The Life-History and Bionomics of the Apple Rust Mite *Calepitrimerus baileyi* (Acari: Eriophyidae)

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ABSTRACT

Ecological studies on the apple rust mite *Calepitrimerus baileyi* Keifer was conducted for one year in an abandoned Anna apple orchard in Egypt. Population dynamic of the eriophyid apple prey was affected by climatic conditions. and vertical distribution, and about 11 generations were recorded whole year. Leaves at middle levels of apple cultivar were found preferable to the mite feeding than those at the top and bottom. *C. baileyi* successfully developed to adult stage when reared on leaf discs from soft lateral apple branches. At 16 and 37°C, the adults began to slow down activity and then died. It was able to develop at temperature between 23-35°C and 65% R.H. Adult life cycle and longevity decreased with increasing temperature. Fecundity was highest at 35°C and averaged 23 eggs per female. Life table parameters showed that the intrinsic rate of natural increase (rm) increased with temperature increase to a maximum of 0.158 at 35°C. Population of *C. baileyi* multiplied 15.94 times in a generation time f 17.47 days at 35°C and recorded 8.79 times in a generation time of 25.8 days at 23°C under laboratory conditions.

Key Words: Ecology, Biology, *Calepitrimerus baileyi,* Acari, Eriophyidae.

INTRODUCTION

The apple rust mite, or Bailey's rust mite, *Calepitrimerus baileyi* Keifer was firstly reported by Keifer (1938) on apple leaves in California and South Dakota (Jeppson *et al.*, 1975). Mite feeding caused browning on the underside of apple leaves, partial defoliation, russet on fruit and delayed or inhibited apical growth.

In Egypt, *C. baileyi* reached damaging levels in many apple orchards, particularly on Anna apple cultivar. No work has been done before on the biology and ecology of this harmful pest. This study presents information on the seasonal trend, behaviour of *C. baileyi* and its life history.

MATERIALS AND METHODS

Ecological Studies:

Ecological studies on *C. baileyi* and its predator, *Typhlodromus pyri* chueten were carried out in an abandoned apple orchard (*Malus domestica* Borb.), seven-years old, Giza, for one year (April 2009 to March 2010). Ten apple trees from Anna cultivar of similar size, vigor and shape were selected. Samples of 25 leaves were taken at random weakly to estimate the eriophyid and phytoseiid mite populations.

To study the comparative abundance of *C. baileyi* and its vertical distribution, 60 leaves were collected randomly from the top, bottom and middle of Anna cultivar. Sampling was conducted on the 15th of every month. Leaves of Anna apple trees from the upper branches (50-70 cm), represented the top-level leaves, while those on the branches of the trees up to a height of 100-120 cm above ground level, represented the bottom-level leaves. The foliage between the top and the bottom levels was regarded as middle-level leaves.

To determine the number of annual generations of *C. baileyi* under environmental conditions, the percentage of immature stages was estimated weekly. Period at which the highest percentage of the immature stages occurred represented a generation.

Biological Studies:

Mites were reared on leaf discs, 2 cm diameter containing a part of midrib, taken from leaves of soft lateral apple branches. The discs were placed ventral side up on moist filter paper. Thirty newly mated females of *C. baileyi* were obtained from infested apple leaves, and placed singly on the leaf discs. Each female was allowed to deposit one egg. Leaf discs were placed in incubators at different constant temperatures (16, 23, 29, 35 and 37°C) and 65% relative humidity and a photoperiod 12/12 h light/dark. Development of mites was observed twice daily. Insemination took place soon after male and female emergence, each newly virgin female was transferred for 24 h to a leaf disc previously inhabited by an adult emerged male, to allow insemination by spermatophores, then females and males were transferred back to their previous substrates. Life table parameters were calculated according to a Basic computer program (Hulting *et al.*, 1999).

