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Demographic parameters of *Bactrocera cucurbitae* and *Bactrocera dorsalis* (Diptera:Tephritidae) pests of cucumber (*Cucumis sativus*) during the seasons of year in the South of Côte d'Ivoir

Assi Apie Nadège Marina, Aboua Louis Roi Nondenot, Obodji Adagba*, Kadio Ekien Alloua Ahébé Bertille, N'Guessan Ehikpa Naomie Melinand

University Félix Houphouët Boigny, Abidjan-Cocody, UFR-Biosciences, Laboratory of Zoology and Animale Biology, Abidjan, Côte d'Ivoire

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Abstract

Bactrocera cucurbitae and *Bactrocera dorsalis*are the major pests of cucumber (*Cucumis sativus*), in Côte d'Ivoire. A study of the biological parameters of these species was carried out during the four seasons of the year for effective control. The experiments were performed in semi-natural conditions in the orchard and in the conditions of ambient laboratory environment. A specific breeding *B. cucurbitae* and *B. dorsalis* has been taken. The different biological parameters have been determined. The study revealed that the numbers of eggs laid by the females of both flies species were higher in the rainy season than during the dry season. The duration of egg incubation was longer at *B. dorsalis* than at *B. cucurbitae* during the four seasons. The duration of the development cycle of the two flies was shorter in the rainy season than during the rainy season. The emergence rate of *B. cucurbitae* was ranged between 44.10 ± 0.19 and 51.70 ± 0.17 % and the emergence rate of *B. dorsalis* was ranged between 28.70 ± 0.18 and 33.80 ± 0.16 %. Longest life was recorded at adult *B. cucurbitae*.. Adult females have lived alongside adult males, in both species, in four seasons. The study on the biology of these two fruit flies showed that *B. cucurbitae* was a serious pest in all the views of the various parameters studied. These results allow a better determination of the periods and means of intervention in the control of *B. cucurbitae and B. dorsalis*

* **Corresponding Author:**Obodji Adagba✉obodjiada@yahoo.fr

Introduction

The sector of fruits and vegetables is an important source of income for producers in the world. Their nutritional values, therapeutic and socio economic are well known and make them indispensable foods in everyday life. In developed countries they are subject to more demanding regulation and an innovation and quality enhancement. In developing countries this sector should also be a priority for our governments to diversify agricultural production, improve the nutritional balance of the population, increase farmers' income and thus improve living conditions of the rural world.

The vast majority of grown vegetables are introduced varieties from Europe, the US and Israel (Sangaré *et al.*, 2009). All these cultures cucumber is much sought after because of its relatively short cycle (Declert, 1990). The cucumber is grown almost everywhere in Côte d'Ivoire today and remains essential in salad dishes. Its annual production is around 30 000 tonnes (Sangaré *et al.*, 2009). The ivorian cucumber shows no exportation. Its marketing is done on site in local markets. Prices vary according to availability in the field. However, this sector still faces many difficulties with orders phytosanitary pests like fruit flies which cause crop losses. *Bactrocera cucurbitae* and *Bactrocera dorsalis* caused extensive damage to cucurbitaceous vegetable. They have been reported as the major limiting factor in obtaining high yields and good quality fruits of cucurbits. Their attack on cucumber not only reduces the yield but also affects the quality of cucumber and as a result, the marketability of the crop is reduced. It was found in Mali in 2000 (Vayssiéres *et al.*, 2004) and has become widespread in West Africa (Benin, Burkina faso, Guinea , Mali, Côte d'Ivoire, Senegal and Togo) over the last 10 years. The melon fly is a particular harmful specie on cucurbit crops in the India Ocean (Mauritius and Reunion). Knowledge of main demographic parameters of *B.cucurbitae* and *B.dorsalis* is helpful in developing efficient management strategies. This study was undertaken to gain precise knowledge of the number of eggs laid per female during its life, the duration of the incubation period of eggs, duration of the biological cycle, rate of emergence, sex ratio and adult longevity.

