# **Biological parametersof the predator, *Amphibolus venator* Klug (Hemiptera: Reduviidae) when preyed on larvae of *Tribolium confusum* Duv. (Coleoptera: Tenebriondae).**

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ABSTRACT:

Certain biological aspects of the predator,*Amphibolus venator* Klug (Reduviidae: Hemiptera) had been studies when preyed on larvae of *Tribolium confusum* Duv.(Coleoptera: Tenebriondae) under laboratory conditions. Development and reproductive capacity of the predator were investigated at three constant degrees oftemperatures (20, 27 and35 ±1$^o$C) combined with three relative humidites (50, 60 and 70 ±5 R.H.). The data revealedthatthe adult predator consumed an average of 354.3 prey at 27$^o$C and 60%R.H. These conditions seemed to be optimum for rearing the experimental predator when fed on larvae of *T. confusum*.At these conditions, ovipositionperiods, number of deposited eggs and preying capacity were highest andassociated with lowest mortalities in mature and immature stages compared with other conditions.

**Key words:**Biologicalparameterspredator,*Amphibolusvenator*,*Triboliumconfusum*, Temperatureandrelative humidity

## INTRODUCTION

Insect pests constitute the most important hazards to stored grains and other products. They destroy not only human food in granaries, but also spoil it with contaminations by faces, kin casts, dead bodies, bad odors and reduce percentages of seed germination (Abdella, 1981)

Methyl bromide (MeBr) is one of the most useful chemical agents for pest control of stored products. Fumigation with MeBr, however, may not be desirable from the standpoint of human health. Moreover,MeBr probably has ozone layer depleting effects (Morimoto *et al* 2007,Murata *et al* 2007 and Imamura *et al* 2008).

Therefore, development of alternative method and switch to Integrated Pest Management (IPM) are urgently needed. Biological control is thus being regarded with increasing interest, since it is nontoxic and safe to human health and environment. (Pingale 1954,Hussain,&Aslam 1970, Abdella 1981, Awadallah*et al.*1984,Tawfik*et al* .1984, Nishi and Takahashi 2002, Russo *et al.*.2004, Murata *et al.* 2007and Imamura *et al.*2008)

The predacious reduviid, *Amphibolusvenator*Klug was found in stored grains infested by several species of stored product insect pests. The predator was found all the year round with a peak during April-September(Hussain andAslam, 1970).

In Japan Nishi and Takahashi (2002) studied the predatory capability of *A. venator*to attack *T. confusum* at 25and 30$^{o}$C.At the high temperature, the number of prey killed by this predator increased at high prey density. Generally, few available reviews were recorded about this predator. Therefore, the present study was conducted to evaluate the optimum laboratory conditions for rearing this predator on the predominant insect pest,*T. confusum*.

## MATERIALS AND METHODS

### Predator rearing:

The predator rearing technique and source of *A. venator*stock culture was recorded by Abd Elgayed and Youssef, 2015(in press)

### Biological parameters:

Experiments were conducted at different constant temperatures, i.e., 20, 27 and 35± 1$^{o}$C each combined with one of the followingrelative humidites,50, 60 and 70±5 % R.H. Tested relative humidites were maintained in desiccators by means of different concentrations of potassium hydroxide (Buxton and Mellanby, 1934 and Abdella, 1981). Such conditions was made to study their effects on the biocycle of the reduviid predator,*A. venator*.

To obtain newly emerged adults of the predator, mature nymphs were collected from the stock culture and translocatedinto a Petri-dish (9 cm in diameter)contained a disc of filter paper to facilitate insect movement and some corn meal for feeding

*T. confusum*larvae. The rearing dishes were inspected daily and at time, newlyemerged adults were collected and paired (Awadallah*et al*., 1984).

