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THE STATUS OF *SORGHUM ARUNDINACEUM* AS A HOST OF *ATHERIGONA SOCCATA* RONDANI (DIPTERA: MUSCIDAE) IN KENYA

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Abstract—Surveys were conducted in two different ecological zones (semi-arid and arid) of Kenya to monitor egg, larval and pupal populations of the sorghum shootfly, *Atherigona soccata*, on a wild host, *Sorghum arundinaceum*. Populations were found to be usually higher on wild sorghum than on local varieties of *Sorghum bicolor*, the cultivated host. During dry periods, shootfly eggs and larvae were still found on wild sorghum, especially in moist areas such as beds of temporary streams or river banks. Population levels seem to be related primarily with the availability of susceptible stems, which in itself is determined by rainfall, soil conditions, density of other vegetation and by the phenology and the distribution of the host plant, *Sorghum arundinaceum*, being a pioneer species which colonizes recently disturbed areas and is subsequently replaced by other grass species. Since no evidence of the existence of an aestivation diapause has been found, it is reasonable to assume that *Sorghum arundinaceum* is a major reservoir for *A. soccata*, especially during the dry season.

Key Words: Atherigona soccata, population fluctuation, *Sorghum arundinaceum*, *Sorghum bicolor*, sorghum shootfly, *Sorghum verticilliflorum*

INTRODUCTION

EARLY planted sorghum crops are likely to be less severely damaged by the sorghum shootfly, *Atherigona soccata*, than late planted crops (BLUM, 1972; RAM *et al.*, 1976; OGWARO, 1979). This observation is generally related to the fact that sorghum shootfly populations are very low towards the end of the dry season and the beginning of the following rainy season (STARKS, 1970). In order to explain the carry-over of populations, it has been suggested that shootfly larvae (CLEARWATER, personal communication) or pupae (OGWARO, 1979) could undergo an aestivation or a quiescence during the dry season, at a time when no or few susceptible shoots are available in the fields. Our own observations, however, indicate that there is no larval or pupal aestivation in the areas under study.

Several wild graminaceous plants have been reported as hosts of the sorghum shootfly in various parts of Africa; the different species have been reviewed by DEEMING (1971). *Sorghum verticilliflorum* was reported by NYE (1960) as a common wild host of *A. soccata* in Eastern Africa; STARKS (1970) noted that in Uganda *Sorghum verticilliflorum* was infested by sorghum shootflies early in the season, but that substantial numbers of flies could be found only after the emergence of the cultivated crop; he suggested that population build-up was not possible on wild sorghum.

GRANADOS (1972) found in Thailand that shootfly populations could not build up on any of the three wild hosts screened by her: *Digitaria ascendens*, *Eleusine indica* and *Brachiara reptans*. The present study was undertaken to investigate the possibility that *A. soccata* could survive the dry season as an active population in the shoots of *Sorghum arundinaceum* in Kenya.

MATERIALS AND METHODS

Three wild species of *Sorghum* occur in Kenya (CLAYTON, unpublished): *Sorghum versicolor* Anderss., *Sorghum purpureo-sericeum* (A. Rich.) Aschers. and Schweinf. and *Sorghum arundinaceum* (Desv.) Stapf, which groups several former species, among which are *Sorghum verticilliflorum* (Steud.) Stapf, *Sorghum aethiopicum* (Hack.) Stapf and *Sorghum brevicarinatum* Snowden. *Sorghum arundinaceum* is by far the most common species in Kenya; it grows from sea level to a maximum altitude of 1600 m and is absent only from areas receiving less than 300 mm annual rainfall. It is particularly abundant on black clay soils, in zones which are subject to temporary waterlogging, along river banks and on disturbed soil; it is often associated with old farmland. *Sorghum arundinaceum* is an annual plant, which behaves like a perennial under favourable conditions.

