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Developmental biology and population growth of turnip aphid, Lipaphis erysimi(Homoptera:Aphididae), fed kale【Research report】

偽菜蚜(同翅目：蚜蟲科)取食芥藍之發育生物學及其族群增長【研究報告】

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Abstract

Parameters of population growth, intrinsic rate of increase, length of generation, and net reproductive rate, etc., were determined for the turnip aphid, Lipaphis erysimi, reared on blooming flowers/seed pods at 25 and 30℃. The blooming flower-fed turnip aphids had the highest intrinsic rate of increase at 25℃ (rm= 0.5299), and seed pod-fed turnip aphids had the smallest rate of increase at 30℃ (rm = 0.3997). Turnip aphids had a higher intrinsic rate of increase, higher net reproduction rate (Ro = 77.8074) and longer mean generation time at 25℃ no matter what they were fed. No significant difference in molt number of nymphs, or nymphal period was found among treatments. However, body length showed a significant difference among different instars for both temperatures and for flower-fed aphids. The survival rate (lx) dropped to zero on day 4 for aphids reared at 35℃. The survival rate started to drop on day 3 at 30℃ and on day 10 at 25℃ for aphids fed on blooming flowers. The survival rate started to drop on day 6 at 30℃ and on day 10 at 25℃ for aphids fed on pods. Reproduction of flower-fed aphids began on day 5 at 30℃ and day 4 at 25℃, and reproduction of seed pod-fed aphids began on day 4 at 25℃, and day 6 at 30℃. The value of mx of aphids reared at 25℃ was higher than that of aphids reared at 30℃ throughout the course of the reproductive period regardless of the food source. Higher numbers of progeny were produced by turnip aphids grown at 25℃ when compared with 30℃ except on day 4 of pod-fed ones at 30℃.

摘要

於室內25及30oC定溫下，以盛開之花朵及種莢為食物餵食偽菜蚜，以探討其生長速率(包括若蟲發育、齡別存活率、齡別繁殖率、平均壽命長度及內在增殖率等因子)。在25oC下取食花朵之偽菜蚜的內在增殖率最高(rm = 0.5299)，而 30oC 取食種莢之偽菜蚜的內在增殖率最低 (rm = 0.3997)。不論所取食之食物類別，在處理溫度25oC處理組皆有較高之內在增殖率、淨增殖率(Ro)及平均世代時間。而蛻皮數及各齡若蟲體長在處理間並無顯著差異。35oC處理組的齡別存活率(lx)於第四天就降到零。取食花朵組，齡別存活率在30oC時自第3天， 25oC自第10天開始下降。取食種莢組，齡別存活率在30oC時自第6天，25oC自第10天開始下降。取食花朵組在25oC自第4天，30oC自第5天開始產後代。取食種莢組，在25oC自第4天，30oC自第6天就開始產後代。就齡別繁殖率，不論食物類別，25oC處理組的數值皆高於30oC處理組的數值。後代產生數25oC處理組皆高於30oC處理組。

Key words: Lipaphis erysimi, life cycle, intrinsic rate of increase

關鍵詞: Lipaphis erysimi、發育生物學、族群增長、內在增值率

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Developmental Biology and Population Growth of Turnip Aphid, *Lipaphis erysimi* (Homoptera: Aphididae), Fed Kale

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ABSTRACT

Parameters of population growth, intrinsic rate of increase, length of generation, and net reproductive rate, etc., were determined for the turnip aphid, *Lipaphis erysimi*, reared on blooming flowers/seed pods at 25 and 30℃. The blooming flower-fed turnip aphids had the highest intrinsic rate of increase at 25℃ (r_m=0.5299), and seed pod-fed turnip aphids had the smallest rate of increase at 30℃ (r_m=0.3997). Turnip aphids had a higher intrinsic rate of increase, higher net reproduction rate (R_o=77.8074) and longer mean generation time at 25℃ no matter what they were fed. No significant difference in molt number of nymphs, or nymphal period was found among treatments. However, body length showed a significant difference among different instars for both temperatures and for flower-fed aphids. The survival rate (l_x) dropped to zero on day 4 for aphids reared at 35℃. The survival rate started to drop on day 3 at 30 ℃ and on day 10 at 25℃ for aphids fed on blooming flowers. The survival rate started to drop on day 6 at 30℃ and on day 10 at 25℃ for aphids fed on pods. Reproduction of flower-fed aphids began on day 5 at 30℃ and day 4 at 25℃, and reproduction of seed pod-fed aphids began on day 4 at 25℃, and day 6 at 30℃. The value of m_x of aphids reared at 25℃ was higher than that of aphids reared at 30℃ throughout the course of the reproductive period regardless of the food source. Higher numbers of progeny were produced by turnip aphids grown at 25 ℃ when compared with 30℃ except on day 4 of pod-fed ones at 30℃.

