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POPULATION ECOLOGY OF MOSQUITOES AND THE STATUS OF BANCROFTIAN FILARIASIS IN EL DAKAHLIA GOVERNORATE, THE NILE DELTA, EGYPT

By

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Abstract

Mosquitoes were surveyed (Oct. 2010 & Apr. - Oct. 2011) in some localities representing 13 centers of El-Dakahlia Governorate. Six mosquito species were collected: *Culex pipiens, Cx. antennatus, Cx. perexiguus, Ochlerotatus detritus*, *Anopheles pharoensis* and *An. tenebrosus*. *Culex pipiens* was predominating (*ca* 79% larvae, 51% adults). *Culex antennatus* and *Cx. perexiguus* were also common. Of the Four types of the breeding habitats, the drainage canals were the most productive (53.4% larvae). For the three common species, the compiled larval density increases as water temp. increased and decreases as pH increased while adult indoor density increases as indoor and outdoor temp. and indoor RH increased and decreases as outdoor RH increased. *Cx. pipiens* significantly associated with *Cx. antennatus* (C_{AB}=0.88 & I=0.48) while *Cx. antennatus* has a moderate association with *Cx. perexiguus* (C_{AB}=0.47 & I=0.36). Out of 908 examined blood samples from ten centers, 7.49% were infected with *Wuchereria bancrofti.* The highest infection rates in some centers were associated with high indoor densities of *Cx. pipiens* females, the main filariasis vector. The situation necessitates a wide vector control program to minimize lymphatic filariasis transmission in this Governorate.

Key words: Mosquitoes, Breeding habitats, Interspecific association, Filariasis, *Wuchereria bancrofti,* Filaria vector, El Dakahlia Governorate, Egypt

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Introduction

El Dakahlia is considered as one of the ancient Governorates in Egypt. The Gov. lies in the Nile Delta at the eastern north sector around the Damietta branch between latitude of 32°-30° N and longitude of 31.5°-30.5°E (Fig. 1).

The Gov. is bordered by El-Sharqiya Gov. on its east side, El Gharbiya Gov. on the west, the Mediterranean Sea on the north, Damietta Gov. on the east north, Kafr El Sheikh Gov. on the west north and El Qalubiya on the south. It has a population of 5,551,592 (2011), i.e. 6.81% of the total population or the third largest Gov. in Egypt and has an area of 3470.90 km^2 (Ministry of Foreign Trade and Industry, 2004). Administratively, the Gov. is divided into 18 centers. The Capital, Al Man-soura is 120 km east north of Cairo.

The Gov. is considered as the Nile Delta base (Egypt's first farm) where the total cultivated area equals 644,880 acre, approximately 10% of the cultivated area of the country. It produces 13% of the country's total production of cotton, 19% of the rice, 10% of the wheat and 5% of the maize crop. The Gov. is rich land with water and fish resources and ranks as the first Gov. in Egypt in terms of the production of meat and eggs.

There is a large industrial base in El Dakahlia including industries of fertilizers, oil hydrogenation, chemicals, spinning and weaving garments, car accessories, natural gas, fruit and vegetable processing and glass.

There are no available reports on previous mosquito surveys in El Dakahlia except that of El Shazly *et al* (1998) in Al Mansoura center who collected 10 species of culicine larvae. Mosquitoes in Egypt play an important role in disease transmission for example (1) Culicine mosquitoes are vectors of filariasis (Southgate, 1979), Rift valley fever virus (Meegan *et al,* 1980), West Nile virus (Hurlbut *et al,* 1956; Soliman *et al,* 2010) and several other viruses (Darwish and Hoogstraal, 1981), (2) Of the anopheline species, *Anopheles pharoensis* is the proven malaria vector, *An. multicolor* is suspected as a vector while *An. tenebrosus* has no role in malaria transmission (Kenawy, 1988).

This study was planned and carried out to provide observations on the ecology of mosquito fauna and associated status of filarial transmission in this Gov. This is an important component for planning and implementing a vector control program based on solid ecological information of mosquitoes mainly the disease vectors.

