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Zaprionus indiana (Diptera: Drosophilidae) in Saudi Arabia and the Effect of Temperature on the Life Cycle

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Abstract. During August and November 1988 a number of drosophilid flies *Zaprionus indiana* Gupta 1970. were collected from the pomegranate fruit at Taif area in Saudi Arabia. The effects of 25°C, 30°C and 35°C on developmental period and survival of different stages in the life cycle of the fly were investigated at 75% relative humidity and under continuous light. The mean egg incubation period, larval and pupal duration periods and adult longevity decreased with an increase in temperature from 25°C to 30°C. However, the mean hatching percentage, larval and pupal survival, weight of adults, cumulative percentage of adult mortality were increased. The reduction in mean adult longevity at 30°C rather than 25°C was associated with great reduction in the mean oviposition period and fecundity from 35.8 ± 12.9 to 1.3 ± 0.9 days; and 112.5 ± 39.7 to 1.2 ± 0.9 eggs, respectively, and all eggs laid at 30°C failed to hatch. Most of the eggs oviposited at 25°C were laid days 11 to 25 after emergence. At 35°C only the mean larval duration period was prolonged, but the mean incubation period and larval duration period were decreased, and all pupae failed to develop to an adult. The mean generation life span was 22.4 days at 25°C, shorter than 29.2 days at 30°C.

Introduction

The Drosophilid fly *Zaprionus indiana* Gupta 1970, was previously recorded only from India and Pakistan [1,2]. Few studies have been conducted on this fly and the only report is given by Shakoori and Butt [2], who studied the effect of various concentrations of Thioacetamide on the flies life cycle. Herein we reported the genus *Zaprionus* for the first time from Saudi Arabia and the results of the laboratory studies on *Z. indiana* life cycle under different temperatures to find out the possibility that the fly could exist in different regions in the Kingdom.

Materials and Methods

Collecting area

The study site is located at Taif area, Makkah province, Saudi Arabia. The area is within the Al-Sarawat Mountain range of western Arabian Peninsula, and is about 1600 m above sea level. The escarpment is mostly wooded with a relatively rich growth of *Acacia* trees and scattered large bushes and perennial shrubs including *Delonix* spp, *Tamarindus* spp., *Anagyris* spp., and *Ziziphus* spp. A full list of the natural vegetation of the study area is given by Migahid [3, p. 939].

Stock colony

The stock colony was established from field-collected flies and maintained in the laboratory at 25°C temperature, 75% relative humidity, and under continuous light. The flies were reared on Formula 4-24 Instant *Drosophila* medium (Carolina Biological Supply Company, U.S.A.) in plastic cages (150 × 100 × 200 mm) with two fine-screen windows (35 mm diameter) and a bottom hole (33 mm diameter) for food supply and maintenance. Vials (100 × 33 mm) containing the culture medium to a depth of ca 2cm were fixed in the cage holes for adult feeding and oviposition.

Experimental temperatures

The life cycle of *Z. indiana* was studied at 25°C, 30°C and 35°C, 75% relative humidity and under continuous light. Each experiment began with 0 - 2 hr old eggs, collected from the stock colony. The eggs were isolated from the stock colony using the method of Clark [4]. The incubation period was calculated at 6 hr intervals.

Larval and pupal duration periods

Zero to six hr old larvae were collected and separately placed in vials (25 × 50 mm) containing fresh medium and stoppre with cotton.

Adult life span

Newly emerged adults were collected every day and weighed. One male and one female were placed into a plastic cage (90 × 60 × 100 mm) of the same design as the cage used in the stock colony. Vials (25 × 50 mm) containing fresh medium were provided daily in each cage for adult feeding and oviposition.

The species identification was confirmed by Dr. L. Tsacas, Laboratoire de Biologie et Genetique Evolutives, France.