Two localities were selected for our study along the Nairobi–Mombasa road: Embakasi, 10 km, and Nzai, 124 km south-west of Nairobi. At Embakasi, situated in the semi-arid zone with a mean annual rainfall of about 800 mm, *Sorghum arundinaceum* covers a large area of black 'cotton' soil which is partly waterlogged during the rainy season.

In the first months of our study, the soil had been recently disturbed and wild sorghum was the main species present. Later, the study area was invaded by various other grass species (*Setaria incrassata*, *Cynodon dactylon*, *Sporolobus pimbertus* and *Eragrostis heteromera*) and several dicotyledons. Sorghum is not

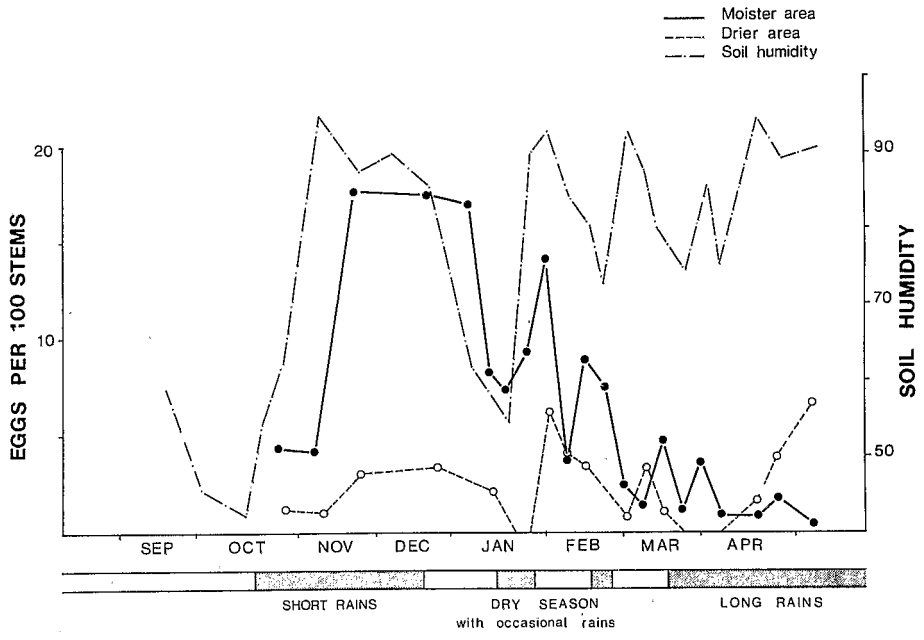

Fig. 1. Soil humidity and fluctuations of *A. soccata* egg numbers in Embakasi (1979–1980).

cultivated in the area, but a few subspontaneous hills of an undetermined variety of *Sorghum bicolor* (the cultivated species) may be found among the wild species, probably witnesses of an old farm in the area. Two sites were selected in Embakasi, one in a seasonally waterlogged area, the other in a much drier zone.

Nzai is at the limit of the arid zone and receives a mean of 600 mm rainfall annually; sorghum is grown locally on a small scale and *Sorghum arundinaceum* is found in patches on farmland and on road embankments. Because of poor farming practices, especially lack of weeding, wild sorghum growth somehow follows that of the surrounding crops: it is only after harvest that the old wild sorghum stems are removed, so that fallen seeds remain on the soil during the whole dry season and germinate during the first rains, together with the crops (maize and sorghum) sown by the farmers.

Samples of approximately 200–600 seedlings or tillers of *Sorghum arundinaceum* were collected every week in Embakasi, and every fortnight in Nzai; only young and green shoots were selected, stems measuring more than 30–35 cm being considered as too old to be attacked by the shootfly.