Materials and Methods

The surveys were carried out (Oct. 2010 & Apr.- Oct. 2011) in some localities representing each of 13 out of 18 centers of El Dakahlia (Tab. 1). Locations (longitude and latitude) of the selected localities were recorded using a global positioning system (GPS) navigator.

Mosquito larvae were collected by netting and adults were collected from inside houses by space spraying (0.2% pyrethroid in kerosene) followed by hand collection as described by Abdel-Hamid *et al* (2009). Keys (Harbach, 1988**;** Glick, 1992) were used for mosquito identification. Along with mosquito collections, water temp. and pH and weather temp. and relative humidity (RH) were measured. The effect of such factors on densities of larvae (No / survey unit, SU=10 net dips) and adults (No/room) was analyzed for the common species. To test and explain the association among the reported common species, data on the co-occurrence of such species was analyzed (Southwood, 1991). To measure the degrees of the significant associations (χ^2 test), the coefficient of interspecific association (C_{AB}±*SD,* based on presence-absence data of two species) and the Index of association or Sorensen's coefficient (*I*, based on the number of larvae) were calculated. Values of such coefficients are ranging from -1 (no association) to +1 (complete association).

The AMRAD-ICT filariasis card test was used to detect the *Wuchereria bancrofti* antigen in the whole blood (Ramzy *et al,* 1999). The finger prick blood samples were drawn onto the card (El-Setouhy *et al,* 2007) and the results (negative/ positive) were read visually after 15 minutes.

Statistical analysis: Mean larval and adult indoor densities (±*SD*) of the reported mosquito species were compared using one-way ANOVA and if significantly unequal, they were exposed to pairwise comparisons by Tukey's HSD tests. Regression analysis was used to examine the relation of larval density to the temp. and pH of the breeding water and of the indoor adult density to the indoor- and outdoor temp. and RH. The slopes of the regressions were tested for deviation from 0 by *t*-test. The SPSS software (Version 11 for windows, SPSS Inc., Chicago, IL) was used for statistical analysis

Results

Culex (*Culex*) *pipiens* Linnaeus*, Cx.* (*Cx.*) *antennatus* (Becker)*, Cx.* (*Cx.*) *perexiguus* Theobald*, Ochlerotatus* (*Oc.*) *detritus* (Haliday), *Anopheles* (*Cellia*) *pharoensis* Theobald and *Anopheles* (*An.*) *tenebrosus* Dönitz were collected as larvae and adults throughout the present survey.

A total of 75,856 larvae were collected in 214 SU's (Tab. 2; Fig. 2). From 429 examined house rooms, a total of 7,088 adults were collected (31.41% by space spraying, 68.59% by hand collection, 67.56% females and 32.44% males). *Cx. pipiens* was predominating as larvae (*ca.* 79%, 280 larva /SU, Q = 6.58-6.79, P<0.01-P<0.001) and was the commonest adult species (*ca.* 51%, 9 adult/room, Q=4.27-6.00, P<0.01-P<0.001). Both larval and adult densities of *Cx. antennatus* and *Cx. perexiguus* were insignificantly different (Q = 1.21 & 1.73 for larvae and adults, respectively, P>0.05). For all the six species, mean densities of both adults and larvae were compiled for each center (Fig. 2) and indicted that the highest larval density (*ca.* 496 larva/SU) was that of El Kordy while the highest adult density (*ca.* 42 adult/ room) was that of El Senbellawein.

Four main types of the breeding habitats were detected of which the drainage canals were the most productive (53.4% of collected larvae) and the least productive one was the water of rice fields (3.1%). The other two types are irrigation canals (23.9%) and sewage and septic water (19.6%). Breeding water was found to have a pH range of 5.5-7.7 but mostly alkaline (>7) and have a temp. range of 21.1-33.2^{o}C. For the three common species, multiple regression analysis (Fig 3) showed that larval density of *Cx. pipiens* decreases as temp. increased and increases as pH increased (P>0.05). Density of *Cx. antennatus* increases as temp. increased (P>0.05) and decreases as pH increased (P<0.05). Also, the density of *Cx. pereiguus* increases as temp. increased and decreased as pH increases (P>0.05).