Results

Collecting site

The drosophilid fly *Z. indiana* was found infesting the pomegranate fruit *Panica granatum* L. during the period from August through November 1988 at Taif area, Makkah province. During this period, the mean air temperature ranged from 14.1 to 24.7°C and the mean relative humidity was 55% (Data obtained from Hydrology Division, Ministry of Agriculture and Water, Riyadh). This is the first member of this genus to be recorded from the country so far.

Zaprionus indiana life cycle at different temperatures

The temperature increase from 25°C to 35°C was associated with significantly decreased in mean egg incubation period from 42.7 to 20.9 hrs. But the increase in temperature from 25°C to 35°C has no significant effect on the hatching percentage (Table 1).

Table 1. Effects of temperatures on the egg incubation period and fertility of *Z. indiana* reared at 75% RH and under continuous light*

Parameter		25°C	30°C	35°C	Significance
Incubation period/h	range	28 - 60	18 - 36	15-36	
	$\bar{x}$	42.7	22.4	20.9	$P \leq 0.01$
	SD	12.1	4.8	6.4	
Fertility %	range	53 - 92	61 - 97	69 - 88	
	$\bar{x}$	74.9	88.2	82.0	**ns
	SD	16.1	4.6	7.9	

*n = 500.

**ns indicates no significant difference between means.

Larval and pupal duration periods

The mean larval and pupal duration periods significantly decreased with increased temperature. Of the larvae, it was about 8.1 days at 25°C and 6.9 days at 30°C. Of the pupae, it was 6.5 days at 25°C and 4.6 days at 30°C (Table 2). At 35°C the larval duration period was increased to 8.6 days and all pupae failed to develop to an adult. Larval and pupal survival was high at 25°C and 30°C (88%, 89% for larvae; 89%, 93% for pupae, respectively). But at 35°C there was a great drop in the larval and pupal survival, to 26% for larvae and 0% for pupae (Table 2).

Table 2. Effects of temperatures on the larval and pupal duration periods and survival of *Z. indiana* reared at 75% RH and under continuous light

Parameter			25°C	30°C	35°C	Significance
Larval duration	♂	n	81	114	52*	
Period / day		range	4-11	6-8	6-9	
		$\bar{x}$	8.2	7.1	8.6	$P \leq 0.01$
		SD	1.2	0.9	1.7	
	♀	n	75	52		
		range	4-10	5-8		
		$\bar{x}$	8.0	6.6		$P \leq 0.01$
		SD	1.3	1.0		
Larval survival %			88	89	26	
Pupal duration	♂	n	81	114		
period / day		range	5-9	4-7		
		$\bar{x}$	6.5	4.9	ND	$P \leq 0.01$
		SD	0.8	0.8		
	♀	n	75	52		
		range	5-8	4-5		
		$\bar{x}$	6.4	4.4	ND	$P \leq 0.01$
		SD	0.9	0.5		
Pupal survival %			89	93	00	

* For both ♂ and ♀.
ND, not determined; all pupae not developed to adults.

Adult activities

The mean adult longevity significantly decreased between 25°C and 30°C and ranged from 25.3 days for ♂ and 25.5 days for ♀ to 42.2 days for ♂ and 50.4 days for ♀ at 25°C (Table 3). The reduction in mean adult longevity between 25°C and 30°C was associated with a significant reduction in mean oviposition period, from 35.8 days to 1.3 days, and in a mean fecundity from 112.5 eggs to 1.2 eggs (Table 3). All eggs laid at 30°C failed to hatch. However, at 30°C the mean weight of adults was significantly higher (Table 3) and the emergence of adults was earlier than at 25°C (Fig. 1).

The increase in temperature from 25°C to 30°C, increased the cumulative percentage mortality and significantly increased the preoviposition period from 6.2 days to 17.8 days; and postoviposition period from 6.1 days to 10.8 (Fig. 2, Table 3).

