PHYSICAL AND CHEMICAL PROPERTIES OF DIFFERENT TYPES OF MOSQUITO AQUATIC BREEDING PLACES IN KUWAIT STATE

A. M. SALIT[1], S. S. AL-TUBIAKH,[1] S. A. EL-FIKI[2] & O. H. ENAN[2]
[1]Insect and Rodent Control Divn., Ministry of Health, Kuwait State
[2]High Institute of Public Health, Alexandria University, Egypt.

Abstract—Certain physical and chemical factors in mosquito larval aquatic habitat, in relation to larval species distribution were studied in different ecosystems of Kuwait State.

Ten types of breeding places were found in the different ecological areas of Kuwait State. These were animal watering basins, seepage of water from agriculture and animal enclosures conditioning, swamps due to mixed storm and sewerage water with Gulf water, manure fermentation basins, water irrigation channels, storm drains, sewerage manholes, inspection chambers, artificial lakes with stagnant water and fountains. Physical properties including depth of water, width, turbidity, temperature, vegetation and light in these mosquito larvae breeding places in relation larval species are explained in the manuscript.

As regards to chemical factors in larval breeding water, larvae of all mosquito species in Kuwait State are mostly alkalinophile (pH 6.27 to 9.78 in storm drains only). *Culex pipiens* complex larvae in the country tolerate comparatively higher organic materials as indicated from nitrogen compounds, and BOD in breeding sited as compared with *Anopheles stephensi* and *An. pulcherrimus* larvae. *Aedes caspius* larvae associated with *Cx. pipiens* complex tolerate higher salinity ranging from 0.2–30%. For *Cx. tritaeniorhynchus* and *Anopheles* larvae, the value were 0.3–6.6% and 0.25–0.7%, respectively, indicating graduation of mosquito fauna from brackish to fresh water.

INTRODUCTION

Early studies revealed that convenient aquatic breeding places for certain mosquito species may be inconvenient for other species. Atkin (1923) attributed the comparatively absence of malaria in certain areas of Egypt and India to the alkalinity of water indicating its inconvenience to the vector breeding. Beadle (1939) reports that although most mosquitoes are restricted to fresh water, a number of species can develop in extremely high concentration of salts.

The most recent survey in Kuwait State (Al-Tubiakh, 1995) detected two species of anopheline mosquito larvae and eight species of culicine mosquito larvae in the country during the year 1994/1995. Previous survey in Kuwait State (Annual Report, Insect and Rodent Control Divn., Min. of Health, Kuwait 1989) reported two additional culicine species, namely, *Cx. (Cx.) univittatus* and *Cx. (Cx.) theileri* which were not encountered in the survey of 1994/95, but *Cx. (Cx.) univittatus* reappeared during the late months of 1995. However, in coastal areas like Kuwait State there might be difference between the mosquito faunas of fresh and brakish waters.

Nevertheless, apart from comparatively little information reported by Pringle (1952) and Salit (1989) on certain physical and chemical factors in relation to mosquito breeding in Kuwait, no further information in this concern is available. Hence, detailed studies on physical and chemical properties of different types of mosquito aquatic breeding places in Kuwait State are lacking. The present paper is concerned with further physical and chemical studies on aquatic mosquito larval habitat in relation to mosquito larval species in the country.

MATERIAL AND METHODS

The present work was conducted in five ecological areas in Kuwait State representing agricultural and animal husbandry farms, urban, semi-urban, border and sea ports areas. In these areas, physical and chemical properties of the aquatic mosquito breeding places were studied in ten types of the main mosquito breeding sites, viz., seepage water from agriculture and animal enclosures conditioning, swamps due to mixed storm and sewerage water with Gulf water (terminal lagoons on the shore of the Gulf), manure fermentation basins, water irrigation channels, storm drains, sewerage manholes, inspection chambers, artificial lakes with stagnant water and fountains.

Proceedings of the Second International Conference on Urban Pests.
K.B. Wildey (editor). 1996

Physical characteristics of each mosquito breeding site were described according to the following parameters:

1. Water movement, expressed as running, moderately moving and stagnant water.
2. Light intensity, expressed as sunny, semi-shaded and deeply shaded.
3. The degree of turbidity of water, expressed as turbid, slightly turbid and clear water.
4. Depth of breeding places, expressed as shallow to moderately deep water (less than 1 metre) or deep water (more than 1 metre).
5. The type of vegetation, either floating or emerged.

