Population Dynamics of Sorghum Shoot Fly, *Atherigona soccata* (Diptera: Muscidae), in Senegal

R. T. GAHUKAR[1]

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Cooperative Program, Boite Postale 51, Bambey, Senegal

Environ. Entomol. 16: 910–916 (1987)

ABSTRACT Fish meal-baited water traps were used for assessing abundance and species composition of shoot flies, which are major pests of late-planted local sorghum cultivars in Senegal. Although 23 species of *Atherigona* were collected and recorded from five regions, *Atherigona soccata* Rondani was the most common and abundant species. Females represented 80–97% of total flies trapped during 1977–81. Abundance was greatest during August–September. More flies were trapped in sorghum fields and grassy weeds than in fields with pearl millet. Correlations between rainfall, temperature, and relative humidity and fly numbers were present at all sites but an interaction existed between these parameters. Maximum temperature did not favor fly abundance. Late-planted sorghum was more severely attacked by shoot flies. Number of flies trapped was not significantly or consistently related to percentage of plants with fly eggs or dead hearts 14 and 28 d after plant emergence.

KEY WORDS *Atherigona soccata*, population dynamics

IN THE SUBSAHELIAN region of West Africa, *Sorghum bicolor* (L.) Moench is a major food crop. It is generally planted just after the first rains, but planting may be delayed or repeated if rainfall is not sufficient for stand establishment. Sorghum shoot fly, *Atherigona soccata* Rondani, attacks late-planted crops, which are susceptible to infestation for 1½ mo after plant emergence. Damage may be to the extent that plant population density is severely reduced. If plants survive, they often tiller excessively and produce less grain. Thus, shoot fly is considered one of the major seedling insect pests of sorghum in West Africa (Adesiyun 1978, Bonzi 1981, Bonzi & Gahukar 1983). In Senegal, surveys during 1977–80 showed that shoot fly was present in all sorghum-growing areas and that shoot fly infestation density varied among localities and years depending primarily on climatic conditions (Gahukar 1980).

Shoot fly females lay ca. 20–25 eggs (Kundu & Kishore 1970) singly on the underside of host plant leaves usually oriented parallel to the leaf midrib. Eggs hatch into small larvae 2–5 d after being deposited. Young larvae eat through the leaf sheath into the stem base and cut the growing point, which causes the central shoot to wither and die (dead heart). The dead-heart condition is evident within 2–3 d after pest attack. Yellowish full-grown larvae, 1.3 mm in length and tapering at each end, feed on decaying plant material just above the cut growing point. Larvae mature in ca. 2 wk, and pupation occurs within the stem or in the soil. Adult flies emerge from pupae within a week. A life cycle of 3–4 wk allows the insect to produce up to 10 generations per year. Similarly, continuous development may occur satisfactorily on weedy grass hosts (Gahukar 1985).

Ecology of the numerous shoot fly species, especially *A. soccata*, in Senegal is not well known. A better understanding of population dynamics of the shoot fly complex would be helpful in developing effective and practical control strategies for this important group. Consequently, experiments were designed to investigate shoot fly population abundance and distribution in different regions of Senegal. Also, shoot fly damage to local sorghum cultivars planted on different dates was measured.

Materials and Methods

Shoot Fly Abundance and Distribution. The trapping system developed by Seshu Reddy & Davies (1978) was used to monitor shoot fly species composition, distribution, and abundance. Square, galvanized metal pan traps (60 by 60 by 7.5 cm) were fitted with cone-shaped metal lids. In the center of the trap, a wire mesh container (7.5 cm diameter, 12.5 cm high) was used to hold fish meal. The fish meal was obtained from a local market where it is readily available. The pan contained 20 liters of water, 20 g of brewer's yeast powder, and 100 g of detergent powder. The liquid was allowed to touch the mesh container holding the fish meal to keep it moist. The flies are attracted by odor to the fish meal and fall into the liquid and drown. Each week, the fish meal was replaced, and yeast and detergent powder were added to the water, which was changed once every 6 d. Traps were positioned ca. 40 cm above ground level.

[1] Current address: FAO/CILSS/USAID Integrated Pest Management Project, ISRA, Boite Postale 199, Kaolack, Senegal.