Table 3. Comparison of weight, longevity, fecundity and ovipositional activities of *Z. indiana* at 25°C and 30°C reared at 75% RH and under continuous light

Parameter			25°C	30°C	Significance
Weight per fly at emergence (mg)	♂	n	81	114	
		range	1.00 - 2.30	1.46 - 2.34	
		$\bar{x}$	1.46	1.95	$P \leq 0.01$
		SD	0.27	0.21	
	♀	n	75	52	
		range	1.19 - 1.84	1.79-2.24	
		$\bar{x}$	1.59	2.02	$P \leq 0.01$
		SD	0.34	0.14	
Longevity/day	♂	n	50	50	
		range	10 - 82	5 - 53	
		$\bar{x}$	42.2	25.3	$P \leq 0.01$
		SD	16.7	13.6	
	♀	n	50	50	
		range	15-85	5-57	
		$\bar{x}$	50.4	25.5	$P \leq 0.01$
		SD	17.2	14.2	
Fecundity/egg		n	50	50	
		range	27-139	0-3	
		$\bar{x}$	112.5	1.2*	$P \leq 0.01$
		SD	39.7	0.9	
Preoviposition period/day		n	50	50	
		range	5-8	14-23	
		$\bar{x}$	6.2	17.8	$P \leq 0.01$
		SD	0.73	3.3	
Oviposition period/day		n	50	50	
		range	9 - 62	1 - 4	
		$\bar{x}$	35.8	1.3	$P \leq 0.01$
		SD	12.9	0.9	
Postoviposition period / day		n	50	50	
		range	0 - 12	0 - 30	
		$\bar{x}$	6.1	10.8	$P \leq 0.01$
		SD	2.8	7.8	

* All eggs oviposited failed to hatch.

