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The effects of temperature for development time, fecundity and reproduction on some ornamental aphid species

Nihal Özder1, Özgür Sağlam[1*]

[(1)] Namık Kemal University, Faculty of Agriculture, Department of Plant Protection, Tekirdağ, TURKEY

* Corresponding author: E-mail: osaglam14@hotmail.com, tel. +90 282 2502086, fax:+902822509929

Abstract

The development time, survivorship and reproduction of the *Sarucallis kahawaluokalani* (Kirkaldy), *Eucallipterus tiliae* L., *Capitophorus elaeagni* del Guercio, *Aphis nerii* Boyer de Fonscolombe, *Cinara cedri* Mimeur were studied on the *Lagerstroemia indica* L., *Tilia tomentosa* Moench, *Elaeagnus angustifolia* L., *Nerium oleander* L. and *Cedrus libani* Loud. at four constant temperatures (20°C, 22.5°C, 25°C and 27.5°C). Total nymphal development time ranged from 7.78 d at 22.5°C to 9.81 d at 25°C of *C.elaeagni*, 9.32 d at 25°C to 12.5 d at 20°C of *E. tiliae,* 7.08 d at 27,5°C to 11.14 d at 20°C of *S. kahawaluokalani*, 15.85 d at 25°C to 12.57 d at 20°C of *A. nerii* and 13.00 d at 20°C to 10.07 d at 25°C of *C. cedri.*

The intrinsic rate of increase (r_m) at 22.5°C had the highest value for *S. kahawaluokalani* and *C. elaeagni* (0.5703) and (0.2945) among all tested constant temperatures. The calculated r_m was higher at 25°C for *E. tiliae* (1.4124) and *C. cedri* (0.2975) and at 20°C *A. nerii* (0.2648). That the optimal temperature for *E. tiliae* and *C.cedri* on *T. tomentosa* and *C. libani* was 25°C, for *C. elaeagni* and *E. tiliae* was 22.5°C on *E. angustifolia* and *T. tomentosa* and for *A. nerii* was 20°C on *N. oleander*.

Keywords: *Aphis nerii*, *Capitophorus elaeagni, Cinara cedri, Eucallipterus tiliae*, developmental time, host plants, life table, *Sarucallis kahawaluokalani*

Introduction

Crape myrtle, *Lagerstroemia indica* L. (Lythraceae), Linden, *Tilia tomentosa* Moench. (Tiliaceae), Russian olive, *Elaeagnus angustifolia* L. (Elaeagnaceae), Oleander, *Nerium oleander* L. (Apocynaceae) and Lebanon cedar, *Cedrus libani* Loud. (Pinaceae) are some of the most important ornamental plants in the world. They are beautiful for summer flowers, fall foliage color, unique bark and growth habits, and their general utility make them excellent landscape plants. These plants make majestic species trees for parks, estates and larger lawns and will be as wide as tall. They are truly picturesque species. Some of these trees produce fragrant and nectar-producing flowers. Medicinal herb lime blossom are used to make perfumes. Also, they are very important honey plants for beekeepers, producing a very pale but richly flavoured monofloral honey. The wood of these ornamental trees are valuable in the manufacture of furniture.

Due to their large leaf areas relative to the ground on which they stand and the physical properties of their surfaces, trees can act as biological filters, removing large numbers of airborne particles and hence improving the quality of air in polluted environments. The role of vegetation and urban woodlands in reducing the effects of particulate pollution is noted here. The improvement of urban air quality achieved by establishing more trees in towns and cities is also illustrated (Beckett, et al.,1998).

Aphids are important pests of many crops, either indirectly, acting as virus vectors, or directly by feeding on plant assimilates. Aphids eject honeydew away from their feeding location preventing them from becoming entangled within the sticky secretion. Honeydew accumulates on objects below aphid secretion. Honeydew accumulates on objects below aphid populations and is commonly seen as a shiny coating on the tops of leaves and stems. Black sooty molds are fungi that grow on honeydew produced by aphid or other phloem feeding insects. Additionally, tree aphids have been implicated in the death of their hosts (Orondo and Day, 1994).

Sarucallis kahawaluokalani (Kirkaldy), *Eucallipterus tiliae* L., *Capitophorus elaeagni* del Guercio, *Aphis nerii* Boyer de Fonscolombe and *Cinara cedri* Mimeur have an almost cosmopolitan distribution (Blackman and Eastop, 1994; Pierce, et al., 1998; Dixon,1971; Ripka, 2001; Flurkiger and Braun, 1995; Mizell and Knox, 1993; Lazzari and Carvalho, 2006) and are present in Turkey (Toros, et al., 2002; Ünal and Özcan, 2005).