Key words: *Lipaphis erysimi*, life cycle, intrinsic rate of increase.

Introduction

Turnip aphid (*Lipaphis erysimi* Kalt.) and green peach aphid (*Myzus persicae* Sulzer) are important pests of crucifers in commercial fields of Taiwan during late fall to the subsequent early summer (Lee 1986). The host plants of turnip aphid have included crucifer (*Brassica*) (Lee 1986; Hsiao 1997), onion (*Allium* spp.), watercress (*Nasturtium officinale*), carrot, kholrabi, lettuce, and tomato (Wijerathna and Edirisinghe 1997). Its biology has been studied by Sidhu and Singh (1964), Kundu and Pant (1968), Sachan and Bansal (1975), and Srivastava (1980) on oilseed crucifers. Their efforts have provided some information on particular plants so far. However, turnip aphids can attack various parts/stages of crucifers by sucking plant juices and also by transmitting several kinds of viruses (Castle *et al.* 1992). Kundu and Pant (1968) have suggested that floral portions were more suitable for quicker multiplication of aphids, and that infestations of turnip aphid eventually would affect seed yield and quality (Bakhetia 1983). Ronquist and Ahman (1990) have indicated that reproductive rates of *L. erysimi* differed when fed on different *Brassica* plants.

The purpose of this study was to investigate the developmental biology and population growth parameters of turnip aphid fed blooming flowers and seed pods of kale.

Materials and Methods

Laboratory colonies of turnip aphid, *Lipaphis erysimi*, were started with around 100 apterous females collected from blooming flowers of kale at the farm of National Chiayi Institute of Technology (NCIT), 7 km outside Chiayi City, Taiwan. This cohort was maintained on kale in incubators set at 25±1°C, 30±1°C, and 35±1°C, respectively, with a 12:12 hour light-dark cycle for at least one generation before the experiment.

Individual plants were grown by sowing four seeds directly into a pot (dia. 15 cm). Soil was collected from the farm of NCIT. The physical properties of this soil were pH 6.82, CEC 8.14, organic carbon 1.16 units. This soil consisted of 39.0% of sand, 23.0% clay and 38.0% silt and classified as loam. Kale was planted in sequence at an interval of 2 weeks in order to simultaneously have blooming flowers and fresh pods (ca. 1-1.5 cm long). Once plants had grown to the four-leaf stage, plants were thinned, and only one plant was left. After 2 months, the blooming flowers and fresh pods of kale were then used as a food source for *L. erysimi*, and placed in a 5.5 cm (dia.) petri dish with moist filter paper to prevent the host part from not wilting for 24 h during rearing.

Forty-five to 50 apterous adults were placed individually on a blooming flower or fresh pod. Twenty-four hours later, only one newly born nymph was left, and the mother adult and other progenies were removed with a camel hair brush. A petri dish with a nymph inside constituted one replication and each host part at each temperature was replicated 45-50 times. Food was changed daily and nymphs at each temperature were transferred to fresh food with the help of a camel hair brush to avoid injury to the insects. Observations on the survival, and development of each nymph were taken daily until its natural death. The numbers of nymph reproducing parthenogenetically as adults were counted and recorded daily. After counting, young nymphs were removed without disturbing the mother aphids. The few alatae produced in the experiment were discarded from the analysis. Only aphids that produced progeny were used in the calculation of age to first reproduction. Age-specific survival (l_x) and age-specific fecundity (m_x) were recorded at daily intervals until adults died. Population growth parameters, such as net reproductive rate (R_o), and intrinsic rate (r_m), were then computed as described by Birch (1948), except the mean generation time ($\bar{T}$) was calculated according to Leslie's method: $T = l_x\ m_x\ e^{-rx}$.