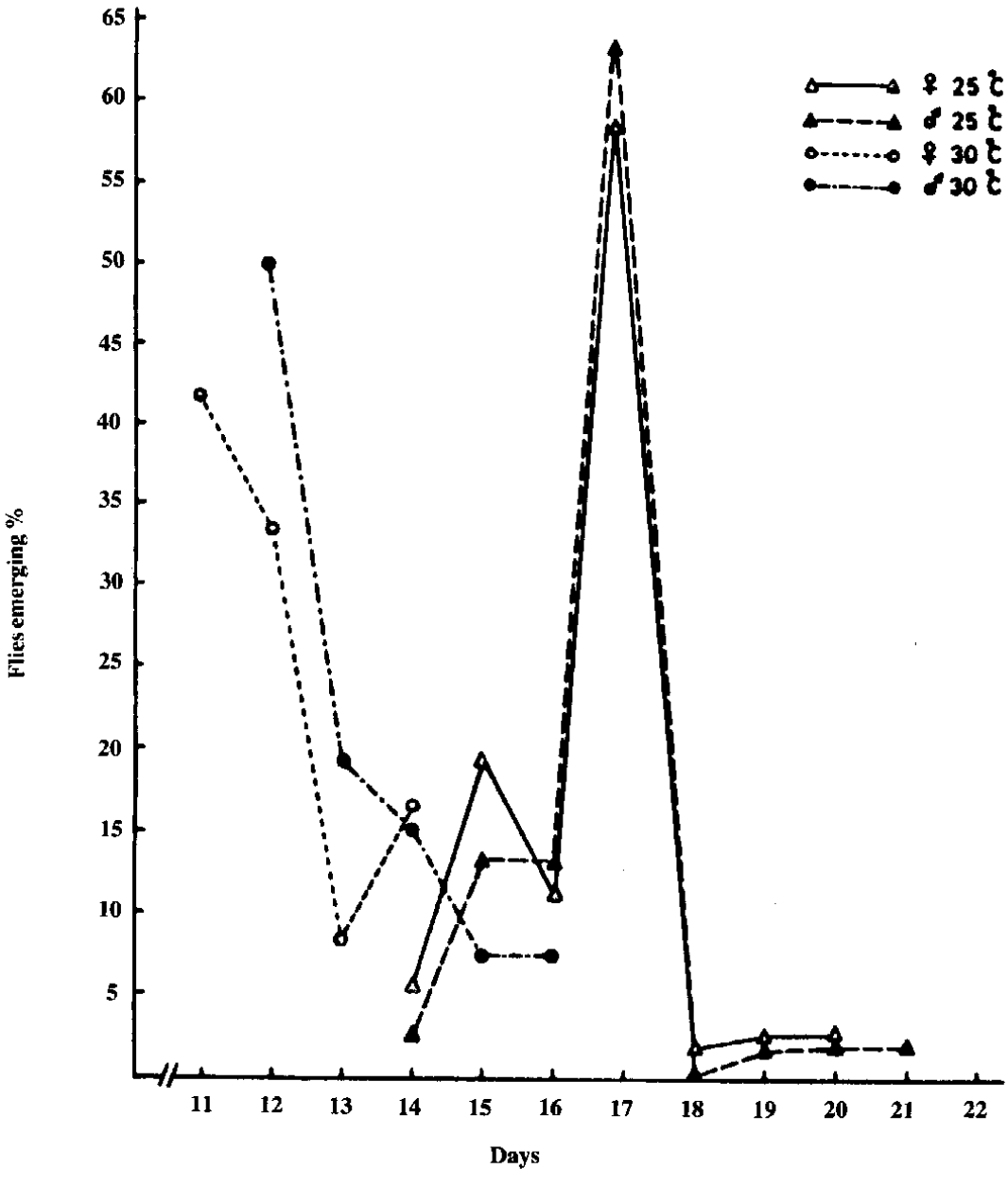

Fig. 1. Effect of temperatures on emergence patterns of *Z. indiana* reared at 75% RH and under continuous light.

Most of the eggs oviposited by females reared at 25°C were laid between the days 11 to 25 of female emergence (Fig. 3).

The mean generation life span which includes the mean egg incubation period and the mean larval and pupal duration periods plus the mean preoviposition period was 22.4 days at 25°C shorter than 29.4 days at 30°C.