For ovipostional experiments, plastic tubes of 3 cm in diameter and 5 cm in height were used. Each tube that contained one couple only, was provided with filter paper disc, covered with a perforated plastic cover and supplied with10 larvae of the prey daily thenkept at the desired temperature and relative humidity. Inspection was made daily and the deposited eggs, after being counted were transferred to other cage. Each cage (3x5 cm) contained 10 eggs was provided with a filter paper disc. Daily inspection took place to count the number of hatched nymphs and to estimate the percentage of hatchability. The newly hatched nymphs were transferred individually(10 replicates were used for each treatment) to rearing tube (3 cm diameter x 5 cm height) which was provided with a disc of filterpaper and the predatory nymph was provided daily with *T. confusum*larvae and kept continuously at the desired temperature and relative humidity. Moulting and mortality rate of the nymphs were recorded until adult emergence which were sexed and confined inside the ovipostional cages.

Preying capacity of differentnymphal instars and adults were investigated dailyfollowing the method described byAwadallah*et al*, 1984).*T. confusum* was reared in glass jars (2 Kg in volume) containing the insects and flour. Jars were provided with corrugated paper to get the larvaeand movement of insects inside the glass jars(Abdella, 1981).

Obtained datawere statistically analyzed and L.S.D.as well as the calculated standard error for biological studies were obtanied according toSenedecor and Cochran(1980 ).

## RESULTS AND DISCUSSION

**Egg stage of *A.venator*:**

Data summarized in table (1) clearly showed that temperature had a negative effect on the incubation period of *A.venator*. The longest incubation period was obtained at 20$^{o}$C ranging between 16.2 days at 50% R.H. and was 15.6 days at

60&70% R.H., while the shortest period occurred at 35°C extending from l0.7 days at 70% R.H. to 11.7 days at 60% R.H. Percentage of hatchability decreased gradually with an increase or decrease in temperature on 27°C, this percentage extended from 45.0to 58.1% at 20°C, while it ranged between 57.5 and 78.0% at 35°C. The effect of the relative humidity varied according to associated temperature. It showed aninsignificant effect at all treatments. The optimum conditions for the egg development of this predator seemed to beat 27°C. and 60 % R.H. at which a relatively short incubation period (14.5 days) and the highest hatchability (93.8%) were reported.

**Nymphal stage of *A.venator*:**

Data summarized in table (1) clearly showed that nymphal development of *A.venator* was affectedby rearing temperature. Nymphs maintained at 20°C. (associated with all tested R.H.) did not complete their development and died during the first stadium at 20°C. and throughout the second stadium (at 35°C &50% R.H.).

All nymphs completed their development through five instars, except two individuals, the development had completed in four instars at 35° C&70% R.H.; the first instar ranged from 7.6 days at 35°C&50% R.H. to 12.4days at 27°C &50 % R.H., the highest percentage of mortality in this instar was 27.3% at 35°C &70% R.H., and the lowest (3.6%) was, however, recorded at 27°C and 60% R.H.

The second nymphal instar did not significantlyaffect by relative humidity and temperature.This period ranged between (5.1 - 6.4 days) and (4.3-5.0 days) at 27 and 35° C, respectively and associated with the mortalities ranging between (0.0 and 3.7%) and (16.7-34.4%), respectively. Under abovementioned conditions, the third nymphal instar extended from 8.7 days to 14.7 days with (0.0 - 7.9% mortality) at 27° C; and from 6.2 days to 7.9 days at 35° C with (9. 5-25.0% mortalities), whilethe fourth instar took longer period than the previous instars, as it ranged between (18. 7-25.3 days) at 27°C and (17.4-20.1days) at 35° C, the mortalities were (0.0-20.8%) and (21.1 – 33.3%), respectively. In the fifth (last)nymphal instar, the shortest period was obtained 35°C&70% R.H.,and the longest was

,however,recorded at 27 $^{O}$C &50% R.H, with the mortalitiesof 26.7% and 13.6%,respectively (tables, 1 and 2).

The total developmental period of nymphal stage was affected significantly with temperature and insignificantly with relative humidity. The shortest period was 60.2 days (ranging between 48 days to 76 days at 35$^{O}$C&70% R.H.), while the longest period was 87.2 days at 27$^{O}$C&50% R.H., the accumulated percentages of mortality associated with these periods were 75.0 and 29.6%, respectively. The data revealed that the optimum conditions for development of the immature stage of this predator were 27$^{O}$C and 60% R.H. At this condition, the five nymphal instars lasted 11.6, 5.10, 9.0, 18.7 and 30.2 days.Such duration were associated with the lowest percent mortalities (3.6, 0.0, 0.0, 0.0 and 7.4%), respectively.