Table 1. Situation and habitat characteristics of five sites used to study shoot fly populations in Senegal, 1977–81

Site	Region	Altitude (m)	Latitude	Longitude	No. of traps	Annual rainfall (mm)
Sefa	Casamance (Kolda)[a]	10	12°47'N	15°32'W	4	1,000–1,200
Nioro-du-Rip	Sine Saloum (Kaolack)[a]	15	13°45'N	15°47'W	2	600–900
Bambey	Diourbel	17	14°28'N	16°28'W	5[b]	500–700
Louga	Louga	38	15°37'N	16°13'W	2	300–500
Fanaye	Senegal River Valley (St. Louis)[a]	10	16°32'N	15°13'W	2	100–300

[a] Renamed in 1984.
[b] Two traps in 1981.

Each year, traps were installed in May in fields of sorghum. Trap number, location, and site characteristics are given in Table 1. Traps were inspected from June to November during 1979 and 1980 at Louga, Nioro-du-Rip, and Fanaye, and during 1979–81 at Sefa. At Bambey, traps were monitored year-round from 1977 to 1981. In addition, two traps were placed in fields of sorghum, pearl millet, and wild grasses at Bambey from July 1977 through December 1978.

Traps were checked and flies removed each Monday, Wednesday, and Friday. Flies were preserved in 70% alcohol. A sample unit was the number of flies collected in each trap within a 2-wk period. Flies of the genus *Atherigona* were preserved for later identification. Flies were separated by sex and males were identified to species on the basis of hypopygial prominence and trifoliate process (Deeming 1971). Females of *A. soccata* were identified using morphological characters described by Clearwater (1981). Daily records of relative humidity, temperature, and rainfall were maintained at all monitoring sites except Fanaye.

Magnitude of Shoot Fly Damage in Relation to Crop Planting Date. At Bambey, two local sorghum cultivars, 'Congossane' and 'CE90', were planted just after the monsoons began (normal planting) at weekly intervals from 21 July to 9 September 1978. In 1979, planting was done from 23 June to 10 October (first three and last four plantings under irrigation), whereas normal planting started from 14 July. A split-plot design with three replications was used. Main plots consisted of planting date, and subplots were cultivars. Each subplot consisted of 10 rows 80 cm apart and 5 m long with ca. 240 plants. Ten days after plant emergence, two plants were retained in each hill at the time of first weeding. Both cultivars produce tillers. A NPK (10:10:21) fertilizer was spread before planting at 150 kg/ha. Urea was applied at 100 kg/ha in two doses: the first 2 wk after plant emergence and the second at boot stage. Two outside rows were borders and not used to collect data.

All plants in the eight test rows were examined visually for the presence of shoot fly eggs on leaves 14 d after plant emergence and for dead hearts 14 and 28 d after plant emergence. These census dates were considered appropriate because most shoot fly eggs are laid on plants 10–15 d old and <30–40 cm tall. Larger plants are rarely attacked, but tillers often are infested.

Data Analysis. Regression analysis was used with fly catch as the dependent variable and weather parameters as the independent variables to determine the relative importance of temperature, relative humidity, and rainfall on shoot fly density.

Correlations were established between planting dates, female fly numbers, and plants with eggs 14 d after plant emergence and with dead hearts after 14 and 28 d. The last variable was considered the dependent variable.

Results and Discussion

Shoot Fly Abundance, Species Composition, and Distribution. The fish meal traps proved to be useful as a technique to assess shoot fly abundance, species composition, and distribution. Seshu Reddy et al. (1981) evaluated various mixtures of fish meal with yeast, ammonium sulfide, dung, biocide (aureomycin), or water and found that fish meal alone was adequate to attract shoot flies. However, it was not found to be a specific attractant because other species (Oscinellinae, Chloropidae) were also trapped during studies reported here.

