freshly moulted apterous *C. foeniculus* adults, ten plants being infested with one and fourteen with four aphids each. Aphids on the plants were counted seven times at 3-day intervals. Counting was carried out *in situ,* on three randomly selected plants, until days 9 and 15 for the high and low levels of infestations, respectively. Because of the large numbers of aphids that developed on the plants after these dates, aphids sampled subsequently were first stored in vials containing 65% ethanol and the counting done in the laboratory.

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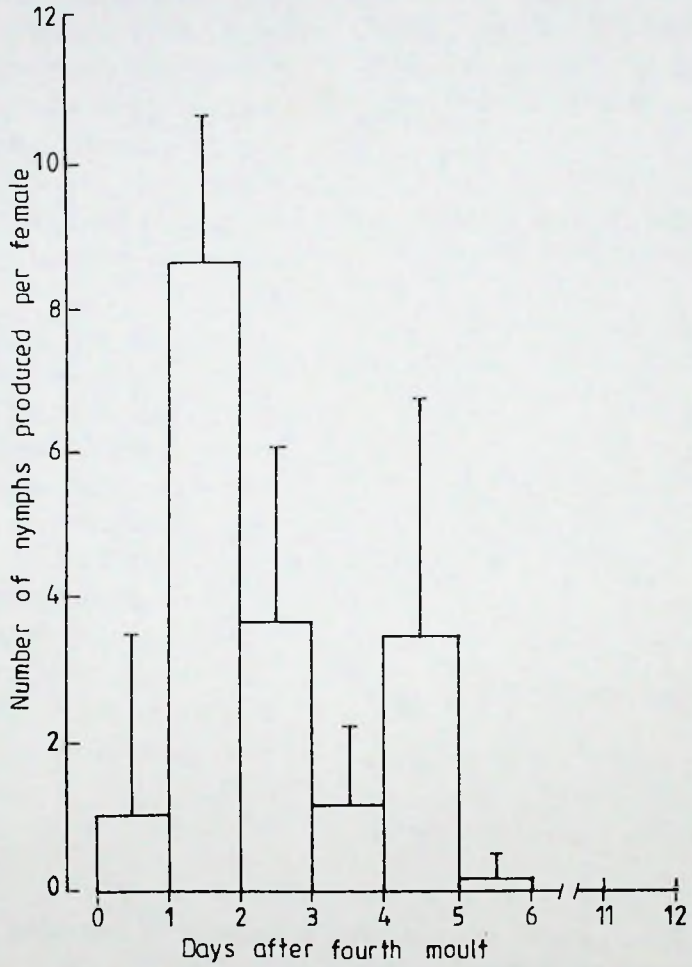