Results

Survival and fecundity

Turnip aphids could complete their development to the adult stage at 25 and 30°C. However, at 35°C, all tested aphids died by day 4 and none of them reached the adult stage. Age-specific survival (l_x) is illustrated in Fig. 1 for aphids fed on blooming flowers and fresh pods of kale

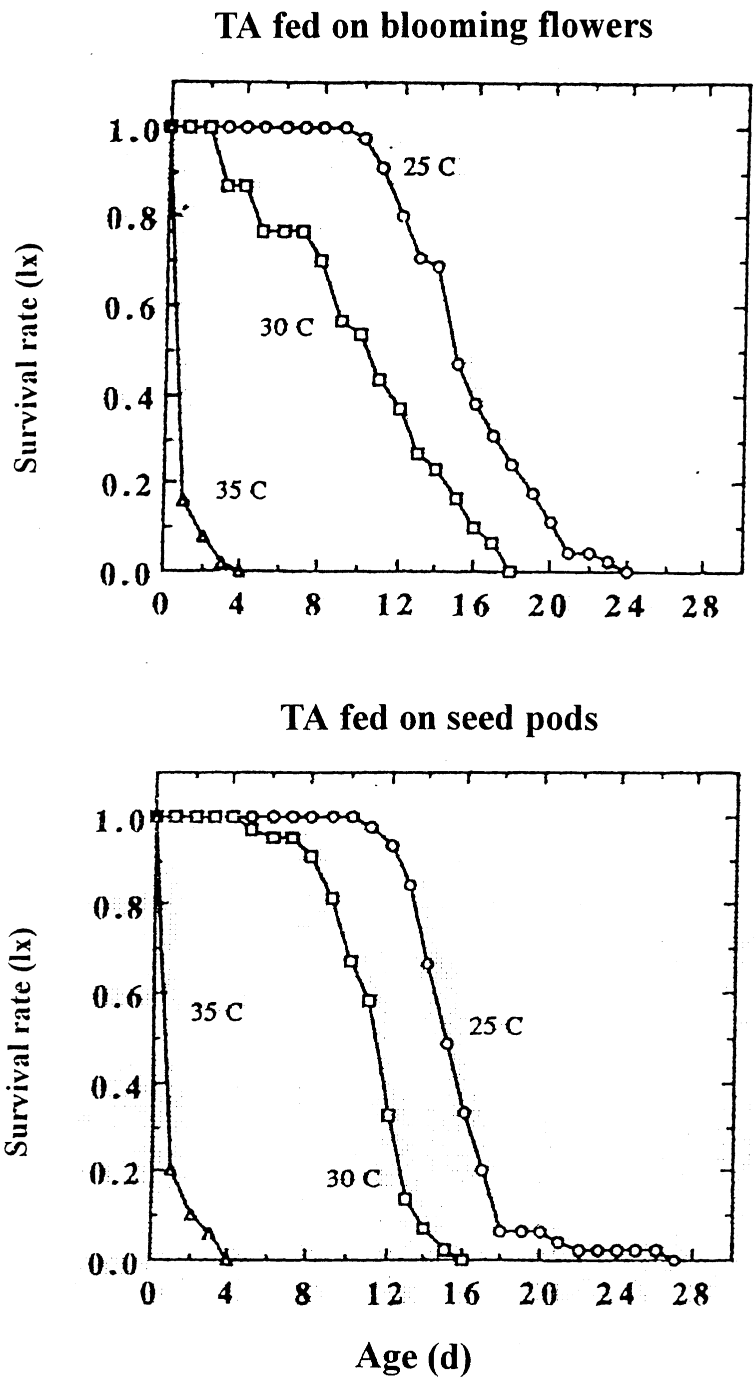


Fig. 1. Age-specific survival rate (l_x) of *Lipaphis erysimi* (Kalt.) fed on flowers and seed pods at various temperatures.

at each temperature. Mortality increased as the temperature increased for aphids fed on the same food source. However, greater mortality was found when aphids were reared on pods than on flowers at the same temperature.

Fig. 1 shows that the survival rate (l_x) dropped to zero on day 4 when aphids were exposed to 35°C. The survival rate began to drop on day 3 at 30°C and on day 10 at 25°C for aphids fed on blooming flowers. The survival rate began to drop on day 6 at 30°C and on day 10 at 25°C for aphids fed on pods. Survival curves for both food sources differed slightly in shape, being steeper at 30°C for aphids fed on blooming flowers than for aphids fed on pods.