**Table (1): Incubation periods of eggs and nymphal durations (days) of*A.venator* reared at different laboratory conditions (Mean ± S.E.)**

| Lab. conditions | | Incubation period (days) | Nymphal stage (days) | | | | | | Life cycle |
|---|---|---|---|---|---|---|---|---|---|
| Temp. $^{o}$C | R.H. % | | 1$^{st}$ | 2$^{nd}$ | 3$^{rd}$ | 4$^{th}$ | 5$^{th}$ | Total | |
| ٢٠ | ٥٠ | 16.2±0.25 | 1.4±0.14 | * | * | * | * | * | * |
| | ٦٠ | 15.6±0.80 | 1.4±0.15 | * | * | * | * | * | * |
| | ٧٠ | 15.6±0.58 | 1.5±0.12 | * | * | * | * | * | * |
| 27 | ٥٠ | 14.2±0.29 | 12.4±0.37 | 6.4 ±0.27 | 14.7±1.8 | 22.0±2.6 | 31.7±3.6 | 87.2±4.22 | 101.4±4.2 |
| | ٦٠ | 14.4±0.22 | 11.6±0.77 | 5.1 ±0.57 | 9.0±0.20 | 18.7±2.30 | 30.2±1.2 | 74.9±3.42 | 88.0±3.20 |
| | ٧٠ | 13.4±0.27 | 11.7±0.58 | 6.3 ±0.37 | 8.7±0.47 | 25.3±2.50 | 28.4±1.9 | 80.4±3.30 | 93.8±3.30 |
| 35 | ٥٠ | 11.2±0.39 | 7.6±0.18 | 4.3 ±0.23 | * | * | * | * | * |
| | ٦٠ | 11.7±0.26 | 10.2±0.40 | 5.0 ±0.20 | 7.9±0.30 | 20.1±2.1 | 24.0±1.5 | 67.2±2.7 | 78.9±2.80 |
| | ٧٠ | 10.7±0.26 | 11.2±0.15 | 5.0 ±0.40 | 6.2±0.20 | 17.4±2.1 | 19.9±1.5 | 60.2±3.2 | 70.9±3.20 |

* Show all individuals of predator died during this instar.

**Table (2): Mortality percentages of the eggs and different developmental nymphal instars of*A.venator* reared on *T. confusum* larvae at different laboratory conditions**

| Temp. °C | R.H. % | Mortality percentages | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Egg stage | Nymphal stage (days) | | | | | |
| | | | 1st | 2nd | 3rd | 4th | 5th | Total |
| ٢٠ | ٥٠ | 41.9 | 100 | * | * | * | * | * |
| | ٦٠ | 51.2 | 100 | * | * | * | * | * |
| | ٧٠ | 55.0 | 100 | * | * | * | * | * |
| 27 | ٥٠ | 15.2 | 6.90 | 3.65 | 7.7 | 8.33 | 13.6 | 29.6 |
| | ٦٠ | 6.3 | 3.57 | 0.0 | 0.0 | 0.0 | 7.40 | 13.9 |
| | ٧٠ | 15.8 | 18.8 | 0.0 | 7.8 | 20. 8 | 16.5 | 34.6 |
| 35 | ٥٠ | 42.9 | 40.0 | 100 | * | * | * | * |
| | ٦٠ | 32.2 | 10.71 | 20.0 | 25.0 | 33.3 | 0.0 | 64.29 |
| | ٧٠ | 22.0 | 27.3 | 34.4 | 9.5 | 21.1 | 26.7 | 75.0 |

* Show all individuals of predator died during this instar.