In general, the compiled density of the three species increases as temp. increased and decreases as pH increased (P>0.05). Regression analysis for the relation of indoor temp. (21.0-35.1°C), outdoor temp. (19.0-33.2°C), indoor RH (28.0-68.7%) and outdoor RH (45.5-75.0%) with the indoor adult density of the three common species (Fig 3) showed that: (1) *Cx. pipiens* density increases as the four factors increased (P>0.05), (2) *Cx. antennatus* density increases as outdoor temp. and RH increased, while it decreases as the indoor temp. and RH increased (P>0.05) and (3) *Cx. perexiguus* density increases as indoor- and outdoor-temp. and indoor RH increased, while it decreases as the outdoor RH increased (P>0.05). The compiled density of the three species increases as indoor and outdoor temp. and indoor RH increased and decreases as the outdoor RH increased (P>0.05). Testing the significance of co-occurrences among the three common species indicated that *Cx. pipiens-Cx. perexiguus* was insignificant ($\chi^2_{(1)}$=1.67, P>0.05) while the other two forms were significant, *Cx. pipiens-Cx. antennatus* ($\chi^2_{(1)}$=16.72, P<0.001) and *Cx. atennatus-Cx. perexiguus* ($\chi^2_{(1)}$=24.79, P<0.001). Calculating the degrees of the significant associations showed that (1) *Cx. pipiens* has a high association with *Cx. antennatus* based on C_{AB} (0.88±0,28) but with moderate association based on I (0.48), (2) *Cx. antennatus* has a moderate association with *Cx. perexiguus* based either on C_{AB} (0.47±0,09) or I (0.36).

Parasitologically, of 908 examined blood samples from ten centers, 68 (7.49%) positive cases of infection with *W. bancrofti* were found (Tab. 3). Infection rates in the different centers were associated with higher densities of *Cx. pipiens*, the main vector. The highest infection rates in Beni Ebid (*ca.* 16%) and Nabaroh (*ca.*13%) were associated with high vector density (8.11 & 8.47 female/room for the two centers, respectively).

Table 1: Coordinates of surveyed localities in El-El Dakahlia Governorate.

Center	Locality	Longitude E	Latitude N
Meet Ghamr	Menit Abu Khalid	31° 20.0’ 21.7’’	30° 38.0’55.1’’
	Kafr Bahida	31° 17.0’ 07.2’’	30° 46.0’44.9’
Aga	El Lawendi	31° 18.0’ 01.9’’	30° 56.0’36.1’’
	Menit Samnoud	31° 15.0’ 25.9’’	30° 57.0’06.0’’
Talkha	Goger	31° 20.0’ 39.3’’	31° 03.0’06.1’’
Belkas	El Banan	31° 21.0’ 32.1’’	31° 16.0’47.6’’
	El Shawamy	31° 21.0’ 47.3’’	31° 16.0’58.7’’
El Senbel-lawein	Tamai El zahaira	31° 27.0’ 15.3’’	30° 55.0’11.8’’
	Tokh El Aqlam	31° 26.0’ 15.6’’	30° 52.0’03.5’’
Tami Alamded	Menshat Sabry Abu Allam	31° 29.0’ 24.8’’	30° 58.0’08.6’’
	Abu Dawood	31° 34.0’ 26.8’’	30° 59.0’56.8’’
Sherbin	Sherbin	31° 30.0’ 13.4’’	31° 15.0’31.1’’
	Abu Sheir	31° 28.0’ 16.6’’	31° 16.0’10.0’’
Dekerns	Ashmon El Roman	31° 38.0’ 18.2’’	31° 05.0’15.8’’
Meniet Al Nasr	Narebaz	31° 44.0’ 05.5’’	31° 09.0’44.3’’
	Old Brenbal	31° 44.0’ 05.5’’	31° 09.0’44.3’’
Meet Salsil	El Kafr El Gedeed	31° 49.4’ 00.9’’	31° 10.0’06.0’’
	El Gawayer	31° 49.0’ 16.1’’	31° 00.9’43.9’’
Beni Ebid	Kafr El Salahat	31° 37.0’ 16.2’	30° 59.0’47.5’’
	Mit Adlan	31° 36.0’ 05.0’	31° 00.0’49.8’’
Nabaroh	Bahout	31° 19.0’ 37.7’’	31° 10.0’31.8’’
El Kordy	El Kordy	31° 32.0’ 07.2’’	31° 07.0’45.2’’