Unhatched eggs were counted in the field and kept separately and stems without fresh eggs were brought to the laboratory to be dissected. The numbers of larvae and pupae found in the stems were recorded. Pupae present in the soil were not recorded because no satisfactory sampling method could be worked out since information concerning pupation is rather contradictory: some authors (BLETON and FIEUZET, 1943) indicate that in most cases pupation occurs in the soil, whereas other reports differ: BARRY (1972) states that pupae are usually found in the stem and occasionally in the soil at the base of the plant. It was therefore decided that, until a more appropriate sampling method was found, the pupal stage would not be used in population monitoring. Larvae and pupae collected were reared in the laboratory and the emerging adults were periodically identified.

Sampling started in August 1979 in Nzai and in October 1979 in Embakasi, before the beginning of the short rainy season, and ended in May 1980, after the beginning of the long rainy season. The survey therefore included part of a dry season (August–October 1979), the short rainy season (October–December 1979), a complete dry season (January–March 1980) and the beginning of the long rainy season (March–April 1980).

Oviposition preference tests were conducted in the screen-house: five seedlings of *Sorghum arundinaceum* and *Sorghum bicolor*, variety CSH-1 were grown in metal trays (38 × 48 cm) on top of which screen cages (38 × 48 × 50 cm) were placed. When the plants were 25 days old, five pairs of flies aged 48 hr fed with sorghum aphid honey dew (UNNITHAN, unpublished) were introduced in the cages and confined for 24 hr; eggs laid on each plant were then recorded.

RESULTS

The general trend in the fluctuation of *A. soccata* numbers, as reflected by egg counts, is shown in Fig. 1 for Embakasi and Fig. 2 for Nzai. The 1979 short rainy season in Embakasi (moist area) was characterized by a sharp increase in egg numbers, which started three weeks after the onset of the rains; numbers remained high (between 15–20 eggs per 100 stems) until the end of the year, when a sharp decrease occurred, after a dry spell in January. Afterwards, egg numbers continued to decrease until early May, when the mean number of eggs per 100 stems dropped to 0.4 (Fig. 1). The comparison of the two areas selected in Embakasi shows that the drier zone received generally 2–3 times less eggs than the moist

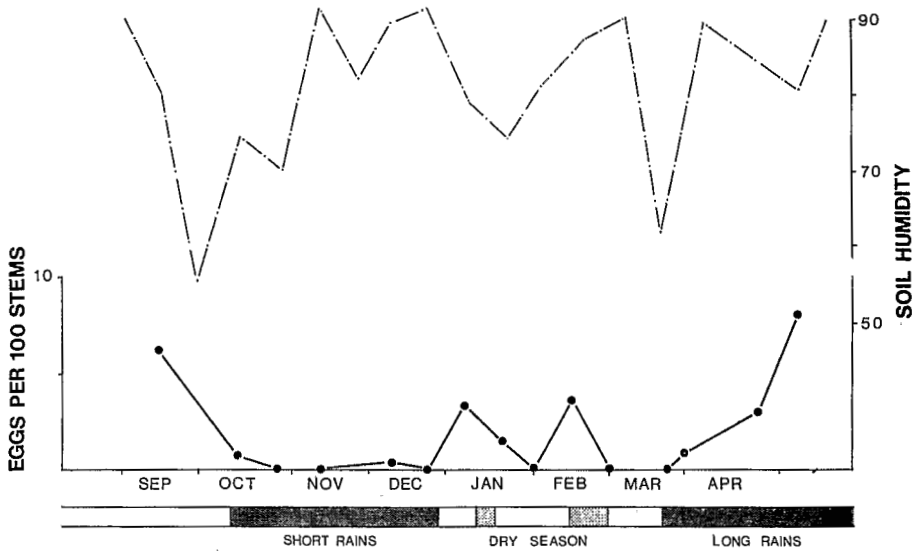

Fig. 2. Soil humidity and fluctuations of *A. soccata* egg numbers in Nzai (1979–1980).

zone, except after the beginning of the long rains, when shoots in the drier area started receiving most of the eggs.