Based on male flies identified, 21 species of the subgenus *Atherigona* Rondani and two species of the subgenus *Acritochaeta* Grimshaw were collected as follows: *Atherigona* (*A.*) *albistyla* Deeming, *A.* (*A.*) *bimaculata* Stein, *A.* (*A.*) *budongoana* van Emden, *A.* (*A.*) *griseiventris* van Emden, *A.* (*A.*) *humeralis* Wiedemann, *A.* (*A.*) *hyalinipennis* van Emden, *A.* (*A.*) *lineata* Adams, *A.* (*A.*) *longifolia* van Emden, *A.* (*A.*) *marginifolia* van Emden, *A.* (*A.*) *mirabilis* Deeming, *A.* (*A.*) *naqvii* Steyskal, *A.* (*A.*) *occidentalis* Deeming, *A.* (*A.*) *ponti* Deeming, *A.* (*A.*) *pulla* Wiedemann, *A.* (*A.*) *rubricornis* Stein, *A.* (*A.*) *samaruensis* Deeming, *A.* (*A.*) *secrecauda* Séguy, *A.* (*A.*) *soccata*, *A.* (*A.*) *theodori* Hennig, *A.* (*A.*) *tomentigera* van Emden, *A.* (*A.*) *truncata* van Emden, *A.* (*Acritochaeta*) *orientalis* Schiner, and *A.* (*Acritochaeta*) *yorki* Deeming.

Nine of the 23 species were relatively common (*A. soccata*, *A. lineata*, *A. marginifolia*, *A. secrecauda*, *A. rubricornis*, *A. humeralis*, *A. hyalinipennis*, *A. naqvii*, and *A. orientalis*), but *A. soccata* was by far the most predominant species. Similar

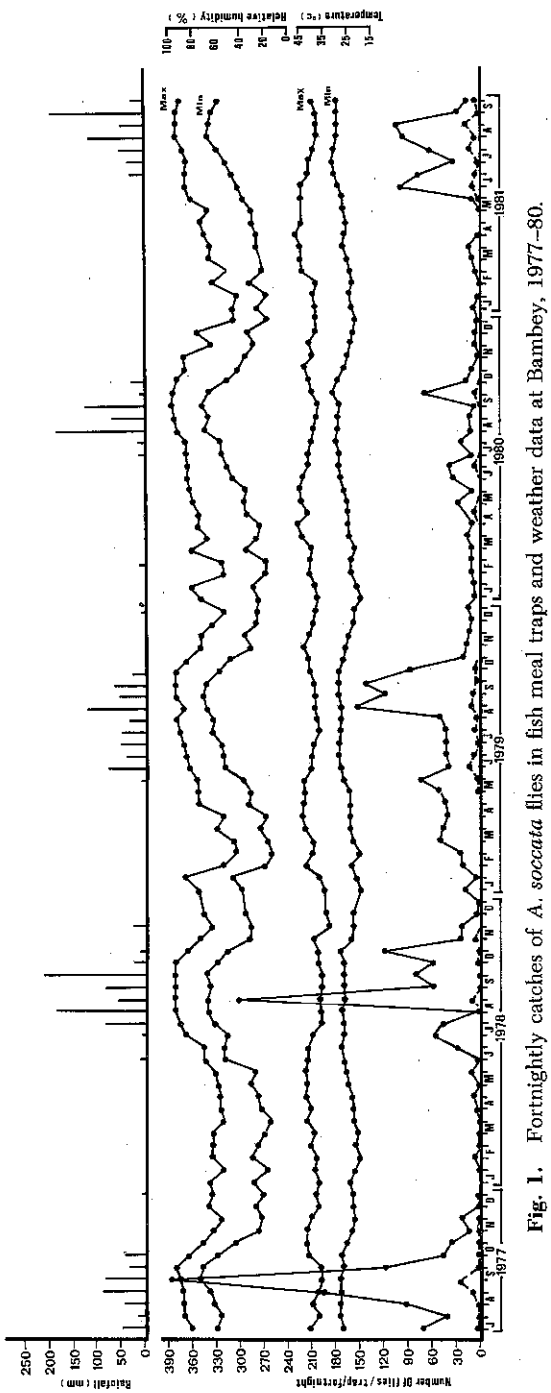

Fig. 1. Fortnightly catches of *A. soccata* flies in fish meal traps and weather data at Bambey, 1977–80.