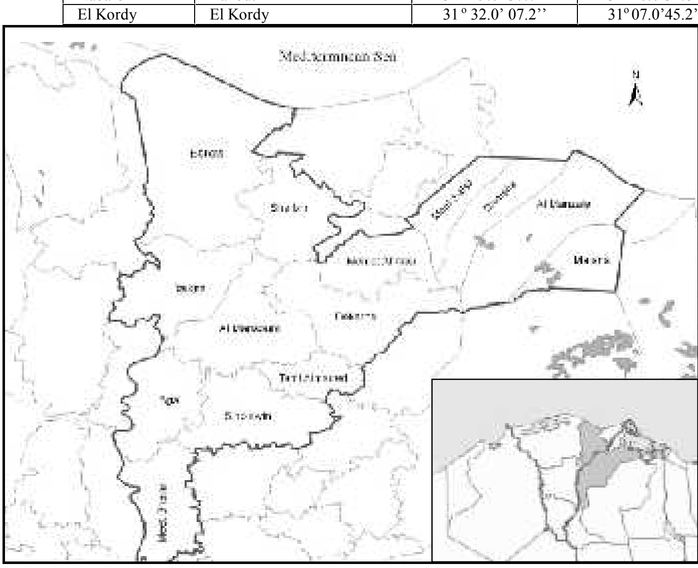

Fig. 1: A map of El-Dakahlia Governorate

Table 2: Mean densities (±SD) of larvae and adults of mosquito species reported in El- Dakahlia Governorate.

Species	Larva / 10 net dip*	Adult / Room*
Culex pipiens	279.97±157.05 A	9.25±5.34 A
Culex antennatus	77.63±89.11 B	3.27±2.35 B
Culex perexiguus	33.70±39.80 B	5.00±2.18 B
Anopheles pharoensis	0.72±0.56	0.07±0.08
Anopheles tenebrosus	0.22±0/00	0.03±0.00
Ochlerotatus detritus	0.88±1.34	0.08±0.07
F (*df*) **	15.18 (2,28)	9.531 (2,36)
P	0.00003	0.00077

* For 3 common species, in each column means with similar letters are not significantly different (*P* >0.05, Tukey’s test),
** For first 3 (common) species

Table 3: Detected cases of filariasis in relation to adult density of main vector; *Cx. pipiens* in El- Dakahlia Governorate.

Center (No Locality)	Blood samples			*Cx. pippins* Female / room
	Examined	Positive		
		No	%	
Meet Ghamr (4)	232	14	6.03	5.77
Aga (3)	135	12	8.89	6.45
Talkha (2)	39	1	2.56	4.47
El Senbellawein (3)	115	11	9.57	7.48
Tami Alamded (3)	76	2	2.63	4.26
Dekernes (2)	56	1	1.79	1.4
Menit El Nasr (3)	98	9	9.18	7.3
Beni Ebid (2)	32	5	15.62	8.11
Nabaroh (3)	103	13	12.62	8.47
El Kordy (1)	22	0	0	1.4
Total	908	68	7.49	

Discussion

The Six reported species in this study were previously encountered in the other Delta Gov.'s (Kaschef *et al,* 1982; El-Said and Kenawy, 1983; Kenawy *et al.,* 1996, 1998; Morsy *et al*, 2004; El-Bashier *et al,* 2006; Abdel-Hamid *et al*, 2009, 2011a, b). Of these, the four culicine species were previously reported in Al Mansoura Center (El Shazly *et al*, 1998) in addition to other six larval species namely Cx. *adairi*, *Cx. deserticola*, *Cx. pusillus*, *Oc. caspius*, *Cs. longiareolata* and *Ur. Uniguiculata*.