Materials and methods

Study area

The study was conducted in the locality of Dabou (Latitude. 5°18'50, 55" N and longitude 4°14'27, 16" w) located in the south of Côte d'Ivoire. The climate is subequatorial characterized by four seasons: two annual rainy seasons (from April to mid-July and September to November) and two dry seasons (from mid- July to August and December to March) (Vennetier and Laclavère, 1978 ; Anonymous, 1979). The study period extended from April 2014 to Mars 2015 with average temperatures varying from 24.7 to 28.6°C, relative humidity ranging between 81.9 - 86.5% and rainfall varying from 22.3 to 485.3 mm. The study was conduct during the four seasons of year.

Breeding of fruits flies

The fruits, bitten by female flies collected from fruit trees, were brought to the laboratory. They were incubated in trays containing sterilized and humidified sand. Sterilization was carried out using an autoclave at a temperature of 121°C and a pressure of 1.5 bars. Some days later, newly formed pupae were collected. The Pupae were then kept in plexiglas boxes (28 x 27 x 9.5 cm) containing sterilized and humidified sand, until adult emergence. The box was coved with muslin.

The newly emerged adult flies were collected according to Drew and Raghu (2002).The male and female of each species were collected and placed inside the rearing cage. On the bottom of each cage there was a 2 cm-thick layer of sieved sand. Honey diluted in water to 5% was provided inside the cage for adult feeding. This honey solution was kept in petro dish and cotton was immersed in this solution. The biological parameters studied were the number of eggs laid per female during its life, the duration of the incubation period of eggs, duration of the biological cycle, rate of emergence, sex ratio and adult longevity.

Determination of the number of eggs laid per female and the duration of eggs incubation period

Two batches of thirty pairs of *B. cucurbitae* and*B. dorsalis*, newly emerged, were made. They were placed, each in muslin sleeve containing five healthy fruits on the cucumber tree. Every 24 hours, the pitted fruits, were removed from the sleeve and was moved to continue the experiments on other healthy fruits on other tree, until the death of the female. For the first batch, the eggs laid by the females were counted, under binocular magnifying glass, by removal of pulp, at the place of the deposit of eggs. The average number of eggs laid per female during its life (L) was calculated by the formula following :

$$L = \frac{\sum ei\ ni}{\sum ni}$$ ei : number of laid eggs; ni: number of the females

For the second batch, fruits containing eggs were placed in trays composed sterilized sand. These eggs were observed daily until hatching. The average incubation period (Pi), which is the time between egg lying (l) of the hatching (h) was noted:

$$Pi = \frac{\sum ti\ vi}{\sum vi}$$ ti = h – l ; vi = number of eggs

Determination of the duration of biological cycle, the rate of emergence, sex ratio and longevity of the adults

At the hatching of the second batch of females, these fruits were monitored daily and the dates of successive exuviae were noted, development times (DL1, DL2, DL3) ofthree (3) larvae stages and the total duration larvae development (Dl) were noted, expressed in days, was given.

$$Dl = \frac{\sum xi\ ni}{\sum ni}$$ *xi* = Time between egg and larva stage 3; *ni* number of larvae stage 3 (TS3).

Pupation (P), expressed in days was noted. It is the time between (TS3) the moment of obtaining the pupa (Tp).

$$P = \frac{\sum ai\ bi}{\sum ni}$$ ai = Tp - TS3: time taken by the larvae stage 3 to become a pupa; bi: number of pupae.

The duration of pupal development (Dp), in days, was determined. It corresponds to the time between pupation (P) and the emergence of the adult (Ea).

$$Dp = \frac{\sum ci\ di}{\sum di}$$ ci = Ea – P : time taken for the pupa to become adult ; di: number of adults.