RESULTS AND DISCUSSION

Seasonal Variations:

The population dynamics of *C. baileyi* and its predatory phytoseiid mite *T. pyri* for a one year study on the apple trees (cv. Anna) and weather records are presented in Fig. 1. In 2009, *C. baileyi* first appeared on apple trees during the first week of April when new Anna apple leaves protruded from the buds. The numbers of mites fluctuated rose in matted hairs of the lower surface of the leaves until the second week of July. The population fluctuation continued at a semi high or moderate levels until the second week of September and then fluctuated with moderate or low levels during October and November. Climatic conditions, the occurrence in matted hairs of the lower leaf surfaces, vertical distribution and prevailing natural enemy may have a role to play.

It is of interest to note that during development, *C. baileyi* displayed deuterogyny which is the occurrence of two types of females, primary and secondry (Keifer, 1942; Jeppson *et al.*, 1975 and Manson, 1984). The primary female or protogyne has a male counterpart and the ventral of both sexes have microtubercles. The secondry female or deutogyne lacks ventral microtubercles, and has no male counterpart. In early April at the beginning of the growing season, the deutogynes started egg-laying. The new progeny or protogynes were commonly found on the leaves from early April until the end of November. At about mid August, a considerable population consisting of eggs, nymphs, protogynes, deutogynes and males was found on the leaves. At early September, deutogynes of *C. baileyi* hibernated in their quarters with rare numbers, mainly in small permanently dormant buds and under loose bark of spurs and around buds on 1-year old shoots, and moved into fruit buds between the bud burst and pink bud stages and into vegetative buds as the buds began to swell.

Three annual peaks of seasonal abundance on Anna apple cultivar were recorded. The highest populations occurred in the third week of June and the second week of both July and August of the study year, averaging 43.8, 57.9 and 42.4 mite individuals per leaf at average temperature 29, 30 and 28°C and 50%, 75% and 60% R.H., respectively (Fig. 1). Highly significant positive correlation (0.858) was noted between mite population and temperature. Significant positive correlation (0.150) also occurred between mite population and relative humidity. It could be concluded that the population responded to high temperature degrees. Injury of apple orchards caused by *C. baileyi* became noticeable early in mid June. The lower surface of the leaves turned brown or bronzed, while the upper surfaces remained nearly green, which suggests that the mites feed mainly on the lower surfaces of the leaves.

About 11 generations of *C. baileyi* were recorded on apple leaves during the study period. The longest generation for *C. baileyi* was that, which passed throughout fall months and lasted for about five weeks, while the shortest generation occurred in summer and lasted for about two weeks (Fig. 2). This confirms again that the changeable environmental factors had a great effect on the apple rust mite. The severe damage occurred in summer.

The numerical changes in vertical distribution of the mite *C. baileyi* on Anna apple trees for one year, with temperatures and relative humidities for the corresponding periods are given in Fig. 3. Tracing the population trend at top and middle revealed that its peak mostly occurred during July, then declined till November. Its density exhibited a gradually increase and decrease throughout summer and fall and still remained at a noxious level during summer. At the middle level, leaves of Anna apples had significantly more numbers of mite species in comparison to the top and bottom levels. The data suggest that the middle leaves were preferable to the mite and are useful for sampling of the apple rust mite population to evolve suitable strategies for the application of chemical control.

Predacious Mite:

In nature, acarine pests are only a part of biological complex of which predacious mites, particularly phytoseiids group, could be of value in checking infestations. The population dynamics of phytoseiid predator *T. pyri* Schueten was studied during a whole year (2009-2010). It was relatively numerous on Anna apple cultivar associated with the apple rust mite *C. baileyi.* Population density started to appear in May then increased and fluctuated till reached two peaks in September and October, then tailed off in November. The predator population positively correlated with that of *C. baileyi.* Its density averaged from 0 to 0.6 individual/leaf (Fig. 1). This may indicate that the eriophyid prey probably play an important part as a prey for the predator.

Biology:

The present study was conducted to determine the effect of different constant temperatures on the developmental duration of different stages, adult longevity and fecundity of protogynes *C. baileyi.* At 16 and 7 C the adult began to cease its activity, then died. Abou-Awad *et al.* (2010) stated that below 20°C the activity of the peach silver mite *Aculus fockeui* (Nalepa and Trouessart) was ceased, whereas at 36°C the new virgin adults died.