Cx. pipiens, the main vector of filariasis (Harb *et al,* 1993) was predominating or the most common species which has its reflection on the situation of filarial transmission in this Gov. Although the collected blood samples were limited (908) and that the Gov. was covered by the Mass Drug Administration (MDA) national program of the Ministry of Health to eliminate lymphatic filariasis (Ramzy *et al,* 2005; El-Setouhy *et al,* 2007), *ca* 8% of inhabitants in ten surveyed centers were found infected with *W. bancrofti*. The highest infection rates reported in some centers (*ca* 16% in Beni Ebid and 13% in Nabaroh) were associated with high indoor densities of *Cx. pipiens* adults (*ca* 8 female/room for the two centers). Similarly, in the adjacent Gov., El Sharqiya (Abdel-Hamid *et al*, 2009) and other Delta Gov.s *e.g*., El Menoufia (Abdel-Hamid *et al*, 2011b), *ca.* 0.4 and 5% filarial infection rates were observed in the two Gov.'s, respectively associated with the abundance of *Cx. pipiens* adults.

Of the surveyed breeding habitats, the drainage canals were the most productive (*ca* 53% of collected larvae) in agreement with the observations in Mansoura Center (El Shazly *et al*, 1998) and other Delta Gov.'s (Kenawy *et al,* 1996; Abdel-Hamid *et al*, 2011a, b) where irrigation and drainage canals are abundant and the most productive type. Rice fields were the least productive habitat (3.10% of collected larvae). El Shazly *et al.* (1998) observed that rice fields were only infested with *Cx. antennatus* ($P > 0.05$).

The characteristics of the breeding

water of the three common species, *Cx. pipiens, Cx. antennatus* and *Cx. perexiguus* mainly the temp. and pH and their effects on larval densities of such species were examined. Breeding water was found mostly alkaline (>7), as previously reported in several Gov.'s (Kirkpatrick, 1925; Kenawy *et al,* 1998; Abdel-Hamid *et al*, 2009; 2011a, b, c). The larval densities of the three species had different relations with both temp. and pH but in general, the compiled density of the three species increases as temp. increased and decreases as pH increased ($P>0.05$). Several authors (Kenawy and El-Said, 1990; Kenawy *et al,* 1996; Abdel-Hamid *et al,* 2009, 2011a, c) had similar/different relations for such three species in the other Gov.s. Moreover, in El Menoufia, Abdel-Hamid *et al* (2011b) found that the total larval density of the same species decreased as both temp. and pH increased ($P>0.05$). Besides, temp. and pH, other physico-chemical factors, *e.g.* salinity and free ammonia are known to affect the survival and abundance of mosquito larvae (Wanji *et al,* 2009).

The influence of climatological factors on the indoor densities of the three common species adults was examined by regression and revealed several relations. In general, the compiled density of the three species increases as indoor- and outdoor temp. and indoor RH increased and decreases as outdoor RH increased ($P>0.05$). Only the available studies on such relations for the same species in Egypt are those of Abdel Hamid *et al.* (2009; 2011a, b, c) in other Delta Gov.s which indicate more or less similar trends for such relations.

The association between two mosquito larval species is the tendency of a species to influence the distribution of another one. The study aimed at evaluating the different forms and degrees of co-existence among the common species in such part of Delta. Calculating the degrees of significant associations indicated that of *Cx. pipiens- Cx. ante nnatus* was high / moderate (C_{AB} = 0.88, I = 0.48) and that of *Cx. antennatus- Cx. perexiguus* was moderate (C_{AB} = 0.47, I = 0.36). It can be concluded that such significantly positive associations among the three common species which use the same habitats indicate that their breeding requirements are similar. Similarly in El Sharqiya and El Gharbia, Abdel-Hamid (2012) reported significantly high degrees of associations among the same species (C_{AB} and I = 0.7 to 1.0). This is supported by observations of El Said *et al.* (1983) in the Nile Delta and that of Kenawy *et al.* (2012) in two urban localities in Cairo Gov. In contrast, Fager (1957) has demonstrated that no association will be seen on the presence-absence data if the two species occur in most of the samples and so are nearly found together. This was observed for *Cx. pipiens* and *Cx. antennatus* in the Nile Delta by El-Said *et al.* (1983) who indicated that in spite of their abundance and high frequency of the joint occurrence, the two species had significantly negative association (C_{Ab}= -0.2 and I= -0.5, $P<0.01$) which may indicate no association between these two species.