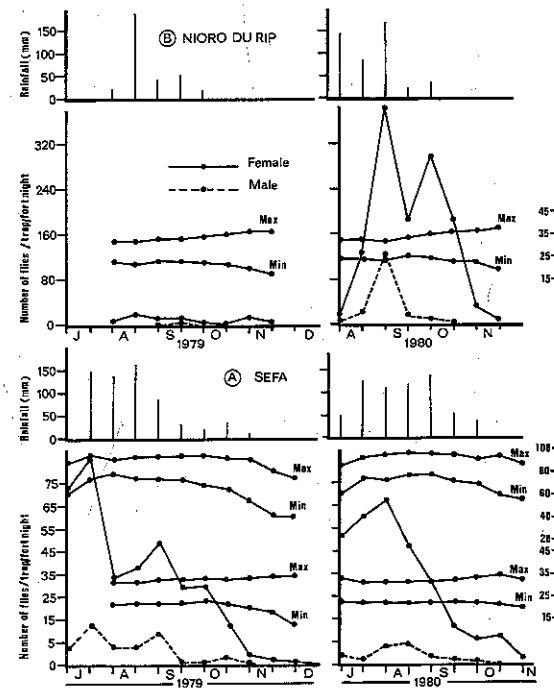

Fig. 2. Fortnightly catches of *A. soccata* flies in fish meal traps and weather data at Sefa (A) and Nioro-du-Rip (B), 1979–80.

results on species composition were obtained by Bonzi (1981) and Bonzi & Gahukar (1983) in Burkina Faso and by Deeming (1971) in Nigeria. *A. lineata* was the second most abundant species collected at all sites, probably because several races and subspecies were present (Deeming 1971); for this survey all forms were combined and reported here as one species.

Of the *A. soccata* collected, 80–97% were females. When shoot flies were reared from sorghum plants with dead hearts, the sex ratio was one male/three females (Gahukar 1985). Using fish meal traps similar to the ones used in this investigation, others have reported similar results: Clearwater (1981) caught 90% females in Kenya, Bonzi (1981) caught 74–80% females in Burkina Faso, and Seshu Reddy & Davies (1978) collected 90–99% females in India. However, Ogwaro (1979) reported a male/female ratio of 1.0:1.4–1.9 from sweep-net catches. These data certainly show that female shoot flies are more attracted to fish meal traps than males. Also, Seshu Reddy et al. (1981) speculated that young female flies, especially those about to lay eggs, are more attracted to fish meal than older female flies. But the biological significance of fish meal as a protein source or an ovipositional site for these shoot flies has not yet been investigated.

In general, peaks of *A. soccata* activity varied from place to place and from year to year. However, trap catches were greatest during late August through late September at all sites (Fig. 1–3). At

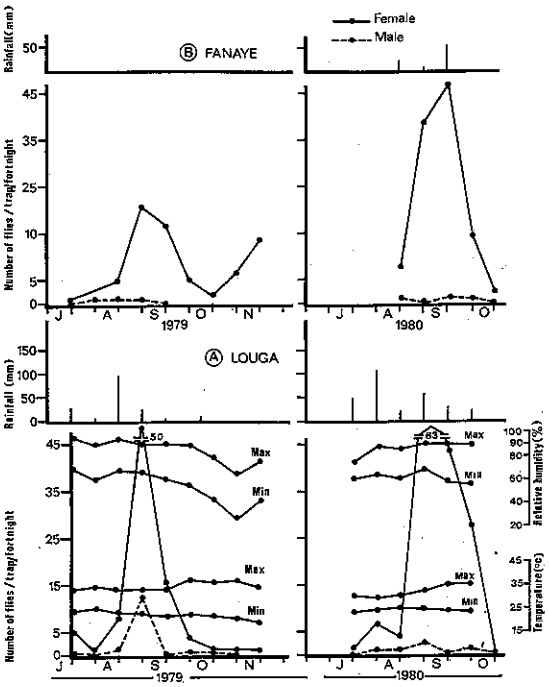

Fig. 3. Fortnightly catches of *A. soccata* flies in fish meal traps and weather data at Louga (A) and Fanaye (B), 1979–80.

