

TEMPERATURE EFFECTS ON DEVELOPMENT AND REPRODUCTION OF THE SOUTHERN RED MITE, *OLIGONYCHUS ILICIS*¹, REARED² ON *ILEX CRENATA*

BY G. H. CHILDS³, T. R. ASHLEY⁴ D. H. HABECK³ and S. L. POE³

DEVELOPMENT
TEMPERATURE
MORTALITY
SURVIVAL RATE
TETRANYCHIDAE

ABSTRACT : Southern red mites, *Oligonychus ilicis* (McGregor) reared on holly, *Ilex crenata* 'Hetzii', completed egg-to-adult development at constant temperatures from 15.5 to 35.0°C. Developmental times generally decreased as temperatures increased and developmental curves for all stages were cubic. Maximum reproductive potential occurred at 26.5°C and length of the pre-, post-and ovipositional periods decreased as temperatures increased. Mortality for both male and females was minimized at 21.0°C. Survival rate of *O. ilicis* was highest for eggs and greatest mortality occurred in the larval stage. Mean generation time was shortest at 35 and longest at 21°C, and the net reproductive rate and the intrinsic rate of natural increase were highest at 26.5°C.

DESARROLLO
TEMPERATURA
MORTALIDAD
SOBREVIVIMIENTO
TETRANYCHIDAE

EXTRACTO : Las mitas meridionales rojas *Oligonychus ilicis* (McGregor) alimentadas de *Ilex crenata* « Hetzii » completaron su desarrollo, de huevos a adultos, bajo temperaturas constantes de 15.5° a 35.0° Centígrados. La duración de su desarrollo generalmente bajó según la temperatura subió, y las curvas de desarrollo de todas sus etapas fueron cúbicas. La producción máxima se alcanzó a 26.5° Centígrados, y la duración de los periodos antes y después de la oviposición disminuyó según la temperatura subió. La mortalidad de ambos machos y hembras fué mínima a 21.0° Centígrados. El porcentaje mayor de sobrevivimiento de *O. ilicis* ocurrió en los huevos, y la mortalidad máxima ocurrió en la etapa larval. El tiempo average de generación más corto tomó lugar a 35° Centígrados, y el máximo a 21° Centígrados. Los porcentajes de reproducción neta y de aumento natural intrínseco fueron mayores a 26.5° Centígrados.

DÉVELOPPEMENT
TEMPÉRATURE
MORTALITÉ
SURVIE
TETRANYCHIDAE

RÉSUMÉ : Les Acariens méridionaux *Oligonychus ilicis* (McGregor), élevés sur *Ilex crenata* « Hetzii », ont achevé entre 15,5°C et 35,0°C leur développement de l'œuf à l'adulte à température constante. La durée du développement a généralement diminuée aux températures les plus élevées et les courbes de développement ont été cubiques pour toutes les stases. Le potentiel reproducteur maximum s'est manifesté à 26,5°C et les périodes de préoviposition, d'oviposition et de postovipo-

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2. Florida Agriculture Experiment Station Journal Series No. 4802. Received for publication.
3. Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611.
4. Insect Attractants, Behavior and Basic Biology Research Laboratory, Agric. Res. Serv., USDA, Gainesville, FL 32604.

sition ont été les plus courtes pour les températures les plus élevées. La mortalité a été minimale à 21,0°C pour les mâles et pour les femelles. Le taux de survie d'*O. ilicis* a été le plus élevé chez les œufs et la mortalité s'est montrée la plus grande chez les stases larvaires. La durée moyenne d'une génération a été la plus courte à 35°C et la plus longue à 21°C, tandis que le taux net de reproduction et le taux intrinsèque d'accroissement naturel ont été les plus élevés à 26,5°C.

The southern red mite, *Oligonychus ilicis* (McGregor), is an economically important mite feeding on the foliage of woody plants both agricultural and ornamental (JEPPSON *et al.*, 1975). In Brazil this mite appears year round on coffee plants causing greatest damage during the dry winter season in high, dry regions of the country (CALSA and SAUER, 1952). In Massachusetts greatest damage occurs on ornamentals in June when peak mite populations migrate to new plant growth. During the latter part of June and throughout July these populations decline but increase again in September when large numbers of overwintering eggs are deposited (MATTHYSEE and NAEGELE, 1952). Mite populations in northern Florida occur on a variety of ornamentals and increase with the onset of cooler weather in late October and early November and remain at high levels until May (DENMARK, 1968). Holly, *Ilex crenata* 'Hetzii', is one of the principal host plants of *O. ilicis* in Florida nurseries. Heavy mite infestations on holly result in unsightly plants, severe leaf-drop, and monetary loss for the nurseryman.