Plant damage is generally a function of insect population levels. Populations with higher rates of increase have greater potential for causing plant injury. Temperature is the most important abiotic factor affecting development and reproduction of aphids. Geographically separated populations of aphids may differ with respect to the influence of temperature on development and population growth. Temperature influences both aphid development and mortality and is a fundamental feature of its life history.

The purpose of this work is to determine the variation of biological parameters of the *S. kahawaluokalani*, *E. tiliae*, *C. elaeagni*, *A. nerii*, *C. cedri* on the *L. indica, T. tomentosa*, *E. angustifolia, N. oleander* and *C. libani* in the laboratory.

Material and methods

Aphid and plant source

S. kahawaluokalani, *E. tiliae*, *C. elaeagni*, *A. nerii*, *C. cedri* were collected from each of species plant: Crape myrtle *L. indica*, Linden *T. tomentosa*, Russian olive *E. angustifolia*, Oleander *N. oleander*, Lebonon cedar *C. libani* in Tekirdağ, Turkey. The aphids were raised on potted plants. Plants were maintained a climatic room held at 25±1°C, a relative humidity 65±5 %, and a light regime (16 h light; 8 h dark).

Development and survival

Nymphal development duration was estimated on *L. indica*, *T. tomentosa*, *E. angustifolia, N. oleander and C. libani* grown at four different temperatures (20±1, 22.5±1, 25±1 and 27.5±1 °C, ambient temperature) under conditions of controlled day length (16 h light; 8 h dark).

For each of 40 replicates per temperature and plant species, apterous adults were placed on an on an isolated cutting of the appropriate species. Observations were made until the adult established, and each twig hosted one progeny. Adults were removed after this occurred. Times were recorded when nymphs underwent ecdysis at each instar. The aphids on each Petri dish were checked daily under a stereoscopic microscope, and their survival was recorded at each constant temperature.

Adult longevity and reproduction

When the immature nymphs became adults, they were observed daily for reproduction and survival and all new-born nymphs were removed from each Petri dishes after counting. These observations continued at all constant temperature regimes until the mature aphid died. Developmental times for each nymphal instar, duration of adult pre-reproductive, reproductive and post-reproductive periods, lifetime fecundity and average daily reproduction were calculated for each aphid. Forty aphids were tested for all temperature conditions.

Data analyses and statistics

Differences in nymphal development times, adult life span, fecundity, and daily reproduction at four constant temperatures were tested by analysis of variance. If significant differences were detected, multiple comparisons were made using Tukey's HSD multiple range test (P=5%).

The effect of different temperatures on biology of the was assessed by constructing a life table, using age specific survival rates (l_x) and fecundity (m_x) for each age interval (x) per day. The intrinsic rate of increase r_m was calculated by iteratively solving the equation $\sum e^{-rx} l_x m_x = 1$, where the age-specific survival rate (l_x) is the proportion of individuals in the original cohort alive at age x, and the age-specific fecundity (m_x) is the mean number of female progeny produced per female alive in the age-interval x. The net reproductive rate, $R_0 = \sum l_x m_x$, also was calculated according to Birch, (1948).

Results

Development times

The developmental times for the immature stage s at four constant temperatures are presented on *L. indica*, *T.tomentosa*, *E. angustifolia*, *N.oleander* and *C. libani* are in Table 1. The developmental times of the *E. tiliae* and *S. kahawaluokalani* decreased significantly, as constant temperature increased on *T. tomentosa* and *L. indica*. Also, developmental times of the *Aphis nerii* on *Nerium oleander* increased significantly, as constant temperature increased. The constant temperature of 27.5°C was lethal of *E. tiliae*, and *A. nerii*. Total nymphal development time ranged from 7.78 d at 22.5°C to 9.81 d at 25°C of *C.elaeagni*, 9.32 d at 25°C to 12.5 d at 20°C of *E. tiliae,* 7.08 d at 27,5°C to 11.14 d at 20°C of *S. kahawaluokalani*, 15.85 d at 25°C to 12.57 d at 20°C of *A. nerii* and 13.00 d at 20°C to 10.07 d at 25°C of *C. cedri* (Table 1.).