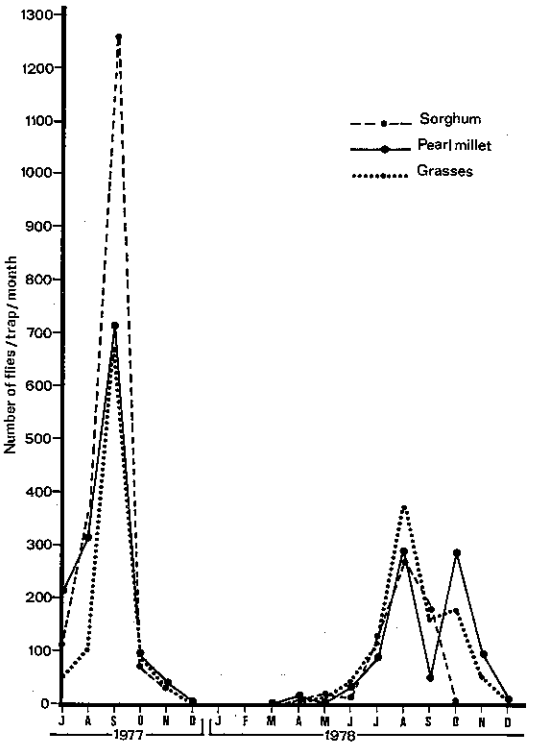

Fig. 4. Number of *A. soccata* flies captured in fish meal traps placed in fields of sorghum and pearl millet and in grassland areas at Bambey, 1977–78.

Bambey, fly catches declined from 1977 to 1980 but increased in 1981 because traps were placed near irrigated sorghum plots and shoot flies developed on border plants and weeds. This resulted in a peak in June, and flies were active thereafter on sorghum. Therefore, the catches were relatively higher in 1981. At Sefa, the early heavy rains and a long rainy season (June–October) favored fly activity on weedy grasses. Moreover, sorghum was planted on different dates. At Nioro-du-Rip, greater numbers of flies were trapped in the 1980 crop season than in 1979 because of heavy rains in August followed by drought in September 1979.

Weather factors influenced fly abundance at four sites. Rainfall appeared to affect fly activity: the more rainfall the more abundant were the flies; these relationships were negative during 1980 for Bambey and Louga because of drought (Table 2). Shoot fly numbers were positively related to maximum and minimum humidity and minimum temperature, as maximum temperature did not favor fly abundance.

The relationship of maximum (x_1) or minimum (x_2) temperature, maximum (x_3) or minimum (x_4)

Table 2. Coefficients of correlation of temperature, relative humidity, and rainfall with shoot fly numbers at four sites in Senegal, 1977–81

Site	Year	df	Temp (°C)		RH (%)		Rainfall (mm)
			Max	Min	Max	Min	
Bambey	1977	10	−0.58*	0.49	0.59*	0.71*	0.82**
	1978	21	−0.28*	0.48*	0.58**	0.54**	0.25
	1979	22	−0.17	0.60**	0.48*	0.64**	0.77**
	1980	22	−0.18	0.62**	0.34	0.43*	−0.12
	1981	16	−0.31	0.69**	0.65**	0.72**	0.38
Sefa	1979	9	−0.76**	0.59	0.55	0.68*	0.64*
	1980	7	−0.74*	0.51	0.23	0.61	0.78*
Nioro-du-Rip	1970	6	−0.49	0.39	NA	NA	0.81*
	1980	6	−0.34	0.48	NA	NA	0.33
Louga	1979	7	−0.42	0.22	0.32	0.42	0.35
	1980	4	0.64	−0.17	0.82*	0.12	−0.15

*, Correlation coefficients are significant at $P < 0.05$; **, correlation coefficients are significant at $P < 0.01$; NA, data not available.