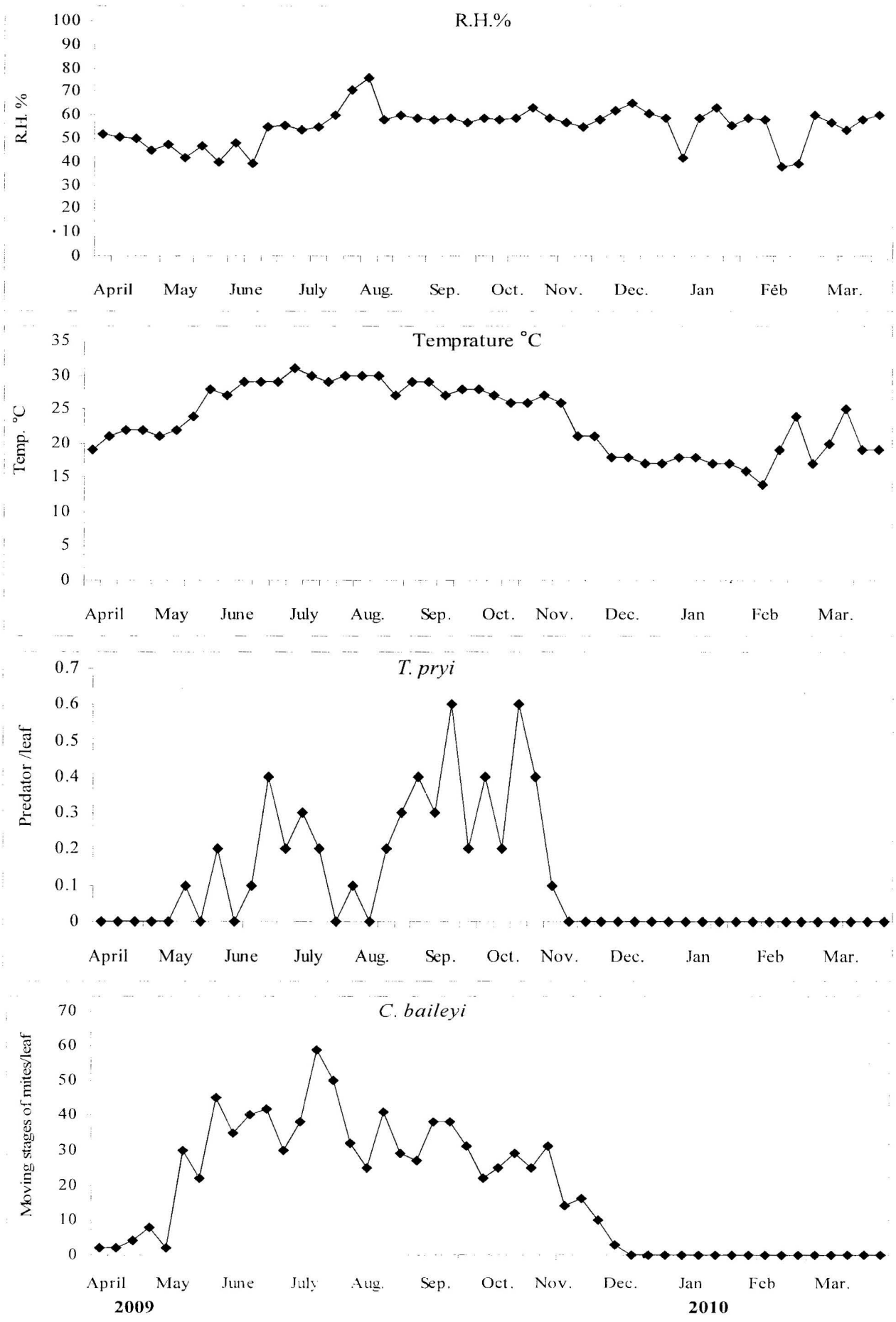

Fig. (1): Population density of the apple rust mite. *C. baileyi* and its phytoseiid predator on Anna apple leaves in abandoned orchard from April 2009 to March 2010 and weather records.