Chemical properties of the water of each breeding site were determined by sampling of water from different breeding types in polyethelene wide mouth bottles 1000 ml., half filled, tightly closed and labeled with breeding place type number and date of collection. These bottles were surrounded with ice, till arrival to the laboratory of water Pollution Control Division, Environmental Pollution Department for chemical analysis according to the procedures described in standard method for the examination of waste water APHA Clescer *et al.* (1989).

The parameters used to indicate the chemical characteristics of water in different mosquito larval breeding types were:

1. pH value.
2. Water salinity %.
3. Ammonia, nitrate and nitrite estimation mg./L.
4. Biological Oxygen Demand (BOD) mg./L.

RESULTS

As shown in Table (1), the two forms of the prevailing *Culex* (*Cx.*) *pipiens* complex larvae in Kuwait State, namely, *Cx.* (*Cx.*) *pipiens molestus* Forskal and *Cx.* (*Cx.*) *pipiens quinquefasciatus* Say associated or not associated with other culicine or anopheline mosquito larval species were encountered in the ten types of water accumulations mentioned in the Table (1). The areas of these breeding places as indicated from Table (1) ranged between 0.5–100 metre wide, mostly shallow or comparatively deeper (5–50 cm.). Other physical characteristics of these water accumulations as shown in Table (1) indicate prevailing turbidity or may slight or no visible turbidity in these breeding sites with or without visible vegetations (algae, emerging and standing plants) in shaded, semi-shaded or sunny areas and with water temperature ranging between 12–32°C.

As shown in Table (1), *Anopheles stephensi* Liston larvae associated with *Cx. pipiens* complex were found in four types of breeding places with depth ranging between 5–50 cm, width 0.5–10 metres. Water accumulation graded from no visible turbidity to turbid, while water temperature ranged between 14–32°C, with or without visible vegetation (algae, emerging and stand plants) and located in shaded, semi-shaded and sunny areas. Table (1) also shows that *An. stephensi* larvae in association with *Cx. pipiens* complex , *An. pulcherrimus*, Theobald, *Cx. pusillus Macquart* and *Cx. tritaeniorhynchus* Giles larvae were found in one type of breeding places. Moreover, *Aedes caspius* Pallas larvae in addition to *Cx. pipiens* complex larvae, *Culiseta longiareolata* Macquart larvae were encountered in four types of breeding places (Table 1). It seems as indicated from the present study (Table 1) that *Aedes caspius* and the two species of *Culiseta* namely *Cu. longiareolata* and *Cu. inornata* prefer shallow (5–30 cm.) and turbid breeding places.

It appears from day time water temperature records during the present study (Table 1) that this temperature generally ranged between 11–32°C in all types of culicine and anopheline breeding places.

Results concerning the chemical characteristics of the aquatic mosquito breeding places in the investigated areas during the present study (Table 2 and Fig. 1), showed that larvae of all mosquito species in Kuwait State were collected from water accumulations with pH ranging between 6.27–9.78. Nevertheless, pH 6.27 was restricted to certain storm-drains water, where only *Aedes caspius* associated with the prevailing *Cx. pipiens* complex were encountered.

As shown in Table 2 and Fig. 1, *Aedes caspius* larvae associated with *Cx. pipiens* complex were found to tolerate comparatively higher salinity up to 30%. For larvae of *Anopheles stephensi* and

Table 1. Physical characterisctics of different type of mosquito larvae breeding places.