Adult longevity and reproduction

Temperature affected adult longevity and fecundity significantly. The mean longevity of adult varied from 7.90 d at 22.5°C to 12.83 d at 20°C for *E. tiliae*, 6.16 d at 27.5°C to 16.88 d at 20°C for *S. kahawaluokalani,* 20.97 d at 22.5°C to 30.42 d at 20°C for *A. nerii* and 15.57 d at 22.5°C to 21.00 d at 20°C. At three temperature (20°C 22.5°C and 25°C) the mean longevity of adult females of *A. nerii* was higher other female (Table 1.).

Fecundity was affected significantly for *S. kahawaluokalani*, *A. nerii* and *C. cedri* at 20 °C through 27.5 °C. Average nymph production of *A. nerii* and *C. cedri* per female reached a maximum of 17.37 and 25.00, respectively at 20°C on, *N. oleander* and *C. libani,* respectively (Table 1.).

Intrinsic rate of increase (r_m), net reproduction rate(R_0), generation time (T_0) and for the *S. kahawaluokalani*, *E. tiliae*, *C. elaeagni*, *A. nerii*, *C. cedri* on the *L. indica, T. tomentosa, E. angustifolia*, *N. oleander* and *C. libani* at four different temperatures are given in Table 2.

The largest r_m was 0.2945 on *E. angustifolia* for *C. elaeagni*, 0.2287 on *T. tomentosa* for *E. tiliae,* 0.5703 on *L. indica* for *S. kahawaluokalani,* 0.2648 on *N. oleander* for *A. nerii* and 0.2975 on *C. libani* for *C. cedri*.

Increasing temperatures resulted in shorter generation times (T_0) for *E. tiliae* on *T. tomentosa*, (14.57 d at 20°C , 11.55 d at 22.5°C, 9.53 d at 25°C) and longer generation times (T_0) for *A. nerii* on *N. oleander* (13.40d at 20°C, 14.77 d at 22.5°C, 18.14 d at 25°C).

Discussion

Temperature is a key biotic factor that regulates insect population dynamics, reproduction, mortality and seasonal occurrence of aphids (Campbell, et al., 1974; Dixon, 1977; Dixon, 1987; Logan, et al., 1976). Although insects are not always subject to constant temperatures in nature, a controlled laboratory study can provide a valuable insight into the population dynamics of a particular species (Summers, et al., 1984). Our data clearly showed the effects of temperature on the development time longevity, fecundity of *C. elaeagni, E. tiliae*, *S. kahawaluokalani*, *A. nerii* and *C. cedri*.

The optimum temperature for development of *E. tiliae* was 25°C. Insects reared at temperatures above the upper threshold develop slower than those reared under more favorable conditions (Stinner, et al., 1974; Curry, et al., 1978; Kersting, et al., 1999). This was less obvious for *E. tiliae* on *T. tomentosa*, where the developmental time decreased to its lowest value at 25°C and further increase in temperature, all instars died. Similar observations were reported by Collins, et al., (2001 b) and Özder, et al., (2007) for *T. salignus*.

The intrinsic rate of natural increase (r_m) is a good indicator of the temperature at which the growth of a population is most favorable, because it reflects the overall effect of temperature on the development, reproduction and survival characteristics of a population (Birch,1948). The intrinsic rate of increase (r_m) summarizes the physiological qualities of an animal in relation to capacity for increase (Andrewartha and Birch 1954).The (r_m) values of different aphid species varied significantly with temperatures. Our results showed that the intrinsic rate of increase (r_m) at 22.5°C had the highest value for *S. kahawaluokalani* and *C. elaeagni* (0.5703) and (0.2945) among all tested constant temperatures. The calculated r_m was higher at 25°C for *E. tiliae* (1.4124) and *C. cedri* (0.2975) and at 20°C *A. nerii* (0.2648), because of the faster development and greater progeny production.

Our results demonstrate that different constant temperature can play an important role in the population gorwth of aphids. A controlled study can provide a valuable insight into the population dynamics of a particular species. That the optimal temperature for *E. tiliae* and *C. cedri* on *T. tomentosa* and *C. libani* was 25°C, for *C. elaeagni* and *E. tiliae* was 22.5°C on *E. angustifolia* and *T. tomentosa* and for *A. nerii* was 20°C on *N. oleander*. This may particularly explain why *E. tiliae* and *C. cedri* populations were significantly higher during the summer months, *C. elaeagni* and *E. tiliae* were significantly higher during the spring months, and *A. nerii* were significantly higher during the early autumn. Also, results obtained in this study might provide useful information to aphid control and developing management strategy.

References

Andrewartha, H.G., Birch, L.C., (1954) The distribution and abundance of animals. University of Chicago Press, Chicago.