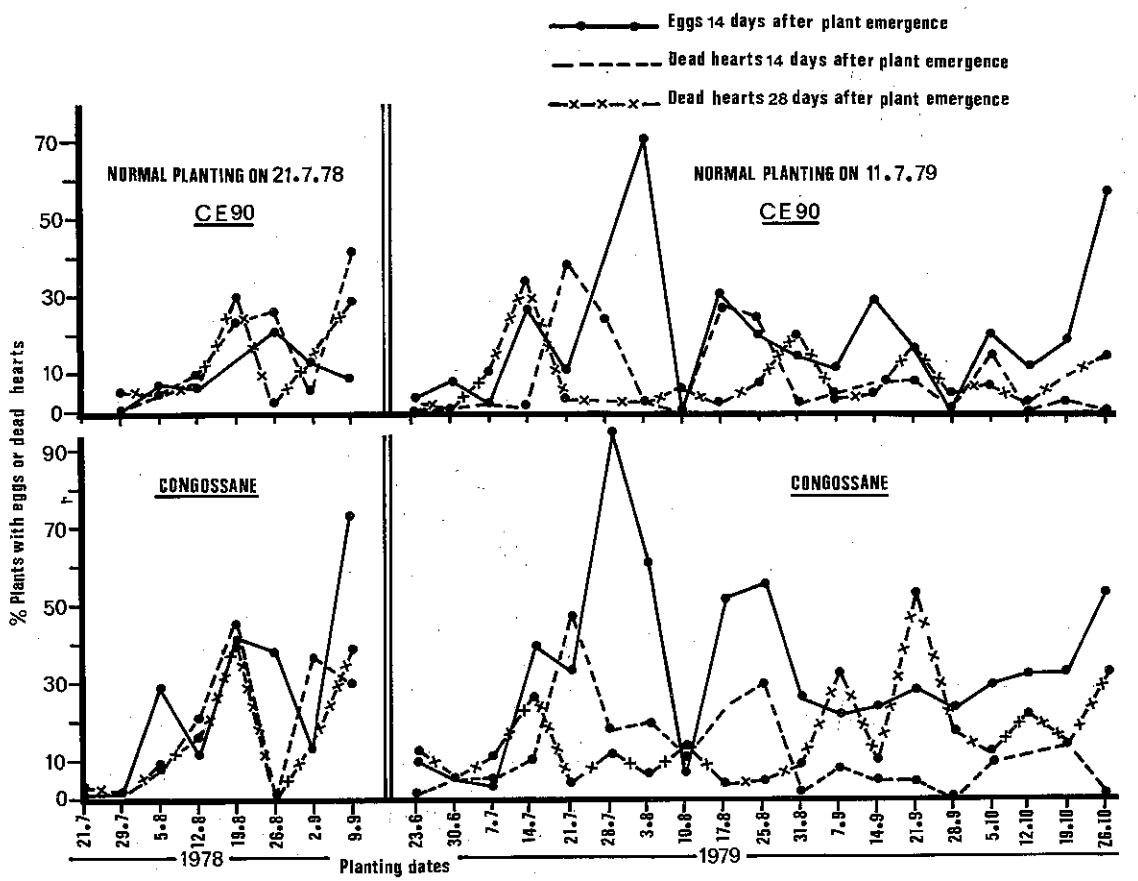

Fig. 5. Effect of planting period of two sorghum cultivars on plant damage by *A. soccata* at Bambey, 1978–79.

play a very limited role in Kenya, as has been studied by Delobel (1983).

In the present study, neither fly trap catches nor egg counts were reliable estimates of subsequent plant damage. These findings do not support the hypothesis (Seshu Reddy & Davies 1978) that sorghum shoot fly populations monitored by fish meal traps could be used in timing control methods and assessing the probable level of pest attack. Consequently, an alternate method of monitoring damaging densities of shoot fly should be searched for and effective pest management strategies developed in areas where sorghum is highly and regularly infested with shoot fly.

Acknowledgment

I thank J. C. Deeming (formerly with the Agricultural Research Institute, Amadou Bello University, Samaru, Nigeria) for his kind help in identifying shoot flies and C. Dancette (National Agricultural Research Center, Bambey, Senegal) for providing weather data. H. C. Chiang, G. L. Teetes, and L. P. Pedigo reviewed the

Table 3. Coefficients of relationship between planting dates, shoot fly numbers, and plants with fly eggs or dead hearts in sorghum, Bambey, 1978–79