Figure 1: Fecundity and nymphal production of *Chomaphis foeniculus* on carrots

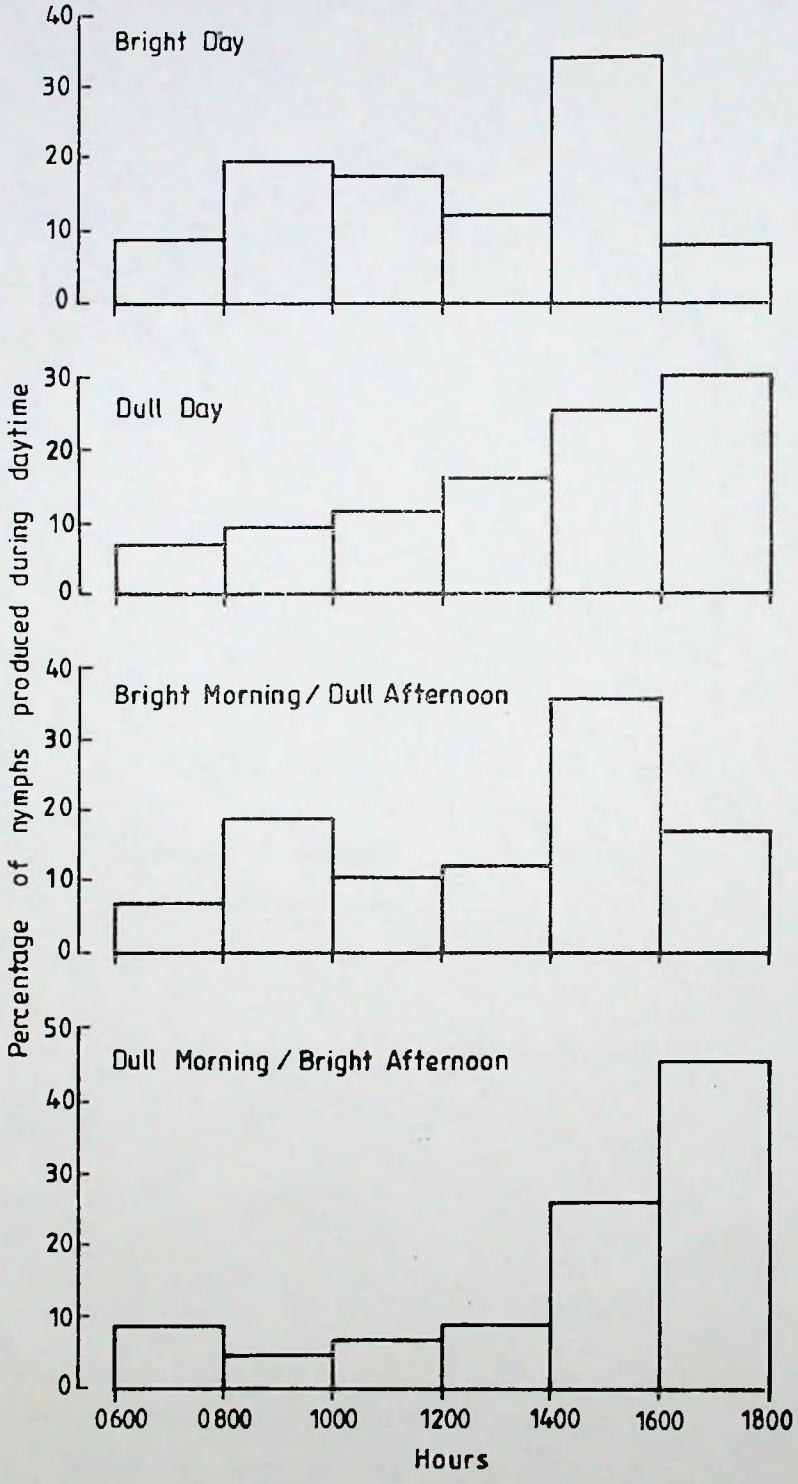


Figure 2: Infllluence of prevalent weather conditions on the diurnal production rhythm of *Chomaphis foeniculus*.

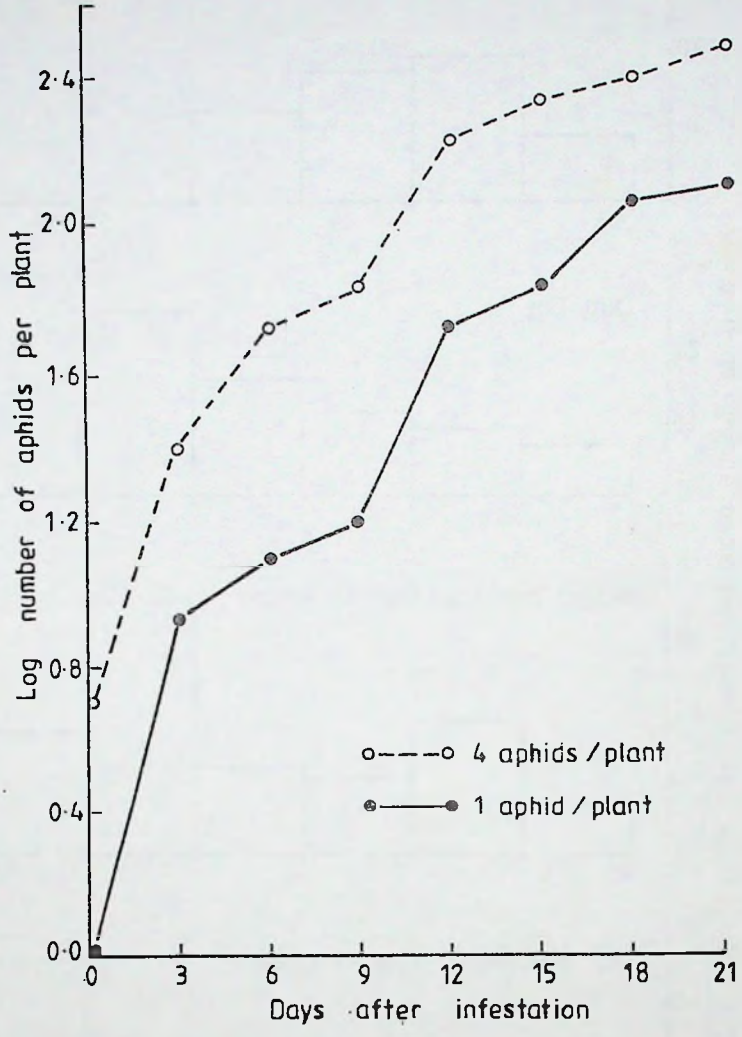


Figure 3: Development of *Chomaphis foeniculus* populations on carrots in the glasshouse

Discussion

The present report establishes the occurrence of *Chomaphis foeniculus* in Uganda. This was to be expected, however, since the pest was already known to occur in the neighbouring countries of Kenya and Tanzania (Eastop, 1958).

Results of the life-cycle study showed that *C. foeniculus* has a short developmental period, low fecundity and a limited reproductive life. The short duration of nymphal development observed for the aphid (Table 1) was similar to those known for many aphid species (Kennedy and Stroyan, 1959), and was probably related to the relatively high temperatures obtained in the glasshouse.

Data obtained also showed that *C. foeniculus* females produced on average fewer than 20 nymphs each during a short reproductive life (Fig. 1). On bright rain-free days, the aphid had two peaks of diurnal reproduction between 0800 and 1000 h and 1400 and 1600 h (Fig. 2). Such diurnal rhythm is a common feature of aphid developmental and reproductive biology (Eastop, 1957; Johnson *et al.*, 1957; Ogenga-Latigo and Khaemba, 1985).

Cloudy and overcast conditions during the day adversely affected reproduction and depressed the morning peak of nymphal production observed on sunny days (Fig. 2). This was probably because low light levels during such days reduced the photo-synthetic activity of plants. Consequently, there was reduced availability of assimilates on which the aphids are intimately dependent for nutrition and development (Taylor, 1957; Kennedy and Stroyan, 1959).

The study also showed that, even from low levels of initial infestation, substantial build-up of *C. foeniculus* populations on carrots occurred (Fig. 3). Although *C. foeniculus* is of relatively low fecundity, its rapid development and short period of reproduction under the relatively high temperatures prevalent in most parts of the country will ensure a high rate of population development for the aphid. The pest, therefore, has a significant outbreak potential and, as carrot production expands in the country, should be closely monitored.

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