The average number of offspring (No) was calculated.

$$No = \frac{\sum ei\ fi}{\sum fi}$$ ei = number of adult emerging ; fi = number of batch

The duration of biological cycle (Dc), expressed in days, the period egg-laying and adult stage, was determined.

Dc = Pi + Dl + P + Dp

The mean of the sex ratio (Sr), as a percentage, was calculated for the offspring of the 30 females.

$$Sr = \frac{\sum gi\ hi}{\sum hi}; gi = \frac{\text{number of male emerging}}{\text{number of female emerging}} \times 100;$$ hi = number of female parent Adults

Adults were fed honey diluted in water to 5%. The number of dead imagoes was increased each day until death of the last individual. The average longevity of adults (Fd), expressed in days, was determined.

$$Fd = \frac{\sum li\ ki}{\sum ki}$$ li: longevity ; ki : number of insects

Statistical analysis

Data processing was carried out using the software Statistica version 6.0. Each test was repeated 30 times. The results were subjected to a variance analysis (ANOVA). Mean separations were done using the Newman-Keuls test at 5 %.

Results

Number of eggs

During the rainy seasons (small and long), the average number of eggs laid by *B.cucurbitae* was higher (ranging between 329.23 ± 3.04 to 336.63 ± 3.56) than those laid during the dry seasons (small and long) which ranging between 285.10 ± 2.14 to 280.50 ± 2.14.

At *B. dorsalis*, the average number of eggs laid also increased (ranging between 167.93±0.91 to 168.13±1.24) during the rainy seasons (small and long) than those laid during the dry seasons (small and long) that have waried from 139.26 ± 0.59 to 145.10 ± 0.08 (table 1).

Table 1. Number of eggs laid by *B. cucurbitae* and *B. dorsalis* according to seasons of year.

	Species of flies	
Seasons of year	*B.cucurbitae*	*B.dorsalis*
Long rainy season	336.63±3.56^{f}	167.93±0.91^{a}
Small rainy season	329.23±3.04^{e}	168.13±1.24^{a}
Long dry season	285.10±2.14^{b}	145.10±0.08^{d}
Small dry season	280.50±2.14^{b}	139.26±0.59^{c}

In the same column and on the same line, the averages followed by the different letters are significantly different.

Number of offspring and sex ratio

The emergence rates for both flies were higher during the rainy seasons than during the dry seasons. The average for the two flies was ranged between 85.50 ± 1.51 to 87.06 ± 1.24 during the four seasons (Table 2).

Table 2. Average sex-ratio and rate of emergence of *B. cucurbitae* and *B. dorsalis* according to seasons of year.

Seasons of year	Mean rate of emergence (%)		Mean of sex-ratio	
	B.cucurbitae	*B.dorsalis*	*B.cucurbitae*	*B.dorsalis*
Long rainy season	51.60±0.17^{c}	33.80±0.16^{b}	85.66±1.50^{a}	85.83±131^{a}
Small rainy season	51.40±0.20^{c}	33.60±0.17^{b}	85.56±1.41^{a}	87.03±1.36^{a}
Long dry season	45.70±0.39^{d}	29.10±0.15^{a}	86.43±1.35^{a}	87.06±1.24^{a}
Small dry season	44.10±0.19^{d}	28.70±0.18^{a}	86.16±1.03^{a}	85.50±1.51^{a}

In the same column and on the same line, the averages followed by the different letters are significantly different.

Duration of egg incubation

At *B. cucurbitae* the average duration incubation of eggs during the rainy seasons (small and long) ranged from 1.50 ± 0.09 to 1.60 ± 0.09 days. During the dry season the average duration incubation was 1.30 ± 0.08 and 1.40 ± 0.09 days respectively at the long and small dry season at *B. dorsalis*. The average duration of incubation of eggs during the rainy seasons (small and long) ranged from 2 to 2.10 ± 0.05 days and during the dry period the average duration incubation of ranged from 1.90 ± 0.05 and 2.20 ± 0.07 days (Table 3).