Age-specific fecundity (m_x) is shown in Fig.2 on a day scale for the treatments. Reproduction of flower-fed aphids began on day 5 at 30°C and day 4 at 25°C; reproduction of pod-fed aphids began at day 4 on 25°C, and day 6 at 30°C (Fig. 2). Age-specific fecundity of aphids reared at 25°C was higher than that of aphids reared at 30°C throughout the course of the reproduction period regardless of the food source. And the reproduction period ranged from day 5 to day 24 at 25°C and day 5 to day 17 at 30°C for aphids fed on blooming flowers. The reproduction period ranged from day 5 to day 22 at 25 °C and day 6 to day 17 at 30°C for aphids fed on seed pods.

Fig. 3 illustrates $l_x m_x$ curves of flower -fed aphids and pod-fed aphids reared at 25°C and 30°C and shows that the generalized triangular shape.

Net reproduction rate

Signifcantly higher net reproduction rates (R_o) occurred at 25°C than at 30°C for aphids fed either on blooming flowers or seed pods. However, a slightly higher R_o value was shown for aphids fed seed pods (=24.45) than for those fed blooming flowers (=22.88) at 30°C (Table 1). Turnip aphids fed blooming flowers had the highest R_o when they were reared at 25°C compared with the other three treatments.

Generation time ($\bar{T}$)

A longer mean generation time ($\bar{T}$) was shown for turnip aphids reared at 25 °C than those reared at 30°C when fed either flowers or seed pods (Table 1). Those aphids fed on seed pods had a lower $\bar{T}$ value than those fed on blooming flowers at both temperatures. The value of generation time between temperatures was different; however, little difference was shown for aphids fed on different food sources. The higher mortality of aphid on day 4 for flower-fed aphid and day 6 for pod-fed aphid reared at 30°C may contribute to the lower R_o value than the R_o value of aphids reared at 25°C. In the present study, a higher intrinsic rate of increase and longer mean generation time were found for aphids reared at 25°C.

Intrinsic rate of increase (r_m)

Aphids fed on seed pods had a lower intrinsic rate of increase (r_m) than aphids fed on flowers (Table 1). Generally speaking, the r_m value ranged from 0.400 to 0.530. Aphids reared at 25°C had a higher r_m value than those exposed to 30 °C. On the contrary, the slightly higher r_m value of seed pod-fed aphids of 25°C might cause by the late start of first reproduction and lower m_x value that has shown the smaller area of $l_x m_x$ in Fig. 4.

The daily fecundity

Figure 5 shows the daily fecundity of each treatment. The number of progeny produced by female turnip aphids reached a peak on day 3 or day 4. Higher numbers of progeny were produced for turnip aphids grown at 25°C when compared with 30°C except on day 4 of seed pod-fed aphids at 30°C.

Nymphal stage and nymphal size

Table 2 shows the data on development of nymphal stage of turnip aphids fed flower or seed pods. The nymphal duration ranged from 1.0 to 1.4 days when reared at 25°C and ranged from 1.0 to 1.5 days at 30°C. The body size increased with developmental stage