Types of breeding places	Water Characteristics						Types of mosquito larval species collected
	Depth	Width	Turbidity	Temp	Vegetation	Light	
1–Animal watering basins	7–25 cm.	0.5–2 m.	No visible turbidity	14–27°C	Some algae	Shaded	*Culex pipiens quinquefasciatus, Culex pipiens molestus, Anopheles stephensi*
2–Seepage of water from agriculture & animal enclosures conditioning	20–50 cm.	3–5 m.	Slight turbidity	14–31°C	emerging grass standard plant algae	semi-shaded	*Culex pusillus, Culex tritaniorhynchus, Culex pipiens quinquefasciatus, Culex pipiens molestus, Anopheles stephensi, An. pulcherrimus*
3–Swamps due to mixed storm and sewerage water with Gulf water	10–30 cm.	30–100 m.	turbid	12–30°C	emerging grass standard plant algae	semi-shaded	*Aedes caspius, Culex pipiens quinquefasciatus, Culex pipiens molestus*
4–Manure fermentation basins	10–30 cm.	2 m.	turbid	15–24°C	algae	semi-shaded	*Culex pipiens quinquefasciatus, Culex pipiens molestus, Culiseta longiareolata, Culiseta inornata*
5–Water irrigation channels & water collection & distribution basins for irrigation	5–10 cm.	0.5–3 m.	turbid	11–25°C	alage	semi-shaded	*Culex pipiens quinquefasciatus, Culex pipiens molestus, Aedes caspius, Culiseta longiareolata*
6–Storm drains	5–10 cm.	2 m.	turbid	15–30°C	some decayed leaves	Shaded	*Culex pipiens quinquefasciatus, Culex pipiens molestus, Aedes caspius*
7–Sewerage manholes	30–50 cm.	2 m.	turbid	16–31°C	No visible vegetation	Shaded	*Culex pipiens quinquefasciatus, Culex pipiens molestus*
8–Inspection chambers	7–10 cm.	1 m.	turbid	15–31°C	No visible vegetation	Shaded	*Culex pipiens quinquefasciatus, Culex pipiens molestus, Anopheles stephensi, Aedes caspius*
9–Artificial lakes with stagnant water	30–50 cm.	5–10 m.	turbid	15–32°C	algae	Sun light	*Anopheles stephensi, Culex pipiens quinquefasciatus, Culex pipiens molestus*
10–Fountains	10–30 m.	5 m.	turbid	14–29°C	algae	Shaded	*Culex pipiens quinquefasciatus, Culex pipiens molestus*

Table 2. Chemical properties of water at different breeding places.

	Water Characteristics						
Types of breeding places	pH	Ammonia mg/L	Nitrate mg/L	Nitrite mg/L	B.O.D. mg/L	Salinity %	Types of mosquito larval species collected
1–Animal watering basins	7.47	2.04	14.1	0.007	0.0–1.0	0.38	*Culex pipiens quinquefasciatus, Culex pipiens molestus, Anopheles stephensi.*
2–Seepage of water from agriculture & animal enclosures conditioning	7.0–9.4	0.33–4.91	0.1–10.5	0.004–6.8	0.0–60	0.3–6.6	*Culex pusillus, Culex , tritaniorhynchus Culex pipiens quinquefasciatus, Culex pipiens molestus, Anopheles stephensi, An. pulcherrimus*
3–Swamps due to mixed storm and sewerage water with Gulf water	7.0–8.18	0.11–0.79	3.0–58.0	0.022–8.38	0.0–47	3.75–12.18	*Aedes caspius, Culex pipiens quinquefasciatus, Culex pipiens molestus*
4–Manure fermentation basins	7.1–7.4	0.07–3.26	5.0–58.8	2.9–3.6	6.5–9.5	5.7–6.7	*Culex pipiens quinquefasciatus, Culex pipiens molestus, Culiseta longiareolata, Culiseta inornata.*
5–Water irrigation channels & water collection & distribution basins for irrigation	7.7–8.05	0.16–16.46	7.9–15.9	3.54–8.0	9.5–21	4.23–6.4	*Culex pipiens quinquefasciatus, Culex pipiens molestus, Aedes caspius, Culiseta longiareolata*
6–Storm drains	6.27–7.58	0.68–19.66	2.3–42.8	0.003–4.3	2–109	0.2–30	*Culex pipiens quinquefasciatus, Culex pipiens molestus, Aedes caspius.*
7–Sewerage manholes	7.01–8.03	0.08–45.1	0.008–25.5	0.0–0.061	1–50.5	0.35–9.51	*Culex pipiens quinquefasciatus, Culex pipiens molestus.*
8–Inspection chambers	7.3–7.8	2.04	8.2–8.4	0.23–0.32	3–45	2.68–3.68	*Culex pipiens quinquefasciatus, Culex pipiens molestus, Anopheles stephensi, Aedes caspius.*
9–Artificial lakes with stagnant water	8.38–9.78	0.63–2.44	0.4–13.3	0.001–3.49	0.0–63	0.25–0.7	*Anopheles stephensi, Culex pipiens quinquefasciatus, Culex pipiens molestus.*
10–Fountains	7.98–8.3	0.22–1.01	3.41–3.7	0.035–1.6	0.0–12	0.74–0.8	*Culex pipiens quinquefasciatus, Culex pipiens molestus*