Duration of development of each larval stage and duration of pupation

For both flies, larval development was longer during rainy seasons than during the dry season. Concerning the average duration of pupation, it was ranged between 1.70 ± 0.08 to 1.90 ± 0.05 days for *B. cucurbitae* during the four seasons. At *B. dorsalis* the average duration of pupation varied from 1.90 ± 0.05 to 2.20 ± 0.07 days (Table 4).

Table 3. Average duration of egg incubation (day) of *B. cucurbitae* and *B. dorsalis* according to season of year.

Species of flies		
Seasons of year	*B. cucurbitae*	*B. dorsalis*
Long rainy season	1.50±0.09^{ab}	2.10±0.05^{cd}
Small rainy season	1.60±0.09^{b}	2.00^{cd}
Long dry season	1.30±0.08^{a}	1.90±0.05^{c}
Small dry season	1.40±0.09^{ab}	2.20±0.07^{d}

In the same column and on the same line, the averages followed by the different letters are significantly different.

Durations of development of the pupa and biological cycle

For both flies, the development of the pupa and the life cycle were longer during the dry seasons than in the rainy season.

The duration of biological cycle ranged from 22.30 ± 0.34 to 22.50 ± 0.30 days during the dry seasons and ranged from 21 ± 0.3 to 21.10 ± 0.33 days during the rainy seasons for *B. cucurbitae*. At *B. dorsalis*, the duration of life cycle ranged from 24.80 ± 0.26 to 25.1 ± 0.26 days during the dry seasons and 23.5 ± 0.19 days during the rainy seasons (Table 4).

Table 4. Average duration of development (day) of immature stage and biological cycle of *B. cucurbitae* and *B. dorsalis*.

		Mean duration (days)			
Seasons of year	Species of flies	Larval development	Pupation	Pupal development	Biological cycle
Long rainy season	*B. cucurbitae*	8.30±0.08^{b}	1.90±0.05^{abc}	9.30±0.08^{a}	21.00±0.3^{a}
Small rainy season		8.28±0.06^{b}	1.80±0.07^{ab}	9.40±0.09^{a}	21.10±0.33^{a}
Long dry season		7 .4±0.09^{a}	1.70±0.08^{a}	12.10±0.05^{d}	22.50±0.30^{b}
Small dry season		7 .5±0.1^{a}	1.70±0.08^{a}	11.70±0.08^{c}	22.30±0.34^{b}
Long rainy season	*B.dorsalis*	9.10±0.05^{de}	2.00^{bcd}	10.30±0.08^{b}	23.5±0.18^{a}
Long rainy season		9.20±0.07^{e}	2.10±0.05^{cd}	10.20±0.07^{b}	23.5±0.19^{a}
Long dry season		8.7±0.08^{c}	1.90±0.05^{abc}	12.30±0.08^{d}	24.80±0.26^{b}
Small dry season		8.9±0.05^{cd}	2.20±0.07^{d}	11.80±0.07^{c}	25.1±0.26^{c}

In the same column and on the same line, the averages followed by the different letters are significantly different.

Life span of adults

For both flies, the average life spans of adults were longer during the rainy seasons than in the dry season. Its was ranged from 69.93 ± 0.78 to 82.73 ± 0.94 days (rainy season) and 66.20 ± 0.72 to 80.33 ± 1.05 days (dry season) for *B. cucurbitae*.