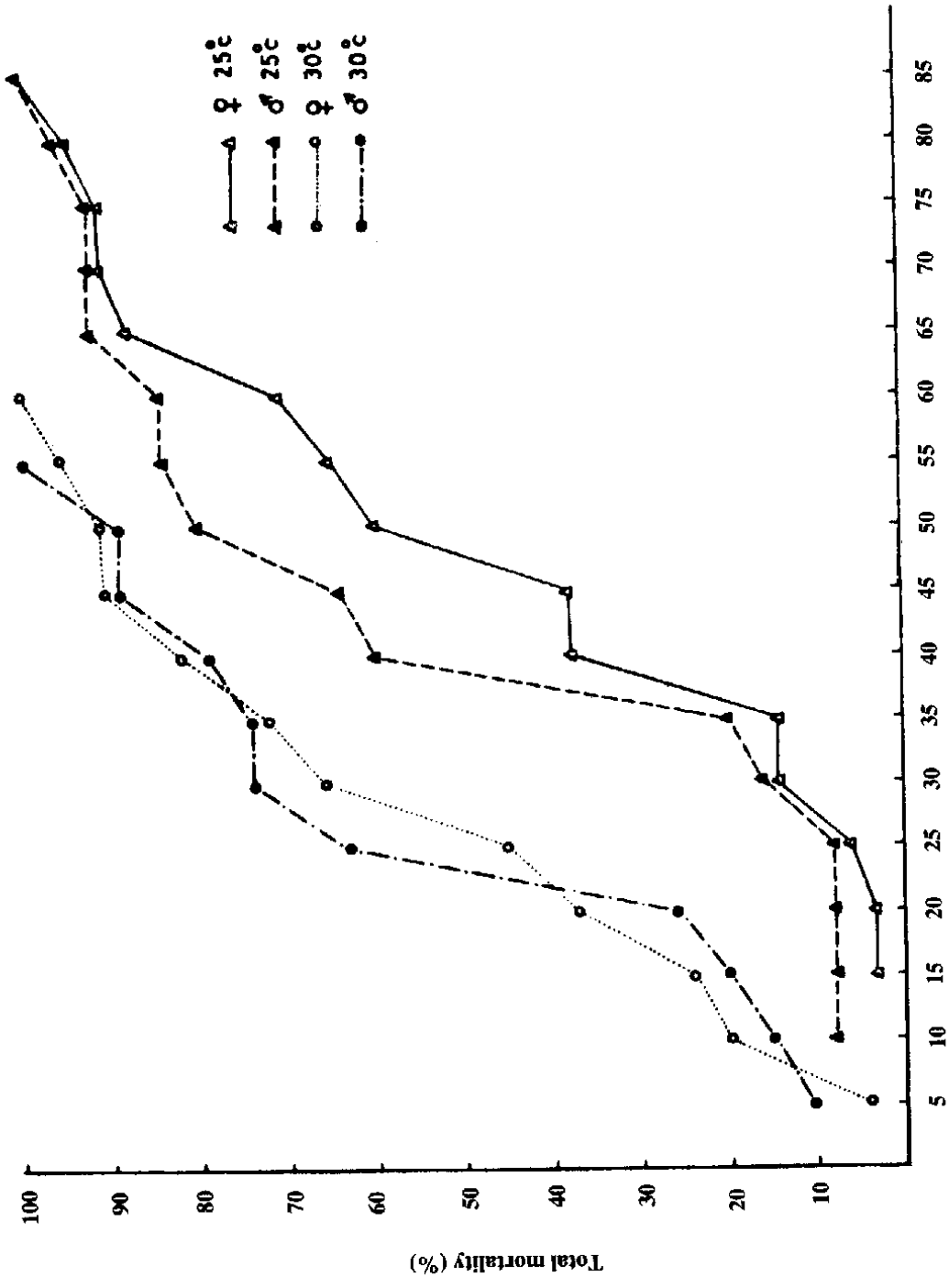

Fig. 2. Cumulative percentage of *Z. indiana* adult (males & females) mortality at various temperatures, 75% RH and under continuous light.