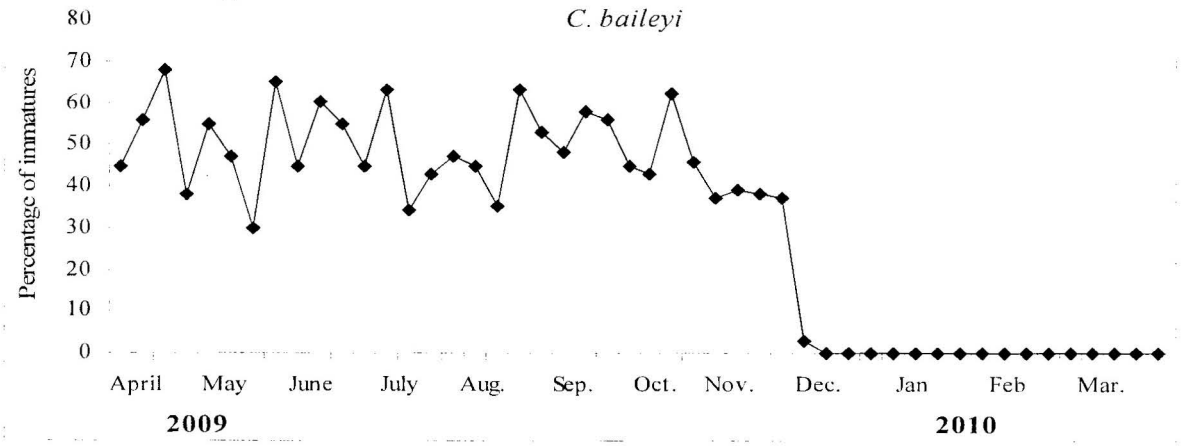

Fig. (2): Percentage of immature stages in the total population of the apple rust mite, *C. baileyi* on Anna apple leaves in abandoned orchard from April 2009 to March 2010.

Table (1): Developmental periods of different stages in days and fecundity rate of *C. baileyi* reared on leaf apple discs at different temperatures and 65% R.H

Mite stage and fecundity	Sex	23°C	29°C	35°C
Egg	Female	5.30±0.16	3.61±0.17	2.90±0.15
	Male	5.10±0.11	3.36±0.12	2.80±0.21
First instar nymph	Female	2.08±0.20	1.84±0.16	1.18±0.09
	Male	2.00±0.17	1.90±0.18	1.09±0.11
Nymphochrysalis	Female	0.31±0.04	0.24±0.09	0.19±0.04
	Male	0.31±0.06	0.24±0.04	0.19±0.02
Second instar nymph	Female	1.75±0.14	1.69±0.13	1.00±0.02
	Male	1.90±0.16	1.81±0.24	1.09±0.09
Imagochrysalis	Female	0.27±0.06	0.21±0.04	0.17±0.08
	Male	0.29±0.09	0.21±0.06	0.17±0.04
Total	Female	9.71±0.34a	7.59±0.32b	5.44±0.18c
	Male	9.60±0.32	7.52±0.17	5.34±0.22
Pre-oviposition	Female	4.50±0.17	3.07±0.14	1.27±0.12
Generation	Female	14.21±0.54a	10.66±0.63b	6.71±0.42c
Oviposition	Female	24.08±0.82a	22.00±0.77a	21.81±1.21a
Total fecundity	Female	12.50	19.70	23.09
Post-oviposition	Female	6.33±0.37	4.76±0.42	2.45±0.33
Longevity	Female	34.91±1.21a	29.83±1.11b	25.53±1.53c
	Male	32.60±1.44a	28.18±0.97b	23.60±1.04c
Life span	Female	44.62±1.27a	37.42±2.09b	30.97±1.13c
	Male	42.22±1.84a	35.70±1.94b	28.99±2.12c
Surviving %	Female	100	100	100
	Male	100	100	100
Number of observations	Female	20	21	22
	Male	10	9	8

Means marked with the same letters in a horizontal column are not significantly different (F-test, $P<0.05$, $P<0.01$)

Table (2): Life table parameters of *C. baileyi* at different temperature degrees and 65% R.H.