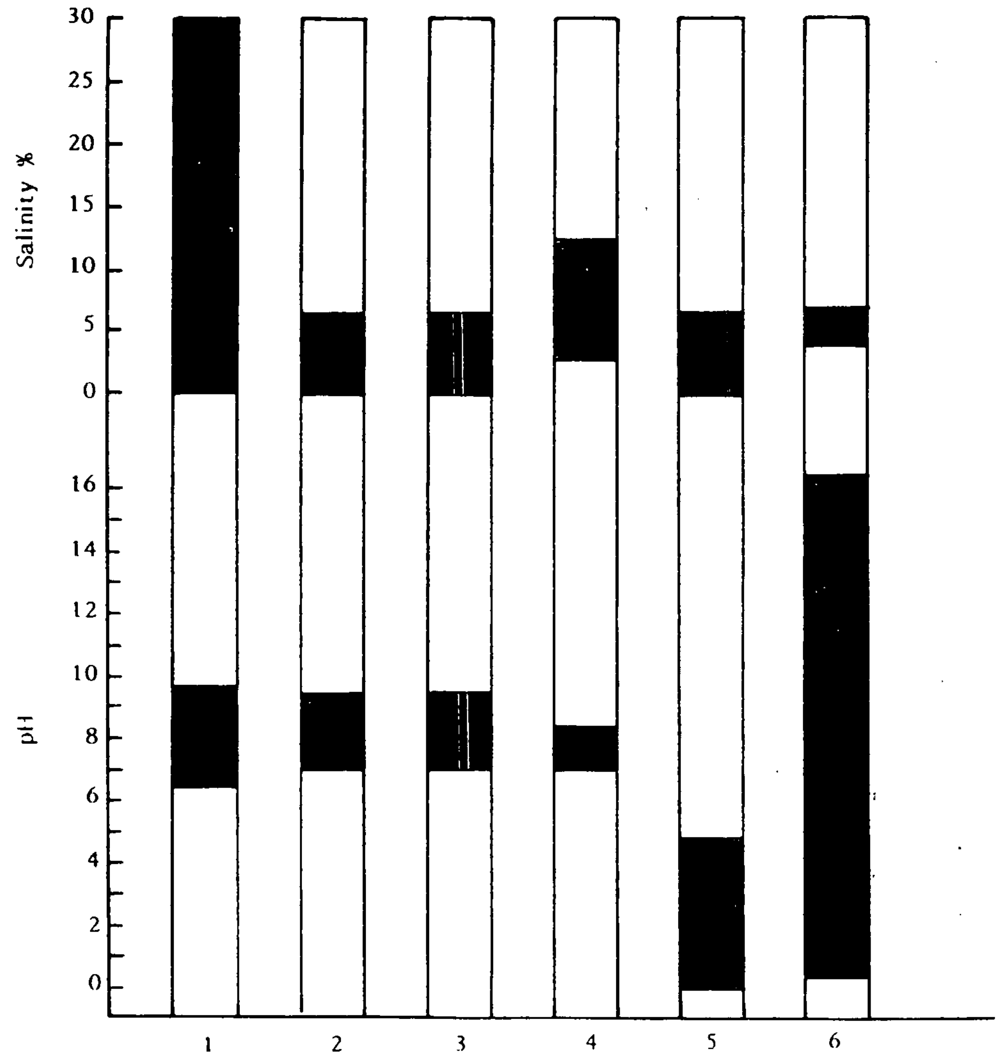

Figure 1. Chemical properties of water in different mosquito breeding places (Kuwait State).

1. *Culex pipiens* complex
2. *Cx. pusillus*
3. *Cx. tritaeniorhynchus*
4. *Aedes caspius*
5. *Anopheles* spp.
6. *Culiseta* spp.

An. pulcherrimus, Cx. tritaeniorhynchus and *Cx. pusillus* in association with *Cx. pipiens* complex larval water salinity ranged between 0.3–6.6%, *Culiseta longiareolata* and *Cu. inornata* associated with *Cx. pipiens* complex, salinity ranged between 5.7–6.7%.

As indicated from Table 2 and Fig. 2, *Cx. pipiens* complex tolerated aquatic breeding places with concentration of ammonia ranging between 0.07–45.1 mg./L., nitrate between 0.008–58.8 mg./L. and nitrites between 0.0–8.38 mg./L. with biological oxygen demand BOD ranging between 0.0–109 mg./L. *Anopheles stephensi* larvae were encountered during the present study (Table 2 and Fig. 2), associated with *Cx. pipiens* complex larvae in breeding places with ammonia not more than 4.91 mg./L., nitrates 14.7 mg./L., nitrites 6.8 mg./L. and BOD 63.0 mg./L. *An. pulcherrimus* was found in one type of breeding sites with ammonia not more than 4.91 mg./L., nitrates 10.5 mg./L., nitrites 6.8 mg./L. and BOD 60.0 mg./L.

