Sonderdruck aus Bd. 93 (1982), H. 1, S. 31–38

Zeitschrift für angewandte Entomologie

VERLAG PAUL PAREY · SPITALERSTRASSE 12 · D-2000 HAMBURG 1

Oviposition and larval survival of the sorghum shoot fly, *Atherigona soccata* Rond., as influenced by the size of its host plant (Diptera, Muscidae)

By A. G. L. Delobel

Abstract

Atherigona soccata females laid more eggs on sorghum plants measuring 4 to 8 cm in height (in the field) or 12 to 16 cm (under cages) than on plants of any other size. Newly hatched larvae survived only on plants measuring less than 24 cm in height. Survival of the first instar larva depended on the size of the host plant. It was influenced by the resistance to penetration of the leaf sheaths and the distance between infestation site, in the case of artificial infestation, and growing point. Survival therefore depended on the ability of the female to select for oviposition a leaf of suitable position.

U.S. Copyright Clearance Center Code Statement: 0044-2240/82/9301-0031 $ 02.50/0
Z. ang. Ent. 93 (1982), 31–38
© 1982 Verlag Paul Parey, Hamburg und Berlin
ISSN 0044-2240 / Inter-Code: ZANEAE

1 Introduction

The most practical control method of the sorghum shoot fly, *Atherigona soccata* Rondani, is the choice of a sowing date that enables the plants to pass the susceptible stage at a period when the shoot fly density is low (JOTWANI et al. 1970; MEKSONGSEE et al. 1981). PONNAIYA (1951a) in India noted that more eggs were laid on plants at the 2nd to 5th leaf stages than on larger ones. TAKSDAL and BALIDDAWA (1975) in Uganda reported that most of the eggs were laid on plants between the 4th and 6th leaf stages. The largest plants on which eggs were laid were found to be in the 8th to 10th leaf stages.

The survival of the first instar larva has been associated with the age of the plant by several authors (PONNAIYA 1951b; BLUM 1967, 1968; YOUNG 1981). The factors involved are expected to be of the same nature as the ones responsible for resistance in certain sorghum varieties: lignification of leaf tissues and deposition of silica bodies. These two factors hinder the movement and feeding activity of newly hatched larvae in older plants.

The present study was conducted to determine the relationships, under laboratory and field conditions, between plant development and oviposition by *A. soccata* females. Also investigated was the relationship between plant size and survival of the first instar larvae.

2 Material and methods

Field experiments were conducted at ICIPE Mbita Point Field Station near Lake Victoria in western Kenya. The sorghum used in all experiments was a highly shoot fly susceptible hybrid of Indian origin, CSH-1. Freshly laid eggs were collected from randomly selected plants which were allowed to grow without interference for ten weeks. The height of each selected plant was measured (from collar to ligule of last expanded leaf). Five small plots, each with six rows of twelve plants sown at five days intervals, were placed under screened cages. Seven days after the emergence of plants in the last row, twenty *A. soccata* pairs were introduced in each cage. One week later, eggs were counted on all leaves and plants were measured; this experiment was replicated three times in 1980. The influence of plant height on survival of the first instar larva was studied in the laboratory. Here, two week old seedlings were artificially infested with newly hatched larvae at the base of the 3rd, 4th and 5th leaf blades. Plants were dissected and their height measured three days later, and the fate of each larva was determined under the microscope.

3 Results

Under field conditions (fig. 1a), 49.1 % of the total number of eggs were laid on plants measuring 4 to 8 cm in length. Only 3.5 % of all eggs were laid on plants with smaller stems; the rest of the eggs was laid on plants measuring 8 to 29 cm.

Under caged conditions (fig. 1b), there was a distinct shift towards egg deposition on larger plants. Of the total eggs laid, 29.4 % were on plants measuring 12 to 16 cm in height. Eggs were laid on leaves of plants measuring up to 53 cm. The height of plants selected for oviposition by adult females, compared with the mean height of all available stems, is shown in table 1. The mean number of eggs per plant increased from 1 to 2.081 in plants measuring from 0–4 to 12–16 cm, then decreased in taller plants (table 2).