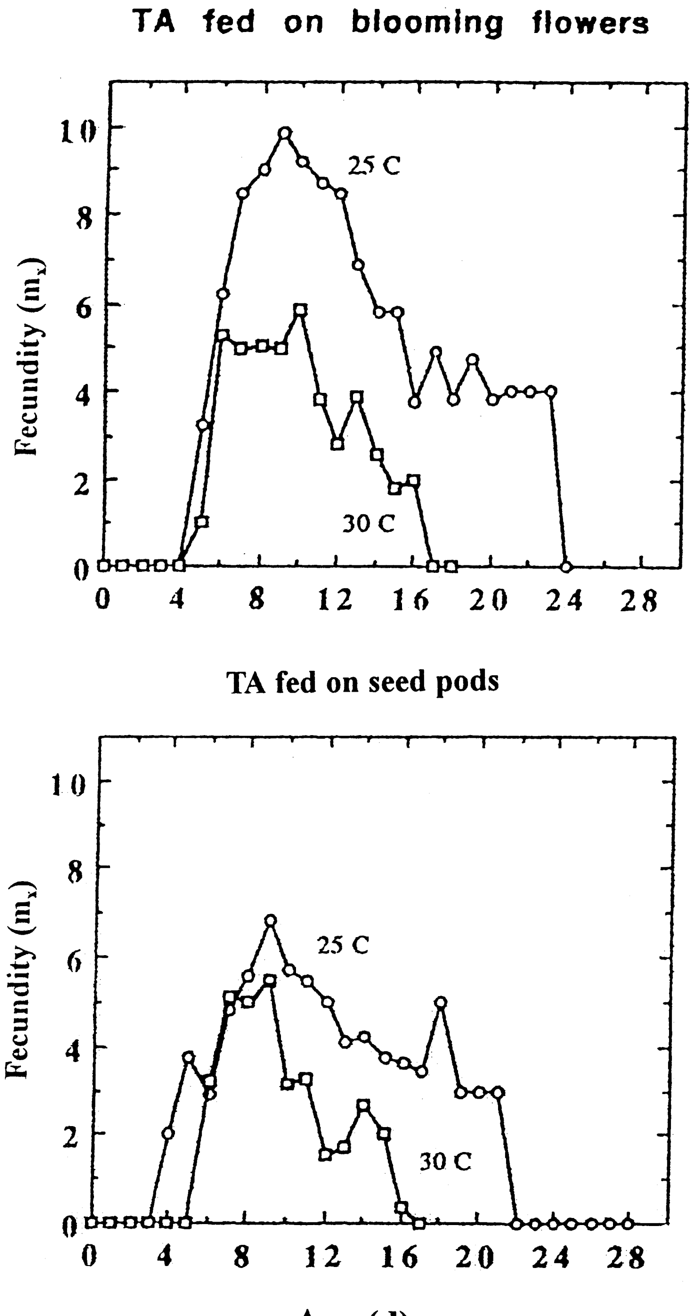


Fig. 2. Age-specific fecundity (m_x) of *Lipaphis erysimi* (Kalt.) fed on flowers and seed pods at various temperatures.

(Table 3). No matter the food turnip aphid were fed, they had smaller body lengths when they reared at 30°C (Table 3).