Conclusion

The prevalence and abundance of *Cx. pipiens,* the main filariasis vector with its known anthropophagous and endophagic characteristics maintain the transmission of such disease in El Dakahlia Gov. Moreover, the common occurrence of this species and other culicine mosquitoes contributes to the risk of other mosquito borne disease transmission in this area. No doubt, a wide vector control program is a must as an important mean to minimize transmission of filarial *bancrofti* and other diseases in this Gov. and perhaps in the neighboring Gov.'s.

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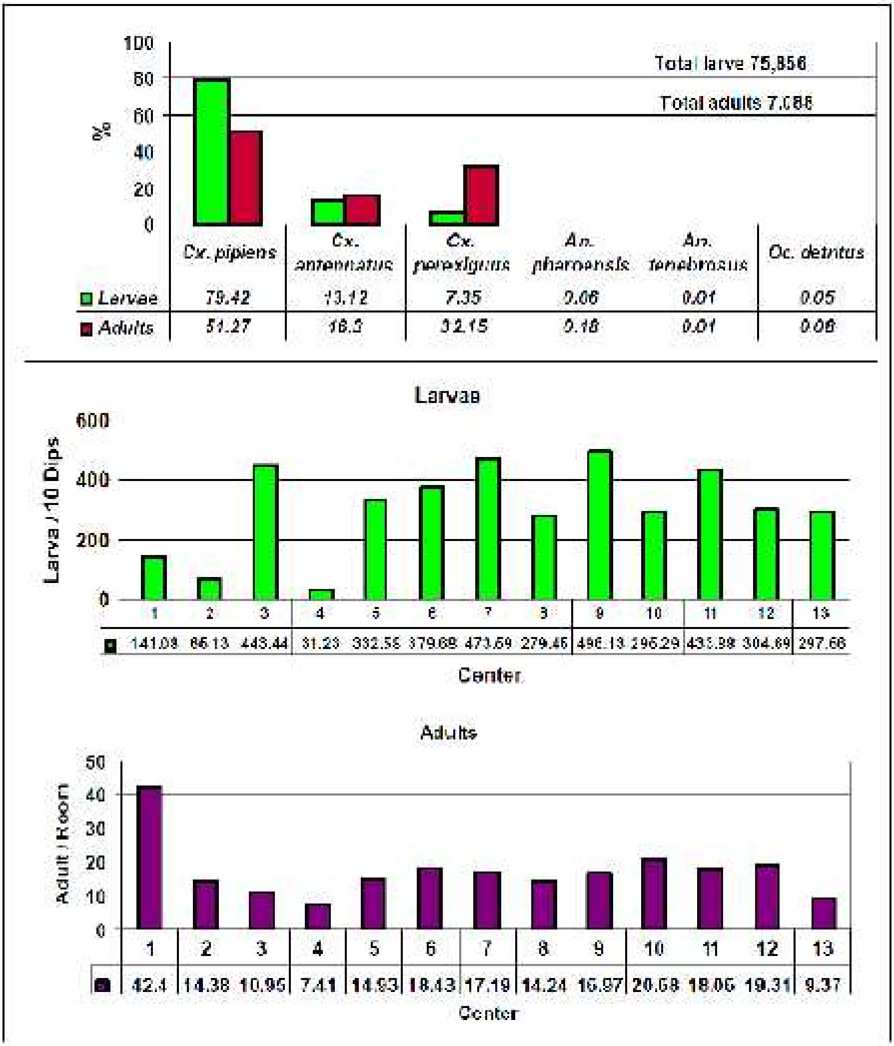

