Salinity and breeding of *Culex quinquefasciatus* Say, *Anopheles funestus* Giles and *Anopheles gambiae* Giles sensu stricto (Diptera : Culicidae) on the Kenya Coast

Franklin W. Mosha [1], Raymond Subra [2]

Summary

Newly hatched larvae of C. quinquefasciatus, An. funestus *and* An. gambiae *s.s. were reared in different dilutions of sea water. Maximum salinities supporting full development for the larvae were 30-40 % sea water for* C. quinquefasciatus and *20-30 % sea water for both* An. funestus *and* An. gambiae *s.s. Possibilities of using salinity as a mean of controlling these species are briefly discussed.*

Key words : Mosquitoes — Salinity — Preimaginal development — Kenya.

Résumé

Salinité et développement préimaginal de *Culex quinquefasciatus* Say, *Anopheles funestus* Giles et *Anopheles gambiae* Giles sensu stricto (Diptera : Culicidae) sur la côte du Kenya. *Cette étude a été effectuée à partir de larves de stade I de* Culex quinquefasciatus, Anopheles funestus *et* Anopheles gambiae *s.s., qui ont été élevées dans différentes dilutions d'eau de mer. Le développement de* C. quinquefasciatus *était interrompu entre 30 et 40 % d'eau de mer. Pour* An. funestus *et* An. gambiae *s.s. la tolérance maximum se situait entre 20 et 30 %. Les possibilités d'utiliser la salinisation des gîtes larvaires comme moyen de lutte contre ces moustiques sont brièvement discutées. La salinisation des gîtes de* C. quinquefasciatus *serait réalisable sur la côte du Kenya et serait sans doute bien acceptée par les populations locales. Par contre les perspectives concernant* An. funestus *et* An. gambiae *s.s.* semblent beaucoup plus limitées.

Mots-clés : Moustiques — Salinité — Développement préimaginal — Kenya.

(1) *The International Centre of Insect Physiology and Ecology, P.O. Box 80804, Mombasa, Kenya. Present address : P.O. Box 8370, Moshi, Tanzania.*
(2) *O.R.S.T.O.M. Medical Entomologist, the international Centre of Insect Physiology and Ecology, P.O. Box 80804, Mombasa, Kenya.*

Introduction

Culex quinquefasciatus Say, *Anopheles funestus* (type form) Giles and *An. gambiae* complex Giles, are the vectors of Bancroftian filariasis in East Africa. The anophelines are also vectors of human malaria. Along the East African coast, *An. gambiae* complex consists of three sibling species, namely *An. merus* Dönitz which breeds in brackish water and *An. gambiae* (sensu stricto) and *An. arabiensis* Patton which breed in freshwater. Larvae of *C. quinquefasciatus* are found mainly in polluted waters of pit latrines and septic tanks, whereas the anophelines prefer unpolluted water. *An. funestus* occurs in permanent and semi-permanent bodies of clear water with emergent vegetation, and freshwater members of the *An. gambiae* complex (*An. gambiae* s.s. and *An. arabiensis*) in shallow open sun-lit ponds.

Salinity as a limiting factor in the breeding of *C. quinquefasciatus*, *An. funestus* and freshwater *An. gambiae* has not been well documented, but it is known to have detrimental effects at high concentrations. The ability of *C. quinquefasciatus* to breed in brackish water has been reported by Macfie and Ingram (1916) and Dunn (1928) in West Africa but the exact limits have not been recorded.

An. funestus shows little tolerance for salt water. Jenson *et al.* (1947) observed that in Mauritius it occurred in salinities of less than 0.2 % NaCl (equivalent to 6.4 % sea water), while in the laboratory trials full development up to the adult stage occurred only in bowls with 0.3 % NaCl (equivalent to 9.6 % sea water) and below.