In Nzai, the situation was quite different: no eggs were laid during the short rains of 1979; only a few eggs were found afterwards, in spite of a higher and more regular rainfall than in Embakasi. In April–May 1980, however, egg-laying resumed with the onset of the rains (Fig. 2). Larval and pupal distribution followed very closely that of the eggs (Fig. 3); pupae were found in stems only during the dry period, which suggests that pupation occurs outside the stems during the rainy season, when the soil is moist.

Shootfly egg and larval numbers were found to be usually higher on wild sorghum than on cultivated sorghum. When sorghum was sown in Nzai at the end of November 1979 and growth favoured by heavy rains which occurred in December, young seedlings were not infested. Later in the season, a few eggs were found occasionally on cultivated sorghum, but always less than on wild sorghum. In April 1980, new tillers were produced by stubbles left in the field and were more heavily infested than wild sorghum. However in May, after wild sorghum seeds had germinated, they became even more infested than *Sorghum bicolor* tillers (Fig. 4). The experiment conducted in the screen house confirmed that wild sorghum could be more attractive to ovipositing females than cultivated sorghum: when females were given a choice between seedlings of the same age of *Sorghum arundinaceum* and of a very susceptible hybrid of *Sorghum bicolor*, CSH-1, about 1.5 times more eggs were laid on wild sorghum (Table 1).

DISCUSSION

An active population of the sorghum shootfly has been found on *Sorghum arundinaceum* during the driest period of the year in the two locations under study. One of the interesting features of the fluctuations of sorghum shootfly populations is that they cannot be clearly related to rainfall or humidity.

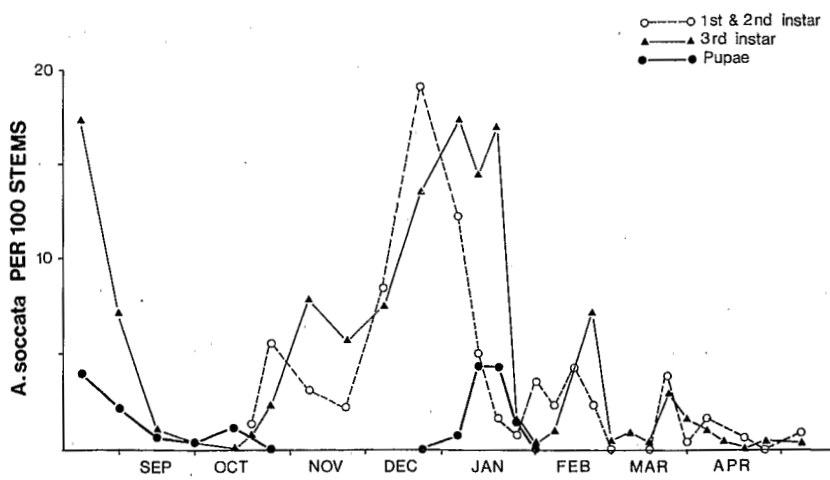

Fig. 3. Fluctuations of larval and pupal numbers on wild sorghum in Embakasi (1979–1980).