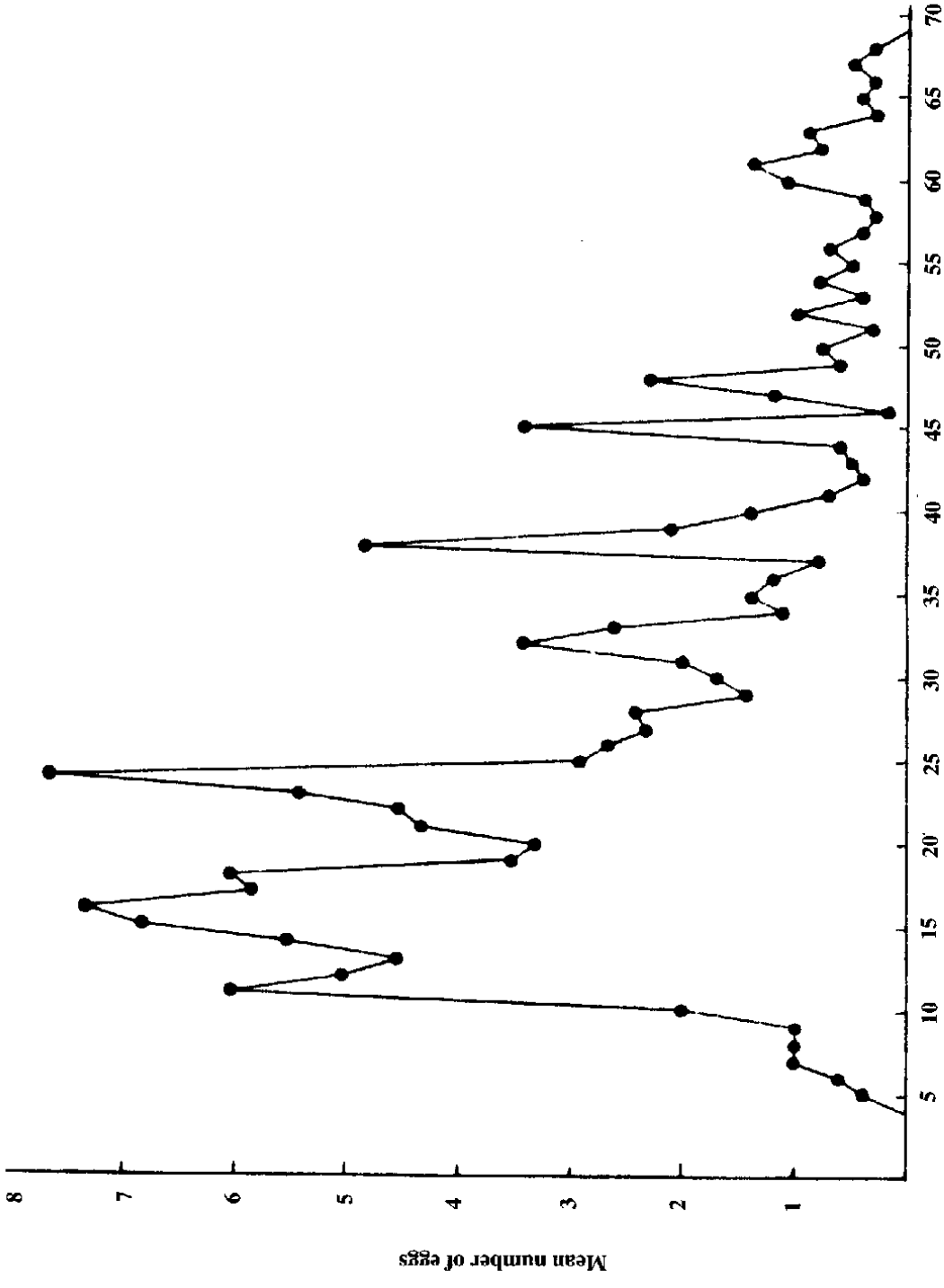

Fig. 3. The mean daily egg production of *Z. indiana* reared at 25°C temperature, 75% RH and under continuous light.

Discussion

The occurrence of the drosophilid fly *Z. indiana* in Saudi Arabia extends its distribution to the western Asia, since the fly was previously known only from the Indian subcontinent , India [1] and Pakistan [2].

The present study indicates that the increase of temperature from 25°C up to 30°C decreased the mean larval and pupal duration periods and adult longevity, but an increase in mean generation of *Z. indiana* life span was observed. This is probably due to an increase in the metabolic rate and it is correlated with an increase in the physical activity of the insect [5-8]. The same results were observed on *Cardiochiles nigriceps* [9], *Rhaconotus roslinensis* [10]. When *Z. indiana* was reared at 22°C the developmental rate was increased [2], this confirms our findings. Furthermore, at high temperature (30°C), there is an increase in adult longevity which was accompanied by an increase in body weight in addition to the high mortality rate found in animals maintained at comparatively lower temperature (25°C). Whereas, at 30°C the fecundity of *Z. indiana* was significantly reduced as we show in Table 3. As a result of decreased reproductive activities, all the energy might have been channelled towards body growth and resulted in an increase in body weight at high temperature. These observations are in line with the findings of Adarsh and Sohi [11], Hollingsworth [12], Hylton [13], Shukla and Singh [14], Ragland and Sohal [6], Miquel *et al.* [7], Sharma *et al.* [15] and Sharma and Jit [8] in different insect species. On the other hand, at high temperature (30°C) the cumulative mortality in adults was high and, at 35°C , all pupae failed to develop into adults, this may be attributed to protein denaturation as well as to the increase in organizational entropy which caused irreversible destruction/inactivation of protein biomolecule [16,17]. Moreover, an increase in amino acid racemization at high temperatures [18] may be responsible for changing the three dimensional configurations of protein biomolecules which resulted in changes in their activities and specification [8]. Similarly, at high temperature, the rate of ontogenesis was increased in different animals which was correlated to the increased biosynthesis of nucleic acids [19,20].