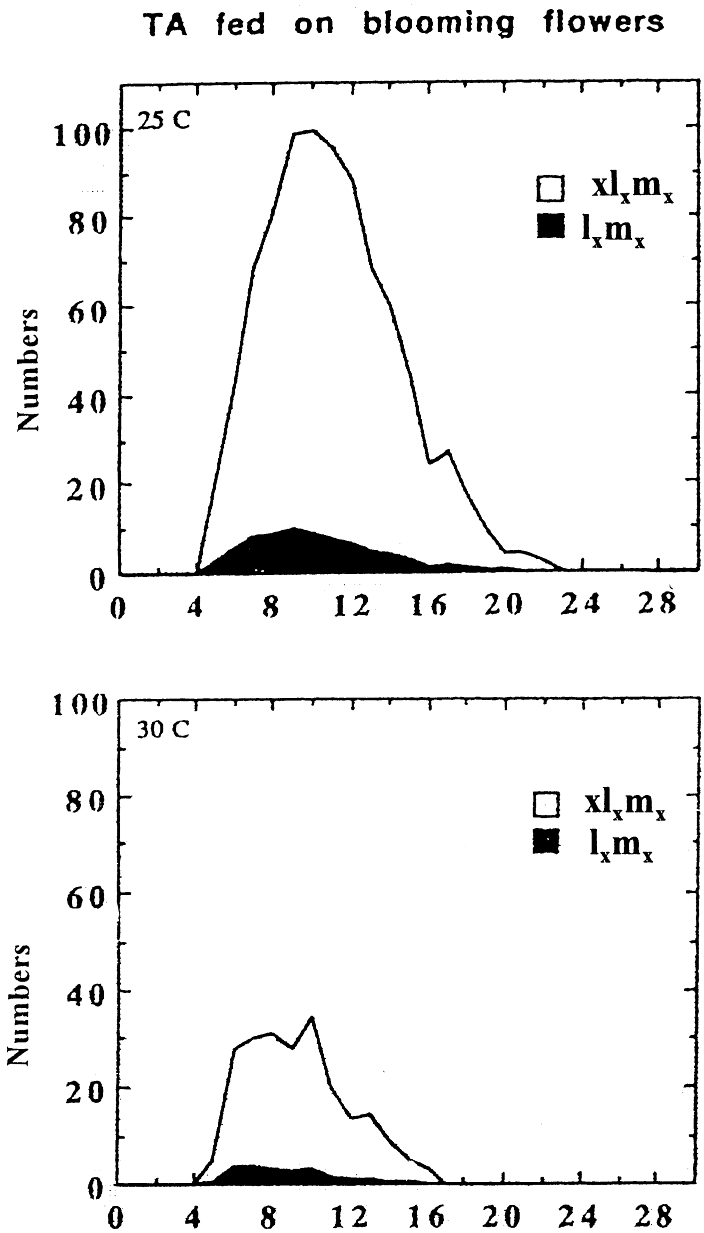


Fig. 3. Distribution of l_xm_x and xl_xm_x of *Lipaphis erysimi* (Kalt.) fed on blooming flowers at various temperatures.

Discussion

The l_xm_x curves of flower-fed aphids and pod-fed aphids reared at 25°C and 30 °C showed the generalized triangular reproductive function as modeled by

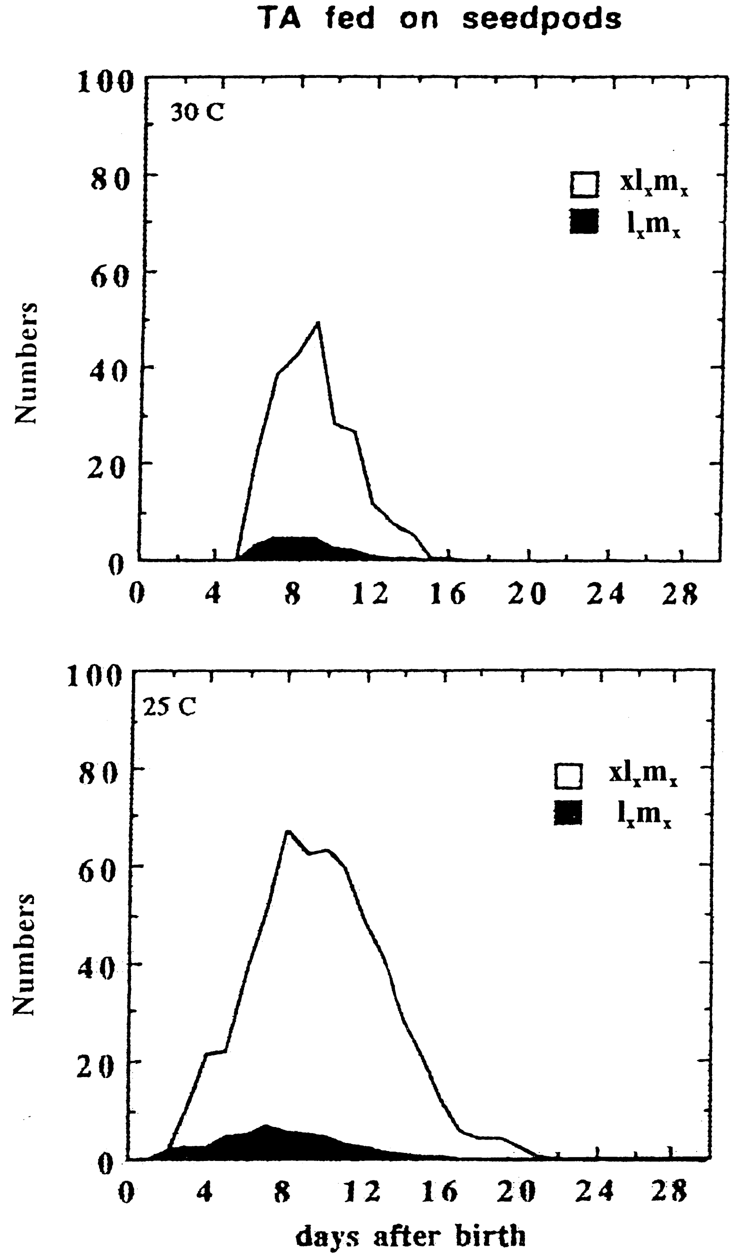
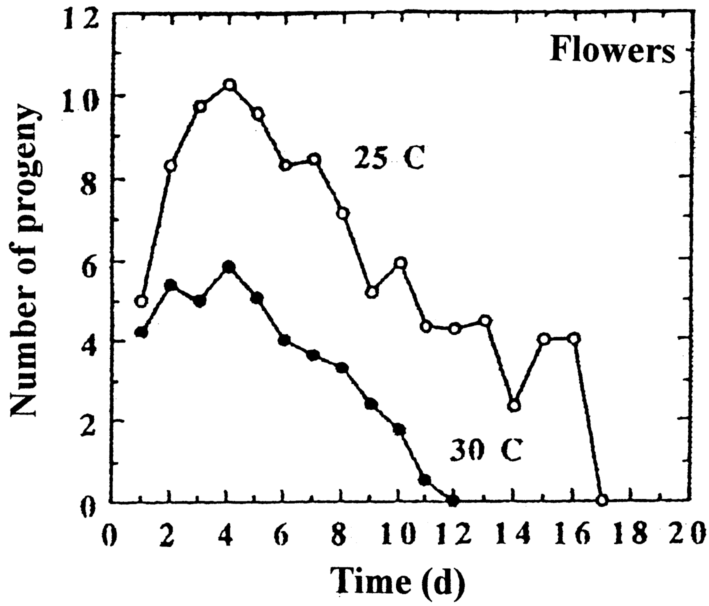