Parameters	23°C	29°C	35°C
Net reproduction rate (Ro)	8.79	13.92	15.94
Mean generation time (T)	25.8	21.87	17.47
Intrinsic rate of increase (rm)	0.087	0.120	0.158
Finite rate of increase (e^{rm})	1.059	1.127	1.171
50% mortality (in days)	45	38	32
Sex ratio (Female/total)	20/30	21/30	22/30
Sex ratio (Female/male)	2.00:1	2.3:1	2.7:1

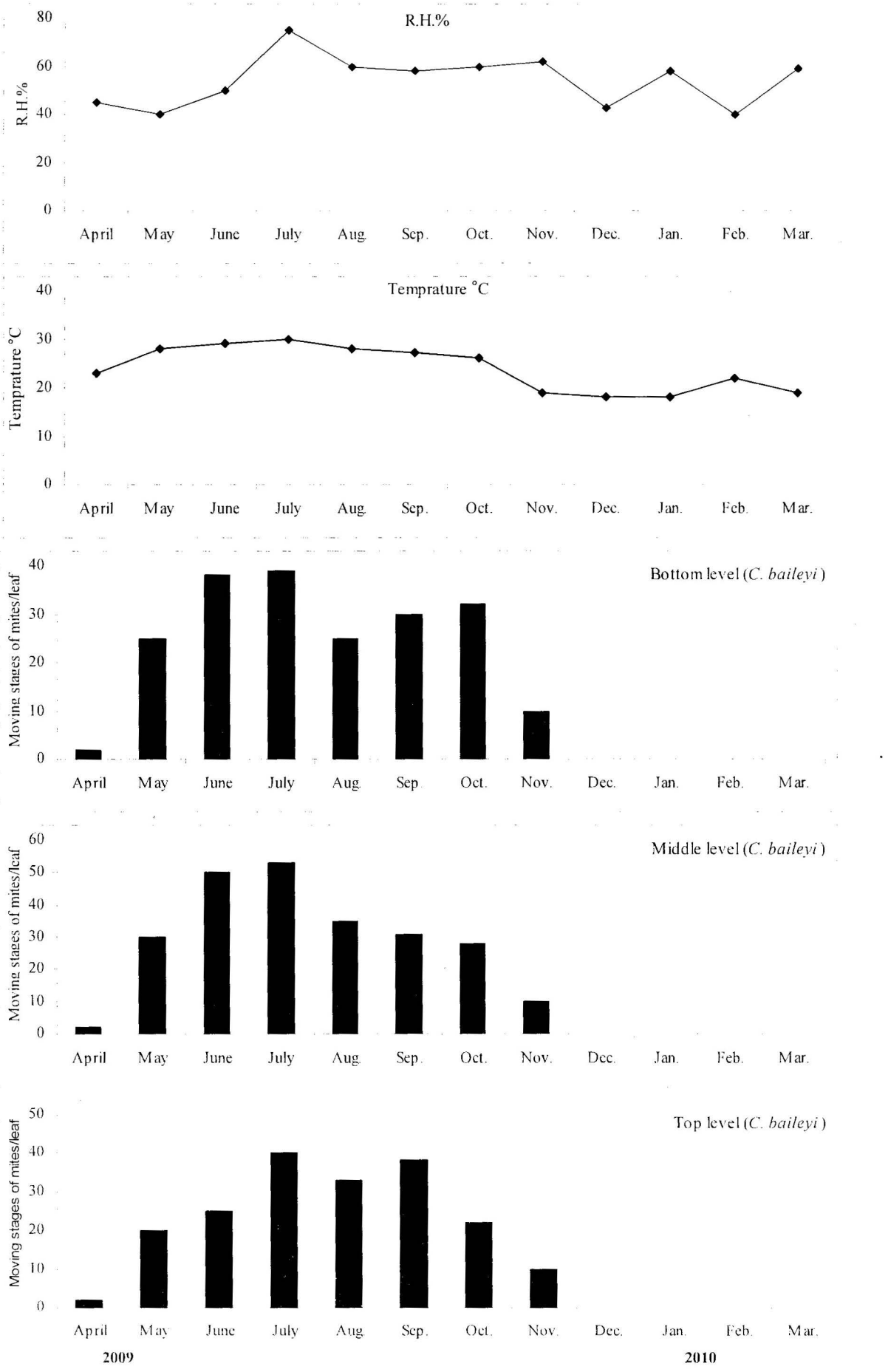

Fig. (3): Population trends of the apple rust mite, *C. baileyi* on Anna apple leaves in abandoned orchard from April 2009 to Marh 2010 and weather records.

However, eriophyoid mites are unique phytophagous mites, due to having many simplification in external and internal structures and with the absence of several organs, are the result of process of adaptation of a high degree in connection with the parasitic mode of life on or inside the plant tissue.

C. baileyi was able to develop successfully from egg to adult through the entire life history at temperature between 23-35°C and 65% R.H. It has two nymphal stages, each followed by a resting stage, before reaching adult (Table 1). The terms used for the resting stages are those proposed by Sternlicht and Goldenberg (1971). It was concluded that the duration of egg (incubation period), first instar nymph, nymphochrysalis, second instar nymph, imagochrysalis, pre-oviposition and post-oviposition decreased as temperature increased.

The egg of *C. baileyi* is circular and translucent when first lade, then turned to light amber and opaque as a result of the embryo development. The egg is 45-51 µm in diameter, and most of eggs are laid alongside the midrib or veins of leaf discs. Egg duration at 23°C was 1.83 times as long as that at 35°C. The total life cycle was completed after 9.71 & 9.60; 7.59 & 7.52 and 5.44 & 5.34 days for females and males at 23, 29 and 35°C respectively. Males developed faster. The life cycle results of Barke *et al.* (1972) on the peach silver mite *Aculus cornutus* (Banks) and Easterbrook (1979) on the apple rust mite *Aculus schlechtendali* (Nalepa) are almost in agreement with the aforementioned temperatures. A generation took 6.71 days at 35°C; a decrease of 6°C and 12°C increased it by 3.95 and 7.50 days, respectively; at least 43% of the generation time was spent in the egg stage. The difference between 23 and 35°C of the generation time was highly significant.