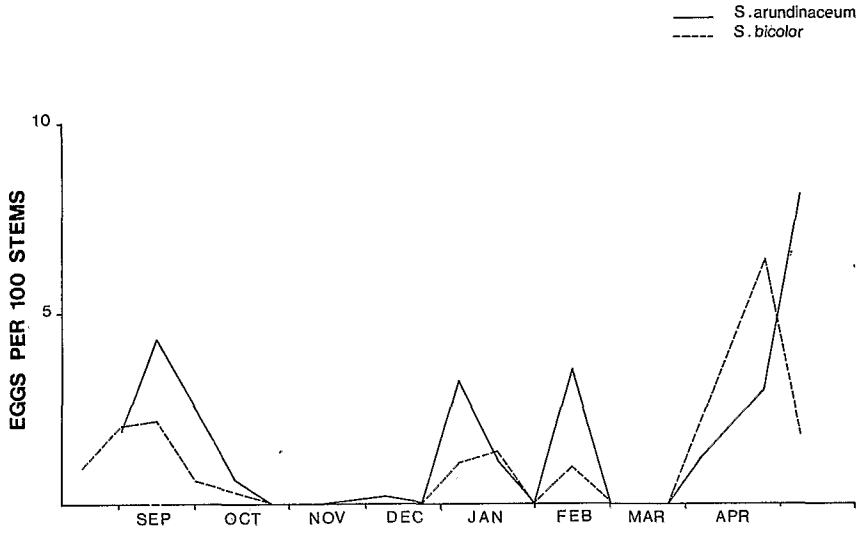

Fig. 4. Eggs laid on wild and cultivated sorghum in Nzai during the short rains and the dry season (1979–1980).

During the first part of the study in Embakasi (moist area), the relationship between soil humidity and shootfly population is very clear: with a delay of a little less than 3 weeks, egg numbers follow the fluctuations of soil humidity. On the contrary, in the last four months of the study, showers occurring in the middle of the dry season, followed by the heavy rains of the long rainy season, cannot prevent the decrease of egg numbers; this decrease may be explained by the fact that, after flowering occurred in December–January, the sorghum hills, which were then already 1-year old, could produce only very few tillers. The mean number of tillers per square meter fell from 35 in early February to 14 in May. Another factor which comes into action is the invasion of the sampling zone by various types of grasses and shrubs, apparently repelling the flies. On the contrary, the drier area produced very few flowers in the beginning of 1980; the soil remained bare around the sorghum hills, so that the production of tillers in April–May was much higher than in the moister area. This probably accounts for the difference observed between the two zones in May.

Table 1. Oviposition preference of *A. soccata* for wild and cultivated sorghums

No. of females	No. of plants	Eggs laid on *Sorghum bicolor* variety CSH-1	Eggs laid on *Sorghum arundinaceum*
5	10	72	67
5	10	48	72
5	10	44	31
5	10	47	87
5	10	40	68
Total		251*	325*

*Difference significant at the 1% level.

Similarly, the difference in egg numbers between Embakasi and Nzai (as well as the fact that the November crop in Nzai completely escaped infestation) cannot be explained by the more arid situation of the latter station, because the two stations received about the same amount of rainfall in 1979–1980.

It could be that the more scattered distribution of wild sorghum plants and the somewhat isolated situation of the sorghum plot did not permit an adequate build-up of *A. soccata* populations. However, other neglected factors such as migration or predation could also account for the discrepancy.

The comparison of the attraction of *Sorghum bicolor* and *Sorghum arundinaceum* to shootfly females explains why more eggs were usually found on wild than on cultivated sorghum. It must however be considered that seedlings used in the experiments were of the same age. It has been shown in *Sorghum bicolor* (DELOBEL, unpublished) that the size of the plant determines the choice of the oviposition site by the female. It can therefore be expected that, in the field (see Fig. 4, April), the selection of the host by the flies will depend not only on the host species but also on the stage reached by the seedlings or the tillers.

The present investigation and also results of our survey (unpublished) in farmers' fields during the dry period after harvesting of sorghum, suggest the absence of or lack of the need for an aestivation diapause, at least under East African conditions.

CONCLUSION

Sorghum arundinaceum, which is an indigenous grass, is a major host of *A. soccata* in Kenya. This wild sorghum species has been described as one of the progenitors of cultivated sorghum, which is probably the result of selection by man of plants with big undeciduous seeds; it is reasonable to assume that *A. soccata* has followed its host plant from grassland to the fields of the first farmers. However, *Sorghum arundina-*

ceum still remains the main or the only host of the sorghum shootfly in locations where sorghum is not grown; in the arid zone, the carrying capacity of the wild sorghum is close to zero during the dry season, except in a few patches, generally in riverbeds or along persistent water streams or pools, where limited subpopulations of the sorghum shootfly, with probably very little connection with each other, persist until the onset of rains. After germination of wild sorghum, the invasion of the newly available shoots probably starts from those few privileged patches.

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