Fig. 4. Distribution of $l_x m_x$ and $x l_x m_x$ of *Lipahis erysimi* (Kalt.) fed on seed pods at various constant temperatures.

Lewontin (1965) and agree with data of both *Spodoptera litura* (Hsiao and Chen 1984) and *Ropalosiphum padi* (Hsiao, 1993).

The present data shown that flower-fed aphids had the highest R_o when reared at



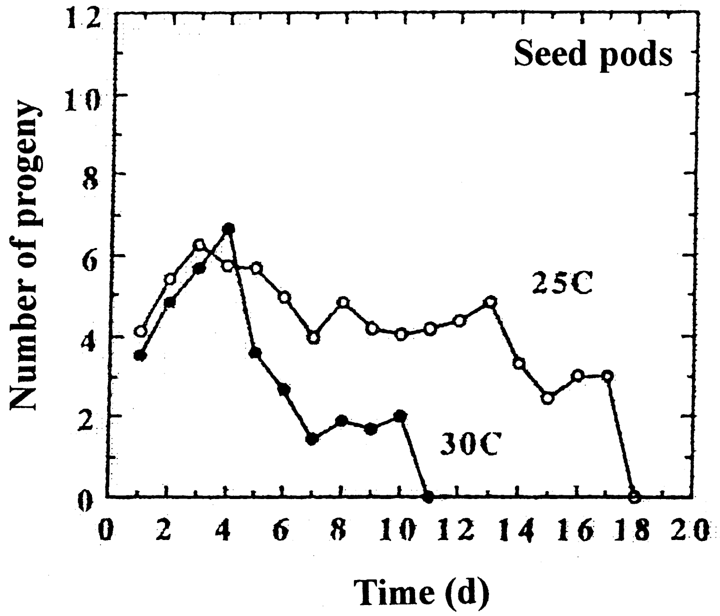


Fig. 5. Daily number of progeny produced by flower-fed and seed pod-fed *Lipaphis erysimi* (Kalt.) at various temperatures.

25°C compared with the other three treatments. Kundu and Pant (1968) reported no significant difference in aphid number on 62- (flowering and initiation of pod) and 72-day (Half pod) - old plants. The present data do not agree

Table 1. Population growth parameters of *Lipaphis erysimi* reared on blooming flowers and fresh pods of kale at different temperatures

Temperature (℃)	Net reproduction rate (R_o)	Mean generation time ($\bar{T}$)	Intrinsic rate of increase (r_m)
		Blooming flower	
25	77.81 a	10.19 a	0.530 a*
30	22.88 c	8.72 b	0.402 b
		Fresh pod	
25	52.44 b	9.83 a	0.403 b
30	24.45 c	8.61 b	0.400 b

* Means in a column followed by the same letter are not significantly different by Duncan's multiple range test ($P < 0.05$).