Salt tolerance studies on *An. gambiae* complex have mainly dealt with the salt water species, namely *An. merus* and *An. melas* Theobald (Muirhead-Thomson, 1951 ; Giglioli, 1964 ; Mosha and Mutero, 1982). However, little attention has been paid to the other members of the *An. gambiae* complex. In divising salinity tolerance test to differentiate between *An. melas* and *An. gambiae* s.l. in West Africa, Ribbands (1944) reported that the maximum concentration in which *An. gambiae* s.l. underwent complete development from egg to adult under laboratory conditions was 37.5 % sea water (= 11.9 g NaCl/litre). Smith and Vail (1959) observed that in the South Pare area of N.E. Tanzania, *An. gambiae* s.l. was breeding in water with 0.13-8.95 % chloride concentration (equivalent to 0.7 - 47.1 % sea water). They also found that recently hatched larvae survived in chloride concentrations equal to 30 % sea water for 8 hours but died within 7 1/2 hours at 34 % sea water. Paterson (1964) recorded an LC_{50} of 52.9 and 45.0 % sea water for laboratory colonies of first instar larvae of *An. gambiae* s.s. (Kisumu strain) and *An. arabiensis* (Mozambique strain), respectively.

The present studies were aimed at determining the ranges of salinity (sea water dilutions) supporting full development of the three vector species. The knowledge gained should contribute to a better understanding of seasonal and spatial distribution of *C. quinquefasciatus*, *An. funestus* and *An. gambiae* complex in coastal areas, and form a basis for planning their control by using salinisation methods.

Materials and methods

The newly hatched larvae of *C. quinquefasciatus*, *An. funestus* and *An. gambiae* s.s. used in these experiments were hatched from eggs laid by wild caught female mosquitoes collected from the Kenya South Coast. The larvae were reared in 4 replicates of 25 larvae each in 250 ml dilutions of 0, 5, 10, 30 and 40 % sea water in distilled water (100 % sea water = approximately 31.35 g NaCl/litre). Since preliminary tests had shown that the larvae of the three species could not develop in salinities higher than 40 % sea water, higher salinities were unnecessary.

The media were placed in glass bowls of 450 ml capacity with a depth of 5 cm in the centre. The larvae were fed on « Farex R » baby food solution, and maintained up to the adult stage in an insectary with temperatures ranging between 26.0-29.5°C.

Results

Percentage survival up to the adult stage of *C. quinquefasciatus*, *An. funestus* and *An. gambiae* s.s. in different dilutions of sea water is shown in Table 1. Maximum salinities supporting full development for the larvae were 30-40 % sea water for *C. quinquefasciatus* and 20-30 % sea water for both *An. funestus* and *An. gambiae* s.s.

No significant differences were observed in larval survival rates at salinities of 0-20 % sea water for *C. quinquefasciatus* and 5-10 % sea water for *An. funestus* and *An. gambiae* s.s. The differences in survival rates were statistically significant at salinity ranges 20-30 % sea water for *An. funestus* and *An. gambiae* s.s. (Table I).

The time taken for full development by *An. gambiae* s.s. and *An. funestus* was the same in all the different dilutions of sea water used. *An. gambiae* s.s. took an average of 9 days and *An. funestus* 19 days. The average period for *C. quinquefasciatus* was 9 days in all dilutions within the ranges 0-20 % sea water, but 12 days at 30 % sea water.

TABLE I

Percent survival rate of newly hatched larvae[a] to adult stages of *C. quinquefasciatus, An. funestus* and *An. gambiae* s.s. in different dilutions of sea water.

% sea water	Percent survival *C. quinquefasciatus*	*An. funestus*	*An. gambiae* s.s.
0	73[b]	67[c]	68
5	60[b]	43[d]	47[e]
10	68[b]	49[cd]	46[e]
20	67[b]	6	13
30	6	0	0
40	0	0	0

[a] Total of 100 larvae of each species tested at each concentration.

e to b Larval survival rate figures bearing the same superscripts in the same column are not statistically different from one another (P 〉 .05, using Bonferroni Chi-square test for 0-20 % sea water concentrations).