For *B. dorsalis* the average time life was ranged from 56.36 ± 0.87 to 65.63 ± 1.31 days in the rainy season and then from 50.70 ± 1.26 to 62.03 ± 0.99 days in the dry season. For all seasons combined, the life times of females were longer than those of males for both flies species (Fig. 1)

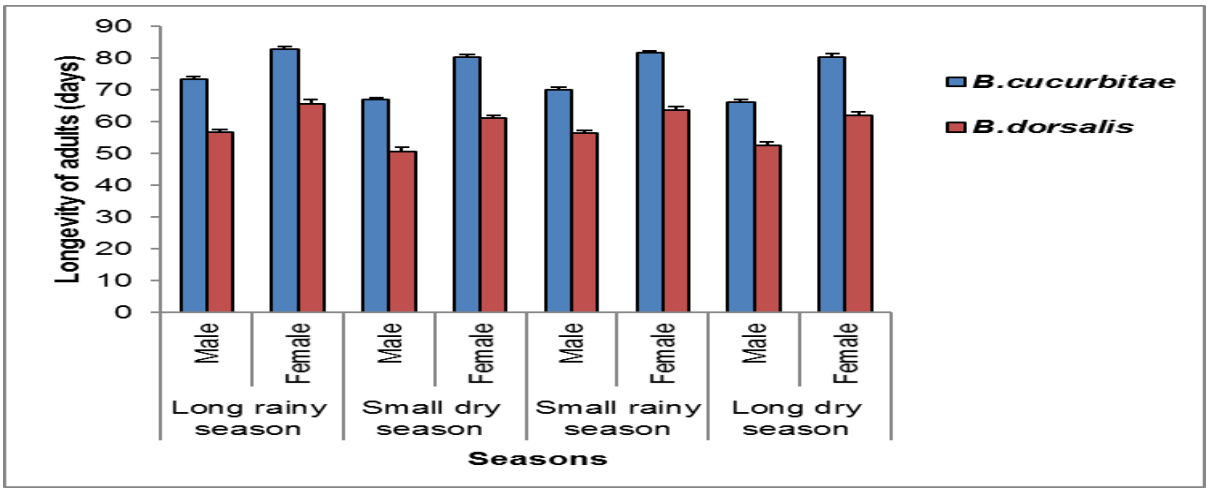

Fig. 1. Average longevity of adults of *B. cucurbitae* and *B. dorsalis* according four seasons of year.

Discussion

Number of egg

The average number of eggs laid by flies' females has varied according to the seasons of the year. During rainy periods, the average number of eggs laid by a female was higher than during dry period in both flies.According Batman (1972), relative humidity and rainfall affect the fertility of insects. During the four different seasons of the year, the average number of eggs laid by females of *B. cucurbitae* was more than a female of *B.dorsalis*. This suggests that the sweet cucumber is a very attractive host fruit for *B.curcubitae*. Before laying the female explores the substrate using her ovipositor, to ensure good incubation conditions eggs (Cortesero 1994; Aboua, 2004). The cucumber seems to be the original host of *B. cucurbitae*. The original host contains all the terms of the optimal development of the insect Cassier *et al.* (1997). For *B.dorsalis* cucumber would be a secondary host. Indeed, the smell of cucumber, his skin hard and green color does not seem to be too attractive for *B.dorsalis*.

Duration of egg incubation

The incubation period was 1 to 2 days in *B.cucurbitae* each season. These results are in the close agreement with those of Waseem *et al.* (2012) who reported that incubation period on cucumber lasted from 24.4 to 38h. Similary, Khan *et al.* (1993) reported approximately the same incubation period as report herein.

Duration of development of each larvae stage

The average duration of development larvae stage of B. *cucurbitae* and *B. dorsalis* differ from one season to another. They were shorter in the two dry seasons where the temperature was the highest and the lowest relative humidity. They were longer in the two rainy seasons where the temperature was the lowest and the highest relative humidity. This result corroborates those of Tano (2012) which reported that temperature and relative humidity influenced the development of immature stages of *Caelaenomenodera lameensis*. In rainy season its development was slow and in dry season its development is accelerated. This argument joined those of Brévault and Quilici (2000) and Duyck and Quilici (2002), which reported that several abiotic factors affect the growth and development of insects; the temperature is probably the most critical environmental factor. This finding is the same as that of Ekesi *et al.* (2006) who indicated that temperature influences the development of the immature stages of *B. dorsalis*. This result corroborates those many authors. The total larval period of *B. cucurbitae* on cucumber differed of those of Mir *et al.* (2014). Other workers reported approximately the same periods as reported, 5 to 11 (Singh and Teotia, 1970); 3 to 8 days (Doharey,1983).