Table 2. Period of life stages of *Lipaphis erysimi* reared on blooming flowers and seedpods at different temperatures

Plant part	Instar (d)			
	1	2	3	4
		At 25℃		
Flowers	1.17	1.2	1.2	1.4
Fresh pods	1.0	1.2	1.3	1.2
		At 30℃		
Flowers	1.0	1.0	1.3	1.5
Fresh pods	1.0	1.4	1.1	1.3

Table 3. Body length of different stages of *Lipaphis erysim* reared on blooming flowers and seed pods at different temperatures

Instar	Body length (mm)	
	Flower Mean±S.D.	Fresh pod Mean±S.D.
	At 25℃	
I	22.69+2.93 d	22.48+2.21 e*
II	28.91+3.36 c	29.33+3.65 c
III	36.02+5.09 b	36.57+5.11 b
IV	42.64+5.31 a	41.75+4.84 a
	At 30℃	
I	22.26+2.93 d	21.05+1.91 e
II	27.17+3.19 c	26.59+3.78 d
III	33.74+3.82 b	32.13+5.30 b
IV	41.38+3.56 a	38.94+4.08 a

* Means in a column followed by the same letter are not significantly different by Duncan's multiple range test ($P < 0.05$)

with theirs and this might be due to using different varieties of Brassica.

Cole (1954) emphasized the important role of the first reproduction in contribution to r_m values. In the present study, aphids reared at both temperatures had the same age (day) of the first reproduction, therefore, the higher r_m

value of flower-fed aphids may due to higher age-specific fecundity.

Hsiao and Chen (1984) reported that the higher the r_m value, the shorter the mean generation time for *Spodoptera litura* fed on soybean. In the present study, the higher the r_m value, the longer the mean generation time which dose not agree with the previous result. The value of r_m presented here provides a direct comparison of the intrinsic rate of increase of turnip aphids fed on different plant parts of kale.

DeLoach (1974) indicated that for turnip aphid reared on detached cabbage leaves at 25°C and 30°C, the values of r_m were 0.372 and 0.207, respectively. Phadke (1982) fed turnip aphids with *Brassica junea* and *B. campestris*, and values of r_m were 0.1690 and 0.1552, respectively. The values of r_m in the present study were much higher than in previous work. This might due to differences of host plants they were fed, and nutrient differences among leaves, flowers and seed pods. The lower value of r_m for seed pod-fed aphids might be due to less water in seed pods, and further study is needed. DeLoach (1974) indicated that turnip aphids in mid-summer sometimes increase to a large number in only a few days in the field. In the present study, the high value of r_m of turnip aphids at 25-30°C agrees with DeLoach's findings.

The present data indicated that total nymphal duration as well as various stadia did not differ significantly as Tripathi *et al.* (1986) reported. However, slightly longer periods of 3rd and 4th instars for aphids were showm when reared at 30°C when compared with aphids reared at 25°C. On the contrary, seed pod-fed 2nd instar has a longer developmental time than blooming flower-fed aphids. Numbers of molts on various host parts did not differ significantly with all treatments. However, a slightly shorter period of 3rd instar was shown for aphids reared at 30°C.

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僞菜蚜(同翅目：蚜蟲科)取食芥藍之發育生物學及其族群增長

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摘　　要

於室內25及30℃定溫下，以盛開之花朵及種莢爲食物餵食偽菜蚜，以探討其生長速率(包括若蟲發育、齡別存活率、齡別繁殖率、平均壽命長度及內在增殖率等因子)。在25℃下取食花朵之偽菜蚜的內在增殖率最高(r_m=0.5299)，而30℃取食種莢之偽菜蚜的內在增殖率最低(r_m=0.3997)。不論所取食之食物類別，在處理溫度25℃處理組皆有較高之內在增殖率、淨增殖率(R_o)及平均世代時間。而蛻皮數及各齡若蟲體長在處理間並無顯著差異。35℃處理組的齡別存活率(l_x)於第四天就降到零。取食花朵組，齡別存活率在30℃時自第3天，25℃自第10天開始下降。取食種莢組，齡別存活率在30℃時自第6天，25℃自第10天開始下降。取食花朵組在25℃自第4天，30℃自第5天開始產後代。取食種莢組，在25℃自第4天，30℃自第6天就開始產後代。就齡別繁殖率，不論食物類別，25℃處理組的數值皆高於30℃處理組的數值。後代產生數25℃處理組皆高於30℃處理組。

關鍵詞：*Lipaphis erysimi*、發育生物學、族群增長、內在增值率。