Beckett, K.P., Freer-Smith, P.H., Taylon, G., (1998) Urban woodlands: their role in reducing the effect of particulate pollution. Environmental Pollution, 99 (3), 347-360.

Birch, L.C., (1948) The intrinsic rate of natural increase of an insect population. Journal of Animal Ecology, 17, 15-26.

Blackman, R.L., Eastop, V.F., (1994) Aphids on the world's Trees: an Identification and information Guide. CAB International in association with The Natural History Museum, London, UK.

Campbell, A.B., Frazer, D., Gilbert, N., Gutierrez, A.P., Mackauer, M., (1974) Temperature requirements of some aphids and their parasites. Journal of Applied Ecology, 11, 431-438.

Collings C.M., Leathe S.R., (2001) Effect of temperature on fecundity and development of the Giant Willow Aphid, *Tuberolachnus salignus* (Sternorrhyncha: Aphididae). Europian Journal of Entomology, 98, 177-182.

Curry, G.L., Feldman, R.M., Sharpre, P.H.J., (1978) Foundations of stochastic development. Journal of Theoretical Biology, 74, 397-410.

Dixon, A.F.G., (1971) The role of aphids in wood formation. II. The effect of the limeaphid , *Eucallipterus tiliae* L. (Aphididae), on the growth of the lime, *TiliaXvulgaris* (Hayne). Journal of Applied Ecology, 8, 393-399.

Dixon, A.F.G., (1977) Aphid ecology: life cycles, polymorphism and population regulation. Annual Review of Ecology**,** 8, 329-353.

Dixon, A.F.G., (1987) Parthenogenetic reproduction and the rate of increase in aphids. In: Minks AK, Harrewijn P (Eds) Aphids their biology, natural enemies and control Vol A., 269-287, Amsterdam: Elsevier.

Flurkiger W., Braun, S., (1995) Sress factors of urban tress and their relevance for vigour and predisposition for parasite attaks. Acta Horticulture 496: 325-334.

Kersting, U., Satar, S., Uygun, N., (1999) Effect of temperature on development rate and fecundity of apterus *Aphis gosspii* Glover (Hom., Aphididae) reared on *Gossypium hirsutum* L. Journal of Applied Entomology 123: 23-27.

Lazzari, S.M.N., De Carvalho, R.C.Z., (2006) Modeling egg distribution of *Sarucallis kahawaluokalani* (Kirkaldy) (Hemiptera : Aphididae) on larger *Stroemica indica* L. (Lythraceae). Neotropical Entomolgy 35 (6), 762-768.

Logan, J.A., Wolkind D.J., Hoyt, S.C., Tanigoshi, L.K., (1976) An analytic model for description of temperature dependent rate phenomena in arthropods. Environmental Entomology, 5, 1133-1140.

Mizell, R.F.III, Knox, G.W., (1993) Susceptibility of Crapemyrtle *Lagerstroemia indica* L., to the crapemyrtle aphid (Homoptera : Aphididae) in Nort Florida. Journal of Entomological Science, 28, 1-7.

Orondo, S.B.O., Day, R.K., (1994) Cypress aphid (*Cinara cupressi*) damage to a cypress (*Cupressus lusitanica*) stand in Kenya. International Journal of pest Management, 40, 141-144.

Özder, N., Sağlam, Ö., Güven, A., Aydın, V., (2007) Effect of temperature on development, mortality, fecundity and reproduction of *Tuberolachnus salignus* on weeping willow (*Salix babylonica*) and Corkscrew willow (*Salix matsudana*), Phytoparasitica 35 (4), 386-391.

Pierce, G.L., Baker, J.R., Linker H.M., Warren, S.L., (1998) Using horticultural oil, pruning, and acephate banding to reduce the first generation of crapemyrtle aphid. Environmental Horticulture, 16 (1), 52-55.

Ripka, G., (2001) New data to the knowledge of the aphid fauna of Hungary (Homoptera: Aphidoidea). Acta Phytopathologica et Entomologica Hungarica, 36 (1/2), 81-87

Stinner, R.E., Gutierrez, A.P., Jr. Butler, G.D., (1974) An algorithm for temperature-dependent growth rate stimulation. Canadian Entomology, 106, 145-156.

Summers, C.G., Coviello R.L., Gutierrez A.P., (1984) Influence of constant temperatures on the development and reproduction of *Acyrthosiphum kondoi* (Homoptera: Aphididae). Environmental Entomology, 13, 236-242.