The population of *Z. indiana* displays a greatly foreshortened life span and reduced fecundity at 30°C and failed to develop to an adult at 35°C. This temperature range is quite common throughout most of the day during mid-summer in Saudi Arabia. The fly might be expected to avoid such extremes of temperature in nature. Field studies are required to investigate the seasonal dynamics of the fly under natural conditions.

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تسجيل ذبابة زبريونس انديانا *Zaprionus indiana* Gupta التابعة لعائلة الدروسوفيلا من رتبة ثنائية الجناح في المملكة العربية السعودية وتأثير درجات الحرارة العالية على دورة حياتها في المختبر

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(استلم في ٢٦ شوال ١٤١٠هـ، قُبل للنشر في ١٨ ربيع الأول ١٤١١هـ)

ملخص البحث. لقد تم في هذا البحث تسجيل ـ لأول مرة ـ ذباب الدروسوفيلا من نوع الزبريونس *Z. indiana* من على ثمار أشجار الرمّان في منطقة الطائف بالمملكة العربية السعودية وذلك خلال الفترة من أغسطس إلى نوفمبر من عام ١٩٨٨م. ويعرض البحث أيضًا تأثير درجات الحرارة المختلفة ٢٥°م، ٣٠°م، ٣٥°م على فترة نمو الذبابة، وكذلك على بقاء ومعيشة الأطوار المختلفة في دورة حياة هذه الذبابة، حيث درست تحت ظروف شملت الرطوبة النسبية عند ٧٥٪. وكذلك عند إضاءة مستمرة. وقد أثبتت الدراسة أن متوسط فترة حضن البيض، وكذلك طول عمر الأطوار اليرقية والعذارى وطول عمر الأطوار اليافعة قد انخفضت نتيجة زيادة درجة الحرارة من ٢٥°م إلى ٣٠°م، بينما ازداد متوسط نسبة الفقس وكذلك نسبة معيشة اليرقات والعذارى بالإضافة إلى أوزان الأطوار البالغة، وكذلك نسبة وفياتها نتيجة زيادة درجة الحرارة من ٢٥ ـ ٣٠°م. كما لوحظ أن هناك انخفاضًا في متوسط أعمار الذباب البالغ عند درجة ٣٠°م خلافًا عما هو في درجة ٢٥°م. وهذا يترتب عليه انخفاض كبير في متوسط فترة وضع البيض، وكذلك في الخصوبة حيث يصل الانخفاض في فترة وضع البيض من ٣٥,٨ إلى ١,٣ يوم، ويصل متوسط عدد البيض من ١١٢,٥ إلى ١,٢ بيضة، بينما لم يفقس أي من البيض الذي وضع عند درجة ٣٠°م، كما دلّت التجارب على أن معظم البيض الذي وضع عند درجة ٢٥°م كان ما بين ١١ يومًا إلى ٢٥ يومًا من وقت الخروج، وقد أثبتت التجارب أيضًا أن متوسط عمر اليرقات التي لم تتحول إلى عذارى قد أطيل عند درجة ٣٥°م، ولكن متوسط فترة حضانة البيض وفترة بقاء اليرقات التي تحولت إلى عذارى قد نقصت. كما أن جميع العذارى لم يكتمل نموها إلى أفراد يافعة. ودلّت التجارب على أن متوسط مدة حياة الجيل هو ٢٢,٤ يوم عند درجة ٢٥°م، وهو أقل من ٢٩,٢ يوم عند درجة ٣٠°م.