Culiseta longiareolata and *Cu. inornata* larvae as shown in Table 2 and Fig. 2) were found in manure fermentation basins associated with *Cx. pipiens* complex with ammonia ranged between 0.7–3.26 mg./L., nitrates 5.0–58.8 mg./L., nitrites 2.9–3.6 mg./L. and BOD 6.5–9.5 mg./L. *Cx.*

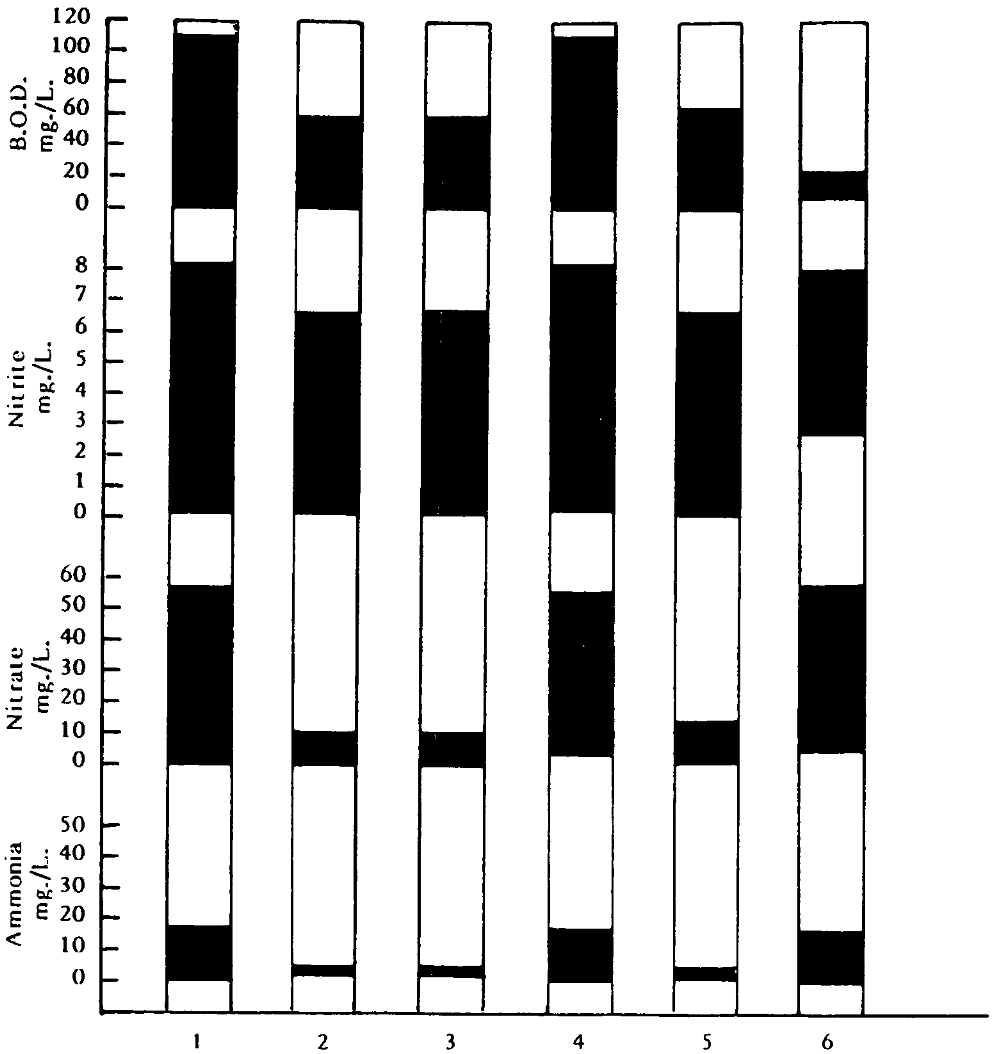

Figure 2. Chemical properties of water in different Mosquito breeding places (Kuwait State).

1. *Culex pipiens* complex
2. *Cx. pusillus*
3. *Cx. tritaeniorhynchus*
4. *Aedes* caspius
5. *Anopheles* spp.
6. *Culiseta* spp.

tritaeniorhynchus larvae in association with *Cx. pipiens* complex, the two *Anopheles* species, *Aedes caspius* and *Cx. pusillus* were found in water seepage from agriculture and animal enclosures conditioning with ammonia ranged between 0.33–4.91 mg./L., nitrates 0.1–10.5 mg./L., nitrites 0.004–6.8 mg./L. and BOD 0.0–60 mg./L. (Table 2 and Fig. 2).