Fig. 2: Relative abundance of different mosquito species (above) and that of all mosquito species in surveyed centers [1 El Senbellawein, 2 Sherbin, 3 Belkas, 4 Meet Salsil, 5 Tami Alamded, 6 Meet Ghamr, 7 Beni Ebid, 8 Aga, 9 El Kordy, 10 Meniet Al Nasr, 11 Talkha, 12 Nabaroh, 13 Dekerns]

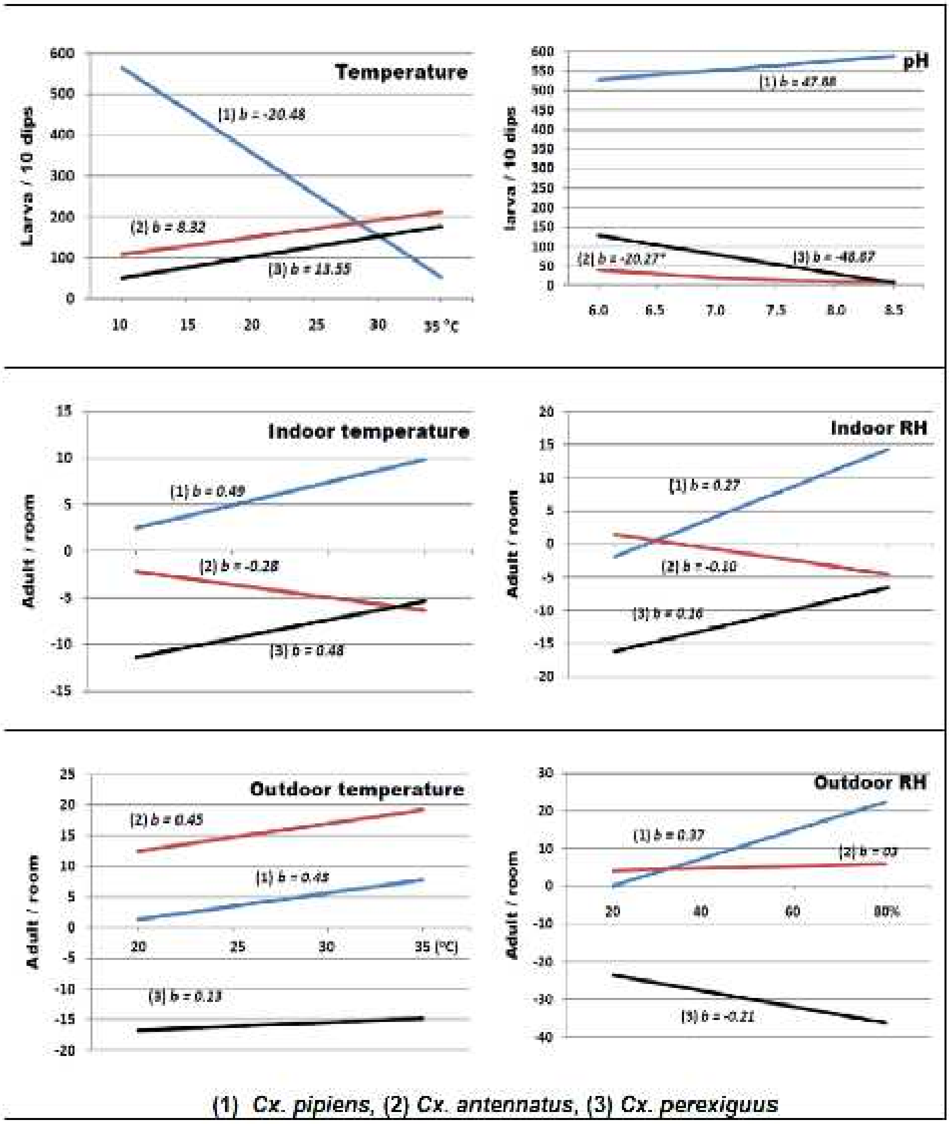

Fig. 3: Regression lines for the relation of mosquito larval density to temp. and pH of breeding water and of adult indoor density to indoor- and outdoor- temp. and relative humidity (*P<0.05, t-test).