Correlations	1978 (df = 6)		1979 (df = 7)	
	'Congossane'	'CE90'	'Congossane'	'CE90'
Planting dates × plants with eggs 14 DAE[a]	+0.74*	+0.72*	+0.16	+0.16
Planting dates × dead hearts 14 DAE	+0.85**	+0.77*	−0.15	−0.16
Planting dates × dead hearts 28 DAE	+0.59	+0.79*	−0.05	+0.09
Plants with eggs 14 DAE × plants with dead hearts 28 DAE	+0.69	+0.31	−0.06	+0.09
♀ fly numbers × plants with eggs 14 DAE	−0.17	−0.19	+0.18	+0.29
♀ fly numbers × plants with dead hearts 14 DAE	−0.25	−0.31	+0.27	+0.16

[a] DAE, days after plant emergence.
*, Coefficients significant at $P < 0.05$; **, coefficients significant at $P < 0.01$.

manuscript and gave valuable suggestions. Thanks are also given to the technical staff of the sorghum entomology section for trap maintenance and shoot fly collections.

References Cited

Adesiyun, A. A. 1978. A common cause of failure of late planted sorghum in Nigeria—the sorghum shoot fly, *Atherigona soccata* Rondani (Diptera: Muscidae). Niger. J. Plant Prot. 3: 162–166.

Bonzi, S. M. 1981. Fluctuations saisonnières des populations de la mouche des pousses du sorgho en Haute Volta. Insect Sci. Appl. 2: 59–62.

Bonzi, S. M. & R. T. Gahukar. 1983. Répartition de la population d'*Atherigona soccata* Rondani (Diptère; Muscidae) et des espèces alliées pendant la saison pluvieuse en Haute Volta. Agron. Trop. 38: 331–334.

Clearwater, J. R. 1981. Practical identification of the females of five species of *Atherigona soccata* Rondani (Diptera: Muscidae) in Kenya. Trop. Pest Manage. 27: 305–312.

Deeming, J. C. 1971. Some species of *Atherigona* Rondani (Diptera, Muscidae) from northern Nigeria with special reference to those injurious to cereal crops. Bull. Entomol. Res. 61: 133–190.

Delobel, A. G. L. 1983. Humidity effects on *Atherigona soccata:* egg development and hatch. Entomol. Exp. Appl. 33: 269–275.

Delobel, A. G. L. & M. C. Lubega. 1984. Rainfall as a mortality factor in the sorghum shoot fly, *Atherigona soccata* Rondani (Diptera, Muscidae). Z. Angew. Entomol. 97: 510–516.

Gahukar, R. T. 1980. Inventaire des insectes nuisibles du sorgho au Sénégal. Centre National de Recherches Agronomiques, Bambey, Sénégal.

1985. Some species of *Atherigona* (Diptera: Muscidae) reared from Gramineae in Senegal. Ann. Appl. Biol. 106: 399–403.

Jotwani, M. G., M. K. Marwaha, K. N. Srivastava & W. R. Young. 1970. Seasonal incidence of shoot fly (*Atherigona varia soccata* Rondani) in jowar hybrids at Delhi. Indian J. Entomol. 32: 7–15.

Kundu, G. G. & P. Kishore. 1970. Biology of the sorghum shoot fly, *Atherigona varia soccata* Rond. (Anthomyiidae, Diptera). Indian J. Entomol. 32: 215–217.

Ogwaro, K. 1978. Ovipositional behavior and host plant preference of the sorghum shoot fly, *Atherigona soccata* (Diptera, Anthomyiidae). Entomol. Exp. Appl. 23: 189–199.

1979. Seasonal activity of the sorghum shoot fly, *Atherigona soccata* (Diptera, Anthomyiidae). Entomol. Exp. Appl. 24: 74–79.

Seshu Reddy, K. V. & J. C. Davies. 1978. Attractant traps for the assessment of sorghum shoot fly, *Atherigona soccata* Rondani populations. Bull. Entomol. 19: 48–51.

Seshu Reddy, K. V., J. D. Skinner & J. C. Davies. 1981. Attractants for *Atherigona* spp. including the sorghum shoot fly, *Atherigona soccata* Rondani (Diptera, Muscidae). Insect Sci. Appl. 2: 83–86.

Taksdal, G. & C. W. Baliddawa. 1975. Studies on the biology of sorghum shoot flies, *Atherigona* spp. (Muscidae, Diptera) and shoot fly–sorghum host plant relationships. Z. Angew. Entomol. 79: 239–249.

Received for publication 10 March 1986; accepted 21 January 1987.