DISCUSSION

It might be observed from the present study that *Cx. pipiens* complex larvae in Kuwait State associated or not associated with other culicine or anopheline larvae breed in a wide range of breeding places (ten types), in shaded, semi-shaded and sunlight exposed areas with various width (0.5–100 metre) and mostly shallow depth (5–50 cm.). Water accumulations temperature ranges between 12–32°C with or without visible vegetations (algae, emerging and stand plants) and with or without visible turbidity.

The early findings of Theobald (1901) state that mosquito larvae seem to prefer shallow water especially where there is a good growth of green algae. Moreover, Shute (1951) observed numerous larvae in above ground static water tanks, whereas larvae of *molestus* were never found even though they were found numerous in water 50 feet or more below ground level. However, Horsfall (1951) observed that larval feeding position may be at the water surface on the bottom and at all levels in between. He found that in comparatively deep water (56 cm.), very few larvae went to the bottom to feed. Moreover, Abd-El-Magid (1987) recorded, the presence of particularly culicine mosquito larvae in drainage channels, cesspools and seepage pools with turbid and slightly turbid stagnant water, shallow depth ranging between 5–20 cm., width between 0.3–5 metre, emergent vegetations and in semi-shaded sites.

Hopkins (1936) attributed the favorable effect of sunlight on mosquito larval population to the requirement of algae to sunlight. These algae as mentioned by this author, are frequently favorable as larval food or an aid in maintaining balance of dissolved gasses and in utilizing organic materials unfavorable for the larvae. However, Russell and Rao (1942) point out that mosquito larvae of *An. culicifacies* normally found in sunny situation will grow perfectly well if planted in shaded ones and vice versa. He also (1942), Thomson (1940) and Wood (1961) state that egg-laying female *An. culicifacies* , *An. minimus* and *Aedes aegypti* may be quite sensitive to light conditions, which may lead to the differential larval distribution. Horsfall (1955) points out that light is not essential for development of *molestus* , *fatigans* (=*quinquefasciatus*) and *pipiens*. Moreover, Kenaway and El-said (1990) report that turbidity significantly affect larval occurrence.

As regards larval breeding water temperature, Thomson (1940) recorded that the actual selection of the mosquito habitat is probably made in the evening or night by the ovipositioning female, at a time when temperature may be quite different. Moreover, Bates (1949) states that temperature conditions in aquatic environment are, in general, much more stable than in aerial environments. However, Symes (1932) found diverse *Anopheles* species in breeding places with similar temperature ranges in Kenya and concluded that temperature was not a limiting factor in determining anopheline breeding places. Nevertheless, Mosna (1949) pointed out that the favourable temperature for the majority of anopheline larvae ranged between 22–35°C. Moreover, WHO (1975) states that the average optimum temperature for development of most mosquito species is around 25–27°C. Kenaway and El-Said (1989) recorded nine culicine species in Egypt breeding in water temperature ranging between 14–39°C but they observed that *Cx. antennatus* and *Cx. pipiens* tolerated a wider range of temperature.

Periodic short exposure to high temperature may be definitely favorable in sense of speeding up growth or lowering mortality, while constant exposure to extreme temperature may be fatal (Huffaker, 1944). WHO (1975) states also that permanent high temperature over 30°C will reduce the average life of mosquito population.

As regards chemical characteristics of the aquatic mosquito breeding places in Kuwait State, it might be observed as indicated from the present study that larvae of all mosquito species in the country are of alkaline tendency (6.27–9.78). However, pH 6.27 was restricted to only one type of breeding places where only *Aedes caspius* in association with *Cx. pipiens* complex were encountered. The alkaline tendency (pH 7.9–8.2) of mosquito larvae in Kuwait State have been also reported in 1983 (Annual Report, Insect and Rodent Control Divn., Min. of Health, Kuwait, 1983). This may lead to a conclusion that larvae of all mosquito species in Kuwait State are mostly alkalinophile.

Series of reading of pH of mosquito breeding places in country-wide studies in Egypt indicated that all of them were alkaline with pH ranging between 7.5–9.0, also a correlation was found between pH and species of mosquito breeding in water (Kirkpatrick, 1925). Following studies by Gad et. al. (1972) in the Red Sea Egypt recorded 6.4–9.0, Farghal (1974) in Assiut Upper Egypt 7.2–8.0 and Hamdy (1987) in Ismailia Egypt recorded 6.9–8.5.