The ovipositing duration decreased with increasing temperature. Female longevity at 23°C averaged 34.91 days, about 1.37 times as long as at 35°C. Total fecundity gradually increased with increasing temperature.

Females deposited an average of 12.5, 19.70 and 23.09 eggs, during the oviposition period that averaged 24.08. 22.00 and 21.81 days, then survived for 6.33, 4.76 and 2.45 days at 23, 29 and 35°C, respectively (Table 1). The highest number of eggs per female was observed to be 23.09 at 35°C. It could be concluded that 35°C is the optimum temperature for development and induced greater production of *C. baileyi.* The data obtained are in agreement with those reported by Abou-Awad *et al.*,(2011), who found the same effect of different temperatures on the mango rust mite, *Metaculus mangiferae* (Attiah). The life history took 44.62 & 42.22; 37.42 & 35.70 and 30.97 & 28.99 days for females and males at the same previous temperatures, respectively. In general, life histories studied by Abou-Awad *et al.*, 2000 and 2011 and Haque and Kawai, 2003 are in agreement.

Life table parameters at three different temperature degrees and 65% R.H. were constructed (Table 2). It showed that the intrinsic rate of natural increase (rm) increased with temperature to a maximum of 0.158 at 35°C and decreased to 0.087 at 23°C. The maximum rate is equal to that of the peach silver mite *A. fockeui* (rm = 0.159, Abou-Awad *et al.*, 2010) which considered the most serious eriophyid mite pests in peach and nectarine orchards. The population of *C. baileyi* also multiplied 15.94 times in a generation time of 17.47 days at 35°C, while its population only increased 8.79 times in a generation time of 25.80 days at 23°C. Therefore, the present results reveal that *C. baileyi*is a disastrous pest to Anna apple orchards in Egypt.

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