Effective control measures for this pest mite incorporate a knowledge of its life history so as to minimize the use of pesticides. No data are currently available relating temperature to the life history of this mite. The objectives of this research were to examine the influence of temperature on the mite's developmental rate, fecundity and mortality, and from these results to construct life tables and to calculate the intrinsic rate of natural increase and other related parameters (BIRCH, 1948).

MATERIALS AND METHODS

Southern red mites were collected in 1979 from field grown holly, *I. crenata*, near MacClenny,

FL and transported to Gainesville, FL. Gravid females (P₁ generation) were subsequently transferred to mite-free holly leaves until 450 leaves each with 5 female mites had been prepared. These mites and leaves were kept at 26.5°C for an 18-h ovipositional period at the end of which all mites were removed. Eggs deposited by these females marked the beginning of the F₁ generation. Five egg-bearing leaves were transferred to a single uncovered petri dish (90-mm diam) and 10 petri dishes were set for each temperature. These dishes contained absorbent cotton saturated with tap water to keep leaves fresh and to prevent mite escape. As the eggs hatched each larval mite was isolated on a holly leaf and returned to the same temperature regime where egg incubation occurred. Holly leaves were changed for individual mites every 4 to 5 days to avoid any effect from leaf deterioration. Mites exuviae were removed after each molt. Dishes were kept in environmental chambers at 13.0, 14.5, 15.5, 21.0, 26.5, 29.5, 32.0, 35.0, and 37.5 ± 1°C with a 12 : 12 photoperiod. Fluorescent illumination (ca. 2150 lum/m²) was used and humidity was not controlled.

To determine how frequently observations should be recorded to best reflect actual developmental times, data for 21.0 and 26.5°C collected at 6-h intervals were analyzed at 6-, 12-, and 24-h intervals. Significant differences (5 % level) were present between 6 and 24 h, but not between 6 and 12 h. Therefore, observations were made every 12 h. The lengths of each stage in the life cycle were recorded. Mites that matured to F₁ generation females were permitted to oviposit and the lengths of the pre-, post- and ovipositional periods as well as longevity and fecundity were recorded. Data were analyzed by analysis of variance and Duncan's multiple range test was used to separate means.

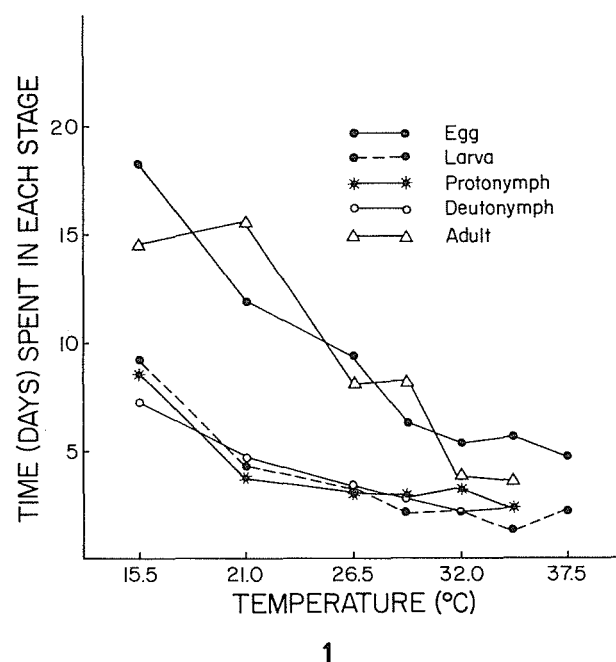


FIG. 1 : Mean time (days) spent in each life stage of the F_1 generation for *Oligonychus ilicis* at seven constant temperatures.