Nevertheless, MacGregor (1927) recorded acidophile and alkalinophile mosquito larval species. Moreover, Woodhill (1938) was able to grow *Cx. fatigans* in pH media ranging from 4.2–9.0 and found slower development in the very acid or very alkaline media. Bates (1949) referred to the influence of acidity on the micro biota and its often correlation with landscape type of the breeding place which are more directly related to anopheline breeding than pH itself.

Regarding salinity in mosquito larval aquatic breeding places it might be indicated from the present study that in coastal areas like Kuwait State, apart from the prevailing mosquito larval species found in all types of breeding places such as *Cx. pipiens* complex larvae encountered in water accumulations with 0.2–30% salinity, there might be a difference between the mosquito fauna of fresh and brackish waters. However, Kirkpatrick (1925) classified the mosquitoes of Egypt to purely fresh water breeders and purely salt water and more or less indifferent. Beadle (1939) found that larvae of *Aedes detritus* could regulate both the total osmotic pressure and the chloride content 0f haemolymph in water of varying salinity. In Kuwait *Aedes caspius* was the only species associated with *Cx. pipiens* complex in water accumulation in storm drains with salinity up to 30%.

Concerning concentration of ammonia, nitrate, nitrite, and BOD in mosquito larval aquatic breeding places, it might be detected as revealed from the present work, that *Cx. pipiens* complex in Kuwait state may tolerate various degrees of water pollution as indicated from ammonia, nitrate, nitrite and BOD content of mosquito larval breeding places. Bates (1949) mentions that the total organic content of water and nitrate content are generally related. He points out that the most obvious characteristics of polluted water is the high content of nitrate and even nitrite.

Brink and Das Chowdhury (1939) found that all fourth instar larvae of *An. stephensi* had died in concentration of ammonium sulfate higher than 0.5% while larvae of *Cx. fatigans* pupated normally in concentration of 1.5% but the first instar larvae of *Cx. fatigans* were more sensitive dying in a concentration of 1%. Moreover, Unti (1946) studied the effect of BOD on mosquito larval breeding sites and found that *Anopheles* larval oxygen requirements in their breeding places, differed according to mosquito species. Nevertheless, he reported that *Cx. quinquefasciatus* showed no embarrassment to water containing no oxygen. Studies on mosquito larval species composition in Kuwait State revealed the predominance of the two forms of *Cx. pipiens* complex viz., *Cx. pipiens molestus* which constitutes 63.23% of larval population and *Cx. pipiens quinquefasciatus* which constitutes 27.73% of larval population in the country compared with other species of lower larval density. *Anopheles stephensi* and *An. pulcherrimus* constitute the lowest larval density, viz., 0.02% and 0.002%, respectively (Al-Tubaikh, 1995).

It might be concluded from the foregoing results that *Cx. pipiens* complex larvae in Kuwait State tolerate comparatively higher organic materials as indicated from nitrogen compounds and biological oxygen demand BOD in breeding sites as compared with other mosquito larvae found in the country.

This may be a factor in the restricted convenient breeding places of both *An. stephensi* and *An. pulcherrimus* mosquito larvae in Kuwait State and the scarcity of adult stage of these anopheline mosquitoes as compared with larval and adult stages of the prevailing *Cx. pipiens* complex in the country.

REFERENCES

Abd-El-Meguid, A.H. (1987). The susceptibility of different mosquito types in Ismailia Governorate to some insecticides. M.Sc. Thesis (Vector Control), High Institute of Public Health, Alexandria: 133 pp.

Al-Tubiakh, Samia, S. (1995). Bionomics of Mosquito in Kuwait. M.Sc. Thesis (Vector Control), High Institute of Public Health, Alexandria: 219 pp.

Annual Report (1983). Insect and Rodent Control Division, Ministry of Health, Kuwait State.

Annual Report, (1989). Insect and Rodent Control Division, Ministry of Health, Kuwait State.

Atkin, S., (1923). The hydrogen ion concentration of the soil and natural water in relation to diseases other than bacterial. Parasitology, 15: 205–210.

Bates, M. (1949). The Natural History of Mosquitoes, Macmillan Company, U.S.A. 379 pp.

Beadle, L.C. (1939). Regulation of the haemolymph in saline water mosquito larvae *Aedes detritus*. J. Exp. Biol., 16: 362–364.