**Table (3): Total number of *T.confusum* larvae consumed by one of*A.venator* nymph during its whole instars and sex ratios under different laboratory conditions**

| Lab. conditions | | Nymphal stage (days) | | | | | | Sex ratio |
|---|---|---|---|---|---|---|---|---|
| Temp. °C | R.H. % | 1st | 2nd | 3rd | 4th | 5th | Total | |
| ٢٠ | ٥٠ | 1.4 (1) | * | * | * | * | * | * |
| | ٦٠ | 1.4(1) | * | * | * | * | * | * |
| | ٧٠ | 1.5(1) | * | * | * | * | * | * |
| 27 | ٥٠ | 12.4(1) | 12.8(2) | 29.4(2) | 66(3) | 94.8(3) | 215.4(2.5) | 1.5-1 |
| | ٦٠ | 23.2(2) | 20.4(4) | 36(4) | 93.5(5) | 181.2(6) | 354.٣(4.7) | 1.8-1 |
| | ٧٠ | 11.7(1) | 6.3(1) | 17.4(2) | 75.9(3) | 85.2(3) | 196.5(2.4) | 1-1 |
| 35 | ٥٠ | 7.6(1) | 7.3(1) | * | * | * | * | * |
| | ٦٠ | 10.2(1) | 10(2) | 15.8(2) | 60.3(3) | 96(4) | 192.3(2.9) | 2.3-1 |
| | ٧٠ | 11.2(1) | 5(1) | 12.4(2) | 52.2(3) | 39.8(2) | 120.6(2.1) | 1-1 |

The correlated parenthesized data show average of daily consumption.

* Show all individuals of predator died during this instar.

## Adult stage of *A.venator*:

### a- Sex ratio:

Adults obtained from all experiments (table, 3) showed that the produced females outnumbered males. The highest sex ratio (females: males ) was2.3:1 at 35°C and 60% R.H., while at 27°C(associated with 50, 60&70% R.H. and at 35°C combined with 70% R.H. the respective sex ratios were 1.5:1, 1.8:1, 1:1 and 1:1.

At 20°C, associated with all experimental relative humidites and at 35°C combined 50%R.H., all nymphs had died during the first and the second instars, respectively. The preying capacity of these instars ranged from 1.4 to 7.6 preys /

nymph and the daily food consumption was (one prey/nymph). At temperature below or above 27$^{o}$C, the rate of food consumption decreased for allnymphal instars. At 27$^{o}$C &60%R.H., the nymph stage consumed 354.3 preys, which decreased to 215.4 and 196.5prey at 50 and 70%R.H., respectively (table3).

In this respect,HussainandAslam, (1970) reported that the total duration of the period from egg laying to adult emergence varied from 14 to 165 days. Nishiand Takahashi(2002) recorded that larvae of *T. confusum* as a preference host compared with adult and pupae of this pest and the number of preys killed by this predator increased at high density at 30$^{o}$C.

**b- Female adults:**

Irrespective to the associated relative humidites, the longest ranges of female life span (97-171 days) and oviposition periods (90-161 days) were recorded at 27$^{O}$C (table4). Below (20$^{O}$C) or above (35$^{O}$C) this temperature an obvious decrease in these periods were noticed. At 20$^{O}$C, the female life span lasted29.3 -33.4 days and its ovipositional period took 12.8-13.4 days , while at 35$^{O}$C, the respective periods were 58.1-89.0 days and 48.0 -80.5 days. The longest female life-span 132.10 days recorded at 27$^{O}$C and 60% R.H., was found associated the longest oviposition period (114.8 days) and when the former period became shortest (58.1 days ) at 35$^{O}$C and 70% R.H. , the later period also became shortest ( 48.0 days ).

Highest rate of egg laying (175.6 eggs /female) was recorded at 27$^{o}$C and 60 %R.H. This coincides with the aforementioned longest longevity and ovipositional period. Also, the least egg productivity (56.8 egg /female) was found associated with the shortest longevity and oviposition period reported at 35$^{O}$C and 70% R.H. The differences between the relative humidites at the same temperature were insignificant. Monthly counts of eggs per female varied significantly according to the various conditions of the experiments, of which temperature was most effective. Highest count (79.6 eggs /female/month) was recorded in the second month at 27$^{O}$C and 60%R.H., while the lowest (6.0 eggs /female/ month) was recorded during the fourth month at 35$^{O}$C combined with 50&70%R.H.(table, 6).