RESULTS AND DISCUSSION

The F_1 generation of southern red mites completed development under constant temperatures ranging from 15.5 to 35.0°C (Fig. 1). The greatest amount of time was spent in the egg and adult stages at all temperatures. All stages survived at 35.0°C, but only eggs and larvae completed their life stage at 37.5°C. Temperatures from 15.5 to 32.0°C reduced the time spent in the egg and adult stages whereas temperatures above 32.0°C did not substantially reduce developmental times for these two stages. Developmental times for larvae, protonymphs, and deutonymphs were most influenced when the temperature was increased from 15.5 to 21.0°C. The duration of these three stages was least influenced by temperature, particularly those above 26.5°C. The lower developmental threshold for eggs is probably near 15.5°C because 142 and 128 eggs held at 14.1 and 12.5°C, respectively, did not hatch or show any detectable signs of development after 45 days.

Stage-specific life tables indicated that the

least amount of apparent mortality occurred in the egg stage for all temperatures tested and the greatest amount of real mortality occurred in the larval stage regardless of temperature (Table 1). The survival rate for the entire life cycle was highest at 21.0°C. This rate showed a pronounced reduction at 15.5°C and at tem-

TABLE 1. — Stage-specific life table for one generation of southern red mite, *Oligonychus ilicis*, reared on holly leaves, *Ilex crenata*.

Temperature (°C)	No. alive	No. dying	Apparent mortality ¹	Real mortality ²	Survival rate ³
15.5					
Egg	79	7	8.9	8.9	91.1
Larva	72	51	70.8	64.6	26.6
Protonymph	21	11	52.4	13.9	12.7
Deutonymph	10	3	30.0	3.8	8.9
Adult	7	7	100.0	8.9	0.0
21.0					
Egg	117	4	3.4	3.4	96.6
Larva	113	60	53.1	51.3	45.3
Protonymph	53	10	18.9	8.5	36.8
Deutonymph	43	12	27.9	10.2	26.5
Adult	31	31	100.0	26.5	0.0
26.5					
Egg	124	9	7.3	7.3	92.7
Larva	115	76	66.1	61.3	31.5
Protonymph	16	9	56.3	7.3	5.6
Deutonymph	39	23	59.0	18.5	12.9
Adult	7	7	100.0	5.6	0.0
29.5					
Egg	101	6	5.9	5.9	94.1
Larva	95	60	63.2	59.4	34.7
Protonymph	35	19	54.3	18.8	15.8
Deutonymph	16	4	25.0	4.0	11.9
Adult	12	12	100.0	11.9	0.0
32.0					
Egg	109	7	6.4	6.4	93.6
Larva	102	77	75.4	70.6	22.9
Protonymph	25	17	68.0	15.6	7.3
Deutonymph	8	3	37.5	2.8	4.6
Adult	5	5	100.0	4.6	0.0
35.0					
Egg	79	16	20.3	20.3	79.7
Larva	63	39	61.9	49.4	30.4
Protonymph	24	14	58.3	17.7	12.7
Deutonymph	10	5	50.0	6.3	6.3
Adult	5	5	100.0	6.3	0.0
37.5					
Egg	42	8	19.0	19.0	81.0
Larva	34	31	91.2	73.8	7.1
Protonymph	3	3	100.0	7.1	0.0
Deutonymph	—	—	—	—	—
Adult	—	—	—	—	—

1. Percent of those individuals reaching the stage that died during the stage.

2. Percent of the initial cohort dying during the stage.

3. Percent of the initial cohort remaining alive at the end of the stage.

peratures of 32.0°C and above. These data demonstrate the substantial effects that temperature exerts during the life cycle of this mite. Since the best survival rates were recorded at 21.0°C it is readily apparent why this mite is a pest during the cooler months of the year rather than during the summertime. Even though the best survival rate was observed at 21.0°C, the mite reached its highest reproductive potential at 21.0°C where the net reproductive rate and intrinsic rate of natural increase were the greatest (Table 2).

TABLE 2. — Net reproductive rate, mean generation time, and intrinsic rate of natural increase for *Oligonychus ilicis* reared on *Ilex crenata* at six constant temperatures.