Toros, S, Uygun, N., Ulusoy, R., Satar, S., Özdemir, I., (2002): The Aphidoiea Species of East Mediterranean Region. Tarım ve Köyişleri Bakanlığı, Ankara.

Ünal, S., Ercan, Ö., (2005) Kastamonu yöresi Aphididae (Homoptera) türleri. Süleyman Demirel Üniversitesi, Orman Fakültesi Dergisi 13 (1), 76-83.

Table 1. Mean (±S.E.) total nymphal duration, fecundity and longevity of female *C. elaeagni, E. tiliae*, *S. kahawaluokalani*, *A. nerii*, *C. cedri* on *E. angustifolia, T. tomentosa*, *L. indica*, *N. oleander* and *C.libani* at four different temperatures.

Aphid species	Hosts	Temperature °C	Total nymphal duration	Adult longevity	Fecundity
C. elaeagni	*E. angustifolia*	20	9.80±0.37 b[z]	11.66±0.33 a	2.66±0.33 a
		22.5	7.78±0.21 a	7.83±1.93 a	5.66±1.05 a
		25	9.81±0.26 b	7.85±1.49 a	6.50±1.36 a
		27.5	8.00±0.57 a	-	-
E. tiliae	*T. tomentosa*	20	12.50±0.42 c	12.83±1.57 c	21.57 ±2.95 a
		22.5	10.23 ±0.23 b	7.90±1.22 a	10.60 ±1.53 a
		25	9.32 ±0.14 a	8.96 ±0.71 ab	21.21 ±2.58 a
		27.5	-	-	-
S. kahawaluokalani	*L. indica*	20	11.14±0.23 b	16.88±2.08 b	4.70±4.31 b
		22.5	7.67±0.10 a	15.29±1.34 b	70.08±5.68 c
		25	7.40±0.25 a	15.78±1.01 b	22.17±3.53 a
		27.5	7.08±0.15 a	6.16±0.61 a	20.32±2.33 a
A. nerii	*N. oleander*	20	12.57±0.28 a	30.42±1.40 b	17.37±0.96 b
		22.5	13.54±0.20 a	20.97±1.48 a	5.02±0.22 a
		25	15.85±0.66 b	23.50±1.75 a	4.11±0.42 a
		27.5	-	-	-
C. cedri	*C. libani*	20	13.00±0.54 b	21.00±3.00 b	25.00±7.00 b
		22.5	11.23±0.21 a	15.57±0.52 a	14.07±2.15 ab
		25	10.07±0.71 a	15.77±0.48 a	17.96±1.99 ab
		27.5	11.00±0.69 a	17.28±1.39 ab	6.57±1.88 a

[z] Within columns, means followed by a common letter do not differ significantly (P=0.05, Tukey's HSD multiple range tests).

Table 2. Life table paremeters of *C. elaeagni, E. tiliae*, *S. kahawaluokalani*, *A. nerii*, *C. cedri* on *E. angustifolia, T. tomentosa*, *L. indica*, *N. oleander* and *C. libani* at four different temperatures.

Reproduction rate(R_0), Generation time (T_0), Intrinsic rate of increase(r_m)

Aphid species	**Hosts**	**Temperature °C**	**Reproduction rate(R_0)**	**Generation time (T_0)**	**Intrinsic rate of increase(r_m)**	**λ**
C. elaeagni	*E. angustifolia*	20	2.00	10.83	0.0640	1.0660
		22.5	10.55	8.00	0.2945	1.3424
		25	10.74	9.63	0.2465	1.2795
		27.5	-	-	-	-
E. tiliae	*T. tomentosa*	20	25.06	14.57	0.2210	1.2474
		22.5	14.05	11.55	0.2287	1.2570
		25	22.88	9.53	1.4124	0.3453
		27.5	-	-	-	-
S. kahawaluokalani	*L. indica*	20	43.96	11.16	0.3390	1.4039
		22.5	70.82	7.47	0.5703	1.7687
		25	22.90	7.28	0.4301	1.5374
		27.5	20.78	14.57	0.2082	1.2315
A. nerii	*N. oleander*	20	34.79	13.40	0.2648	1.3032
		22.5	17.66	14.77	0.1943	1.2145
		25	16.82	18.14	0.155	1.1683
		27.5	-	-	-	-
C. cedri	*C. libani*	20	27.00	12.50	0.2636	1.3016
		22.5	18.08	11.92	0.2428	1.2748
		25	24.14	16.70	0.2975	1.3465
		27.5	14.00	11.80	0.2236	1.2506