Survival rates of depositing females showed that most of the individuals had survived throughout the first month of oviposition period. At 20$^{O}$C, this rate decreased rapidly and all individuals died without laying eggs during the second month. But at 27$^{O}$C, all females that kept at 60 or 70% R.H, survived up to the sixth month and deposited eggs, and survived until the fifth month at 50%R.H. While 70, 90 and 90% of the experimental females maintained at 35$^{O}$C and the respective relative humiditesof 50, 60 and 70%, died before laying eggs during the fourth month. Generally, the rate of survival decreased during the successive months as temperature increased from 27 to 35$^{O}$C, or decrease to 20$^{O}$C. Consequently, the longest ovipositional period was reported at 27$^{O}$C and the shortest was at 20$^{O}$C.(table, 4).

### c- Male adults:

The life span of males was estimated under the same conditions of temperatures and relative humidites. Irrespective of the later factor, the longest longevity (66.4-105.3 days) was recorded at 27$^{O}$C and the shortest (10.9-28.8 days) was, however, obtained at 20$^{O}$C, while intermediate ranges of (26.1-44.8 days) were reported at 35$^{O}$C. Generally, the statistical analysis showed that differences among the means of these periods were significant except at 27$^{O}$C and 60% R.H., which was appeared highly significant (table,4).

**Table (4): Adult longevity of*A.venator* as being affected by laboratory conditions (Mean ±S.E.)**

| Lab. conditions | | Adult longevity (days) | | | | |
|---|---|---|---|---|---|---|
| | | Male longevity | Female longevity | | | |
| Temp. °C | R.H. % | | Pre-oviposition | oviposition | post oviposition | Total |
| ٢٠ | 50 | 10.9 ± 0.88 | 18.3 ± 1.10 | 13.4 ± 1.86 | ** | 31.7± 1.90 |
| | 60 | 24.0 ± 3.90 | 17.6 ± 1.01 | 15.8 ± 1.80 | ** | 33.4 ± 2.30 |
| | 70 | 28.8 ± 7.60 | 16.8 ± 0.84 | 12.8 ± 1.40 | 0.20 ± 0.10 | 29.30 ± 1.60 |
| 27 | 50 | 70.8 ± 7.9 | 14.9 ± 0.8 | 100.8 ± 4.50 | 0.90 ± 0.23 | 115.5 ± 4.8 |
| | 60 | 105.3 ± 6.4 | 10.4 ± 0.9 | 114.8 ± 7.2 | 2.1 ± 0.72 | 132.1±7.3 |
| | 70 | 66.4±5.3 | 10.9±0.8 | 113.6±7.2 | 1.7±0.40 | 126.2±6.5 |
| 35 | 50 | 26.1 ± 3.6 | 7.71 ± 0.30 | 80.5 ± 6.2 | 0.9 ± 0.25 | 89.1 ± 6.1 |
| | 60 | 35.6 ± 6.3 | 9.2 ± 0.42 | 63.4 ± 7.8 | 1.3 ± 0.42 | 73.1 ± 7.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 70 | 44.8 ± 5.31 | 8.7 ± 0.8 | 48.0 ± 8.6 | 1.4 ± 0.43 | 58.1 ± 8.2 |

**** indicate that female s were died during oviposition period**

## Table (5): Total number of *T. confusum* larvae consumed by one of*A.venator* adult during its whole life under laboratory conditions