Temperature (°C)	Net reproductive rate	Mean generation time	Intrinsic rate of natural increase
15.5	1.4914	7.1127	.0562
21.0	3.7811	7.3119	.1819
26.5	6.3800	5.2260	.3546
29.5	2.9466	5.0100	.2157
32.0 ¹	—	—	—
35.0	1.4500	2.5695	.1446

1. Insufficient data for collections.

Additional data were gathered for each temperature on those mites that became adults in the F₁ generation (note Table 1 for actual number). The F₁ females exhibited a general decreasing pattern in the lengths of the preoviposition, oviposition, and postoviposition periods as the temperature increased (Table 3). The longest ovipositional periods occurred at

TABLE 3. — Mean days (\pm SE) required at six constant temperatures for preoviposition, oviposition and postoviposition periods and longevity of F₁ female southern red mites, *Oligonychus ilicis*, producing eggs and females not producing eggs.

Temp. (°C)	Preoviposition	Oviposition	Postoviposition	Female longevity	
				Eggs produced	Eggs not produced
15.5	2.9 \pm 0.7	5.4 \pm 2.0	9.1 \pm 1.1	17.4 \pm 3.0	7.5 \pm 0.5
21.0	2.8 \pm 0.3	5.5 \pm 1.6	7.2 \pm 2.0	15.4 \pm 2.4	8.5 \pm 0.0
26.5	1.5 \pm 0.0	10.0 \pm 0.0	1.0 \pm 0.0	12.0 \pm 0.0	7.0 \pm 0.0
29.5	2.5 \pm 0.3	4.0 \pm 1.2	3.8 \pm 0.9	10.3 \pm 1.8	7.0 \pm 0.0
32.0	0.5 \pm 0.7	1.8 \pm 1.8	1.0 \pm 0.0	4.3 \pm 1.8	2.3 \pm 1.3
35.0	1.8 \pm 1.8	1.8 \pm 0.8	2.0 \pm 1.0	5.5 \pm 2.0	—

21.0° and 26.5°C. The longest postoviposition period occurred at 15.5°C and the shortest preovipositional period was at 32.0°C. The best ovipositional pattern for achieving maximum reproduction potential occurred at 26.5°C where the greatest number of eggs per female was laid in the shortest period of time (Fig. 2). Temperatures below 26.5°C and above 29.5°C substantially lengthened and shortened the ovipositional period, respectively.

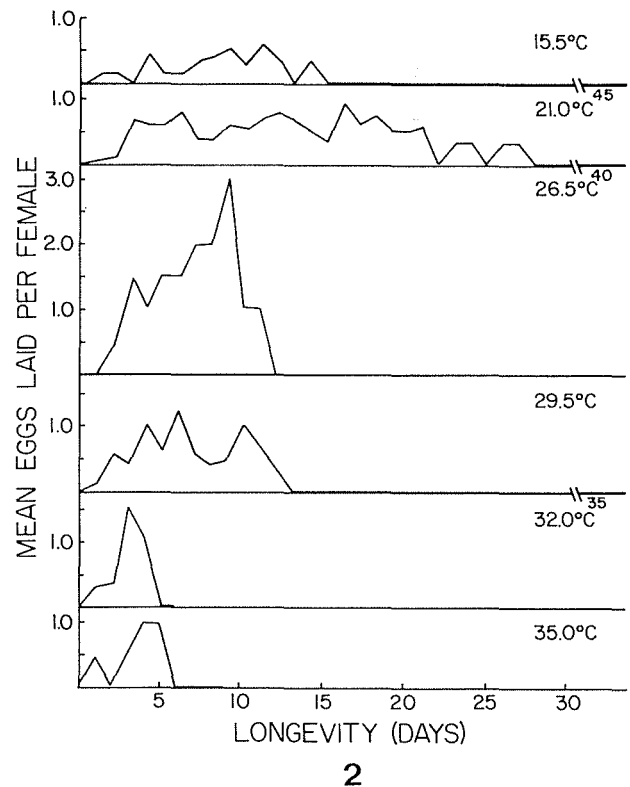


FIG. 2 : Mean eggs laid per female *Oligonychus ilicis* per day at six constant temperatures.

Mortality curves for the F₁ generation adults indicated that optimum longevity occurred at 21.0°C for both males and females (Fig. 3). Temperatures above or below 21.0°C substantially reduced longevity. The eggs deposited by the F₁ generation females were monitored as they developed and passed through their successive life stages in the F₂ generation (table 4). Eggs and adults experienced the greatest shortening of the life stage as the temperature in-

TABLE 4. — Mean days (\pm SE) required for development during the F₂ generation of eggs, larvae, protonymphs, and deutonymphs, and longevity of male and female, *Oligonychus ilicis*, reared at six constant temperatures on *Ilex crenata* leaves.