Brink, C.J.H. and Das Chowdhury, D.K. (1939). Ammonium sulfate as a combined fertilizer and mosquito larvicide. J. Malaria Inst. India 2: 111–112 (Abstracted).

Clescer, S., Greenberg, A.E., Trussell, R.R. and Franson, M.H. (1989). Standard method for examination of water and waste water. 7th Ed., American Public Health Association, 1015, 15th Street, N.W., Washington DC 20005: 200 pp.

Fargal, A.I. (1974). Studies on culisine mosquitoes in Assiut area. M. Sc. Thesis, Dept. of Plant Protection, Faculty of Agriculture, Assiut University: 168 pp.

Gad, A.M. and Salit, A.M. (1972). Mosquitoes of the Red Sea, Egypt, J.M.E. Honolulu, U.S.A. 9(6): 581–582.

Hamdy, A.M., 1987. The susceptibility of different mosquito types in Ismailia Governorate to some insecticides. M.Sc. Thesis in Public Health Science (Vector Control): 133 pp.

Hopkins, G.H.E., 1936. Mosquitoes of the Ethiopian Region, I larval bionomics of mosquitoes and taxonomy of culicine larvae. London Brit. Mus. (Nat. Hist.). 8: 250 pp.

Horsfall, W.R., 1955. Mosquitoes, their Bionomics and Relation to Disease. 1st. Ed., New York, Ronald Press Co.: 547–588.

Huffaker, C.B., 1944. The temperature relations of the immature stages of malaria mosquito, *Anopheles quadrimaculatus*, with a comparison of the developmental power of constant and variable temperatures in insect metabolism. Ann. Ent. Soc. Amer., 37: 1–27.

Kenaway, M. A. and El-said, Sh., 1989. Characterization of culicine mosquito habitats in the Nile Delta Egypt. 14th International Conference for Statistics, Computer Science, Social and Demographic Research, 1: 211–231.

Kenaway, M. A. and El-said, Sh., 1990. Factors affecting breeding of culicine mosquitoes and their association in the Canal Zone, Egypt. Proc. Int. Conf. St. Camp Soc. Res. and Dem., March, 1990.

Kirkpatrik, T.W., 1925. Mosquitoes of Egypt. Cairo Government Press: 224 pp.

MacGregor., M.E.,1927. Mosquito surveys. London, Wellcome Bureau of Scientific Research: 282 pp.

Mosna, E., 1937. The natural history of mosquitoes. The Macmillan Co., New York: 379 pp. cited from Bates, M. (1949).

Pringle, G., 1952. A preliminary survey of insect-born diseases in the State of Kuwait. Provisional survey report, 6–8, May, 1952: 9 pp.

Russell, P.F. and Rao, T.R., 1942. On relation of Mechanical obstruction and shade Ovipositioning of *Anopheles culicifacies*. J. Exp. Zool., 91: 303–329.

Salit, A.M. (1989). Country experience of management of vector control by country participants. EM/REC/WKP/ENV/Dec/35f, Pakistan, Lahore 7–16 Oct., 1989: 22 pp.

Shute, P.G. (1951). *Culex molestus*. Trans. Roy. Ent. Soc. London, Vol. 21, Part 7: 380–382.

Symes, C.B. (1932). Notes on the infectivity, food and breeding waters of anophelines in Kenya. Red.Med.Res. Lab. Kenya No. 4: 28 pp.

Theobald, F.V. (1901). A monograph of the Culicidae Mosquitoes. London Brit. Mus. (Nat. Hist.), 1(18): 424 pp.

Thomson, R.C.M. (1940). Studies on the behavior of *Anopheles minimus* Pt. 1: The selection of the breeding place and the influence of light and shade. J. Malaria Inst. India, 3: 268–294.

Unit, O.Z. (1943). Practical Malariology. W.B. Saunders Co. Philadelphia, London Quoted from Russell et. al. (1946).

WHO (1975). Manual on practical Entomology in malaria, prepared by the WHO Division of Malaria and other Parasitic Diseases Part (1). Vector Bionomics and Organization of Anti-Malaria Activities.

Wood, R.J., (1961). Oviposition in DDT-resistant and susceptible strains of *Ae. aegypti* (L) in relation to light preference. Bull. Ent. Res. 52: 541–560.

Woodhill, A.R., (1938). Salinity tolerance and pH range of *Cx. fatigans* with notes on the anal papillae of salt water mosquitoes. Proc. Linn. Soc. N.S.W., 63: 273–281.