| Lab. conditions | | Adult | | | | |
|---|---|---|---|---|---|---|
| | | | Female | | | |
| Temp. °C | R.H. % | Male | Pre-oviposition | oviposition | post oviposition | Total |
| ٢٠ | 50 | 21.8(2) | 36.6(2) | 26.8(2) | ** | 63.4(2) |
| | 60 | 28(2) | 35.2(2) | 31.6(2) | ** | 66.8(2) |
| | 70 | 57.6(2) | 33.6(2) | 25.6(2) | 0.40(2) | 58.6(2) |
| 27 | 50 | 212.4(3) | 44.7(2.2) | 322. 6(3.2) | 2.7(3) | 346.5(3.1) |
| | 60 | 421.2(4) | 41.6(4) | 746.2(7.6) | 6.2(3) | 951.1(7.2) |
| | 70 | 139.4(2.1) | 27.3(2.5) | 318.1(2.8) | 3.4(2) | 353.4(2.8) |
| 35 | 50 | 52.2(2) | 16.9(2.2) | 201.3(2.5) | 1.6(2) | 222.8(2.5) |
| | 60 | 113.2(2) | 18.4(2) | 126.8(2) | 1.9(1.3) | 146.2(2) |
| | 70 | 89.8(2) | 17.4(2) | 96(2) | 2.8(2) | 116.2(2) |

**Parenthesized data show average of daily consumption**

**** indicate that female s were died during oviposition period**

## Table (6): Monthly number of eggs laid by mated of*A.venator* female adults fed on *T. confusum* larvae under different laboratory conditions

| Lab. conditions | | Monthly number of eggs | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Temp. °C | R.H. % | 1st | 2nd | 3rd | 4th | 5th | 6th | Total |
| ٢٠ | 50 | 10.6(100) | ** | ** | ** | ** | ** | 10.6±2.20 |
| | 60 | 29.3(100) | ** | ** | ** | ** | ** | 29.3±4.73 |
| | 70 | 28.8(10) | ** | ** | ** | ** | ** | 28.8±2.42 |
| 27 | 50 | 26.9(100) | 24.9(100) | 27.6(100) | 8.7(70) | 7.0(10) | ** | 95.1±10.12 |
| | 60 | 24.1(100) | 79.6(100) | 44.7(100) | 15.5(80) | 9.2(50) | 16.0 (10) | 175.6±22.03 |
| | 70 | 25.5(100) | 44.9(100) | 32.6(100) | 20.4(90) | 13.5(20) | 12.0(10) | 140.3±30.4 |
| 35 | 50 | 25.7(100) | 44.2(100) | 18.4(80) | 6.1(30) | ** | ** | 88.4±9.9 |
| | 60 | 32(100) | 38(90) | 11.9(50) | 18(10) | ** | ** | 83.6±10.5 |
| | 70 | 34(100) | 16.1(70) | 18.0(20) | 6(10) | ** | ** | 56.8±8.6 |

**Data in parenthesis indicates percentage of survived females.**

**** indicate that females were died during these periods**

As shown in table (5), the highest total and daily consumed preys per adult (female or male) were recorded at 27$^{o}$C, reduced either obviously with the decrease of temperature to 20$^{o}$C or slightly at 35$^{o}$C. On the other hand, regarding relative humidity, the highest records were also obtained at the medium R.H (60%), while the lowest ones were associated with 70%R.H. Consumed preys by females outnumbered obviously those consumed by males.

Generally, it could be concluded that the most optimum thermal condition for the life cycle of the predator *A.venator*was found to be 27$^{O}$C, combined with 60% R.H.Under this condition, this predator passed its immature stage in short period (14.4 days incubation period , 74.9 days total nymphal period, associated with highest percentage of hatchability (93.7% ) and lowest percentage of nymphal mortality (13.9%). On the other hand, under these conditions, all females deposited eggs up to the third month during the ovipositional period and 80 % reached to the fourth month, while 50% of eggs were laid during the fifth month, andonly 10% were deposited until the sixth month of ovipositional period, where no females reached this period under the other conditions except at the same temperature and 70% R.H. Consequently, the highest amount of the total eggs (175.6 eggs / female) and longest ovipositional period (114.8 days) were reported under the same conditions.

Imamura *et al.*(2006) estimated the life history parameters of *A. venator*at 25, 27.5, 30, 32.5 and 35°C. on*T.confusum*larvae and reported thatas the temperature increased from 25°C to 35°C, the intrinsic rate of natural increase increased from 0.0081 to 0.0275. The same authors observed that, 35°C was the optimal temperature for population increase of *A. venator* under stored conditions.

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