Discussion

The results from laboratory observations show that larvae of *C. quinquefasciatus*, *An. funestus* and *An. gambiae* s.s. are not tolerant to high salinities, suggesting a possibility of their control by increasing the salinity of their respective breeding sites. Under natural conditions, even in coastal areas, salinity in the larval habitats is normally not sufficiently high to reduce the breeding of *C. quinquefasciatus*. An analysis of the breeding water from 12 % (4/42) of the pit latrines in a shoreline village on the south Kenya coast showed low salinities of 2.6-6.0 % sea water during neap low tides and 5.3-7.9 % sea water during spring high tides. Thus, even in such breeding sites it would be necessary to raise salinity above the level found tolerant by *C. quinquefasciatus*. Such a control method involving the addition of domestic salt into pit latrines would most probably be quite acceptable to local people since they have been practicing it for many years in the belief that it lowers pit latrine water level. Domestic salt is also cheap and readily available in many coastal villages from local cottage industries where it is made by boiling sea water.

The low tolerance to salinity shown by *An. funestus* and *An. gambiae* observed during the present studies may to a large extent be responsible for their very low densities in coastal shoreline villages as recently observed by McMahon *et al.* (1981) and Mosha and Mutero (1982). *An. gambiae* s.s. could thust be controlled by directing high tide water to its semi-permanent breeding sites, but this method seems to be limited because of high cost and the risk of colonization of these sites by the brackish water species *An. merus*.

ACKNOWLEDGEMENT

We are most grateful to the United Nations Environment Programme for funding this project through the International Centre of Insect Physiology and Ecology. Our sincere acknowledgement are also extended to Messrs. J. Otieno, M. Ngumah, L. Odongo and R. Musyoki for their field assistance. Lastly we would like to thank Dr. M. W. Service for his comments on the manuscript and Dr. F. Ruvuna for his assistance in the statistical analysis.

Manuscrit reçu au Service des Éditions de l'O.R.S.T.O.M. le 6 octobre 1983

REFERENCES

DUNN (H.), 1928. — Further observations on mosquito breeding in tree-holes and crabholes. *Bull. ent. Res.*, 18 : 247-250.

GIGLIOLI (M. E. C.), 1964. — Tides, salinity and the breeding of *Anopheles melas* (Theobald, 1903) during the dry season in the Gambia. *Riv. Malar.*, 43 : 245-263.

JEPSON (W. F.), MOUTIA (A.) and COURTOIS (C.), 1947. — The malaria problem in Mauritius : The bionomics of Mauritian anophelines. *Bull. ent. Res.*, 36 : 177-208.

McMAHON (J. E.), MAGAYUKA (S. A.), KOLSTRUP (N.), MOSHA (F. W.), BUSHROD (F. M.), ABARU (D. E.) and BRYAN (J. H.), 1981. — Studies on transmission and prevalence of Bancroftian filariasis in 4 coastal villages in Tanzania. *Ann. trop. Med. Parasit.*, 75 : 415-431.

MACFIE (J. E. S.) and INGRAM (A.), 1916. — « The Domestic mosquitoes of Accra ». *Bull. ent. Res.*, 7 : 161-177.

MOSHA (F. W.) and MUTERO (C. M.), 1982. — The influence of salinity on larval development and population dynamics of *An. merus* (Diptera : Culicidae). *Bull. ent. Res.*, 72 : 119-128.

MUIRHEAD-THOMSON (R. C.), 1951. — Studies on saltwater and freshwater *Anopheles gambiae* on the East African coast. *Bull. ent. Res.*, 41 : 487-502.

PATERSON (H.E.), 1964. — Saltwater *Anopheles gambiae* on Mauritius. *Bull. Wld. Hlth Org.*, 31 : 635-644.

RIBBANDS (C. R.), 1944. — Differences between *Anopheles melas* and *Anopheles gambiae*. II. Salinity relations of larvae and maxillary palp banding of adult females. *Ann. trop. Med. Parasit.*, 38 : 87-99.

SMITH (A.) and VAIL (J. M.), 1959. — Relationship between salinity and breeding of *Anopheles gambiae* in North-Eastern Tanganyika. *Nature, Lond.*, 183 : 1203-1204.