Duration of development of the pupa

As for the duration of pupal development, it was longer in the two dry seasons and shorter in two rainy seasons. Extending the pupal development time would be that the pupa takes longer to turn into imago, when the temperature is high. A similar observation was made by Ekesi *et al.* (2006), Rwomushana *et al.*(2008) who reported that the high temperatures slow down the development of fruit flies within nymphs or kill, to the point where no adult emerges from the pupal at a constant temperature of 35° C. According Batman (1972), low relative humidity of the environment in dry periods causes a high mortality of adult flies that should provide a lot effort before leaving the dry soil. In sum, the duration of life cycle of *B.cucurbitae* was shorter than *B.dorsalis* in the rainy season and in the dry seasons.

This could certainly explain the strong outbreak of Tephritidae flies observed during periods of rain. Similar results were demonstrated by N'depo *et al.*(2010) during dynamic of *B. dorsalis* on mango; this is consistent with results obtained in Togo (Amevoin *et al.*, 2009; Vayssières *et al.*, 2014).

Duration of biological cycle

The duration of life cycle of *B.cucurbitae* was shorter than *B.dorsalis* in the cucumber during four seasons of the year. This difference could explain by the structure, the composition and the physiology of the pulp of the cucumber.

Indeed some plant species is more conducive to larval development compared to other plants. These are called preferred host plants. Mwatawala*et al.* (2006), Quilici (2007) and N'depo *et al.* (2010) were observed that the infestation of cucumber by *B. dorsalis* is low. In Reunion Island *B. cucurbitae* cause severe damage to cucurbit crop (Etienne, 1972; White and Harris, 1992; Vayssières 1999; Hurtrel and Quilici, 1997).

Rate of emergence

The emergence rates were higher in *B. cucurbitae* than *B.dorsalis* during different seasons of the year. This difference is due to the fact that cucumber helps larval emergence of *B.cucurbitae*, the latter being its original host Cassier *et al.* (1997). For each species of fly emergence rates were higher during the rainy season and during the dry seasons. This would explain the high abundance of fly during rainy periods.

Life span of adults

The lives of adult flies were shorter or longer according to the species. The female life span was longer than this of males. The short span of life of males would be the fact of the great energy released by them during mating. Also according to (Batman, 1972; Meats and Fay, 1983), the males can mate frequently but becomes unresponsive for several weeks after each coupling.

This is what Williams (1966) has called "*reproduction* cost" concept linking the effort of reproduction to the other functions of the insect. This result was differend of those of Ekesi *et al* (2006) and N'Guessan (2011) who reported that for *B. dorsalis*, males lived longer than females in mango and orange.The life times of *B. cucurbitae* adults were longer than *B.dorsalis* adults. Short life times of adults *B.dorsalis* would be related to the longtime of development of their stages pre-pupal Aboua *et al.* (2010).

The long-time development of pre-imaginal stages of *B.dorsalis* seem to affect the life of adults. Indeed, the long-time need for optimal development of the larvae, would extendits period of development and would shorten the life of the adults from those.

Conclusion

The study of demographic parameters showed that *B. cucurbitae and B.dorsalis* are holometabolous insects. Biological cycle includes three instars and a pupal stage. The duration of the biological cycle of *B. cucurbitae* and *B. dorsalis* have been longer during rainy season The male development time was shorter than this of females, as at *B. cucurbitae* and *B.dorsalis*. The number of eggs laid by the female of *B. cucurbitae* was higher than the female of *B. dorsalis*. *B. cucurbitae* has a higher reproductive capacity than *B. dorsalis* on cucumber.

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