Temp. (°C)	Sex	Stage				
		Egg	Larva	Protonymph	Deutonymph	Adult
15.1	M ¹	—	—	—	—	—
	F	18.4 \pm 0.2	9.4 \pm 0.5	8.8 \pm 0.6	7.4 \pm 0.5	14.6 \pm 2.8
21.0	M	12.4 \pm 0.1	4.6 \pm 0.4	3.7 \pm 0.2	3.9 \pm 0.3	16.4 \pm 2.2
	F	11.5 \pm 0.2	4.4 \pm 0.2	3.9 \pm 0.3	5.2 \pm 0.5	15.0 \pm 2.3
26.5	M	9.5 \pm 0.2	2.6 \pm 0.4	3.5 \pm 0.9	3.6 \pm 0.6	7.6 \pm 1.3
	F	11.5 \pm 0.5	3.0 \pm 0.0	4.0 \pm 1.5	3.0 \pm 0.0	9.5 \pm 2.5
29.5	M	6.2 \pm 0.2	2.7 \pm 0.3	2.0 \pm 0.3	2.3 \pm 0.3	2.3 \pm 1.2
	F	6.0 \pm 0.0	1.8 \pm 0.2	2.9 \pm 0.2	2.9 \pm 0.3	9.9 \pm 1.6
32.0	M	5.5 \pm 0.0	1.5 \pm 0.0	1.5 \pm 0.0	1.5 \pm 0.0	5.0 \pm 0.0
	F	5.3 \pm 0.3	2.0 \pm 0.0	3.0 \pm 0.3	2.3 \pm 0.4	3.3 \pm 1.1
35.0	M	5.2 \pm 0.2	2.2 \pm 0.4	1.8 \pm 0.2	1.7 \pm 0.7	2.2 \pm 1.0
	F	5.5 \pm 0.5	1.3 \pm 0.3	2.0 \pm 0.5	3.3 \pm 1.8	5.5 \pm 2.0

1. No males reached adulthood at 15.5°C.

creased and the duration of the deutonymph stage was least affected by increasing temperatures.

The southern red mite was able to complete its development over a temperature range of ca. 20°C with a low temperature of 15.5 and a high temperature of 35.5°C. Eggs of this mite did not show any detectable signs of development at 14.1°C. The mite achieved its highest reproductive potential at 26.5°C and its greatest longevity occurred at 21.0°C.

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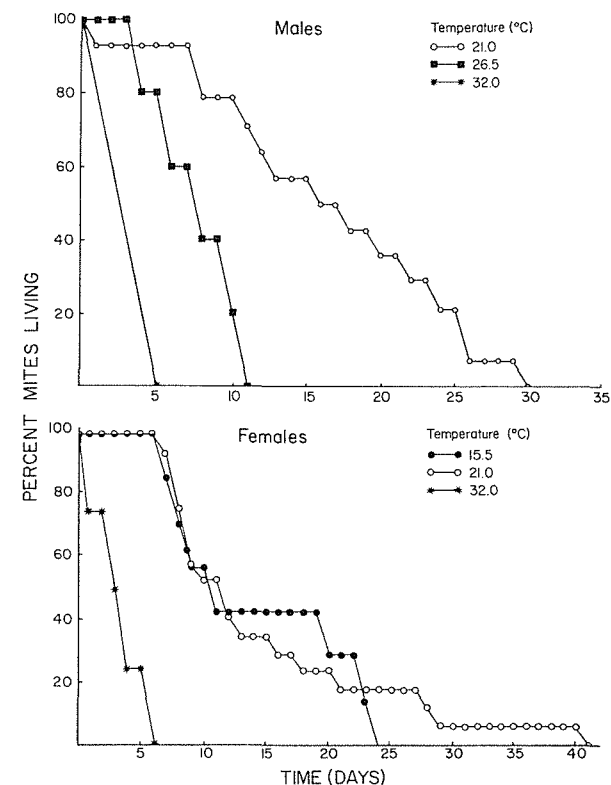


FIG. 3 : Mortality curves for adult male and female *Oligonychus ilicis* at selected constant temperatures.

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