Plants measuring less than 4 cm and more than 44 cm never received more

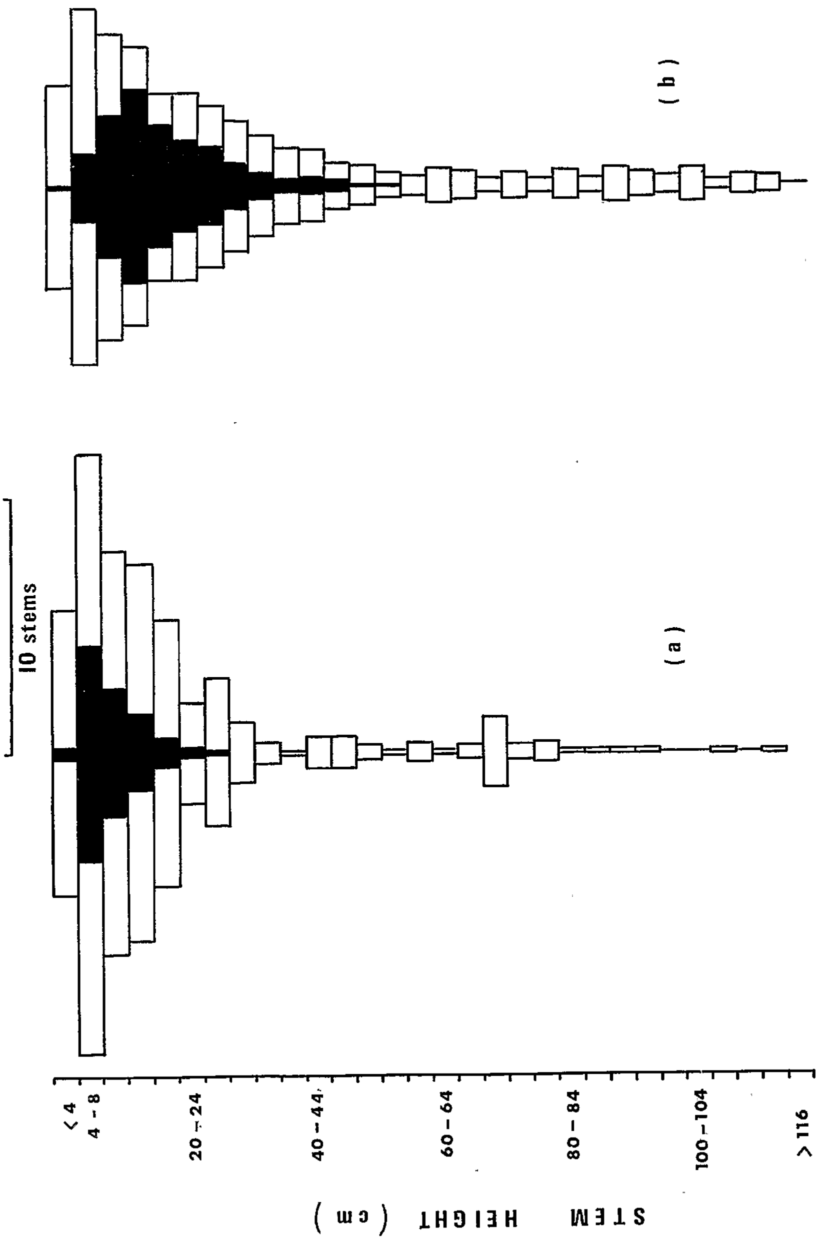

Fig. 1. Size distribution of infested (solid shading) and total stems; (a) in field experiment, (b) under cage

than a single egg. The proportion of plants bearing eggs in each size class was also highest in stems measuring 12 to 16 cm; it was extremely low in smaller plants (only 1.5 % of plants measuring less than 4 cm were infested) and decreased in plants taller than 16 cm. Although mean stem size was different in each of the three replications, no significant difference was observed between replications in the size of plants selected for oviposition (table 1).

Table 1. Relationship between height of plants and selection of oviposition site by *Atherigona soccata*

Replications	Stem height	Height of stems with eggs[1]
A	33.28 ± 1.82	19.61 ± 1.23
B	29.92 ± 1.96	18.61 ± 0.76
C	19.87 ± 0.75	17.25 ± 0.65
A—B	not sign.	not sign.
B—C	highly sign.	not sign.
A—C	highly sign.	not sign.

[1] Mean height in cm + standard deviation

Table 3. Effect of infestation site on fate of newly hatched larvae

Fate of larva	Infestation site		
	3rd leaf	4th leaf	5th leaf
Survived	4	16	45
Died in stem	5	12	9
Unable to penetrate stem	56	37	11

Table 2. Attractiveness of sorghum stems of different sizes towards oviposition by *A. soccata*

Stem height (cm)	0–4	4–8	8–12	12–16	16–20	20–24	24–28	28–32	32–36	36–40	40–44	44–48	48–52	52–56	>56
Mean number of eggs per infested stem	1.000	1.047	1.600	2.081	2.077	1.600	1.416	1.467	1.444	1.250	1.200	1.000	1.000	1.000	–
Percentage of infested stems	1.52	18.42	45.92	68.13	65.00	50.00	47.06	34.88	24.27	16.00	20.83	20.00	7.14	12.50	0

In terms of leaf stage (i. e. the number of completely expanded leaves), eggs were found in equal numbers on plants in the 5th, 6th and 7th leaf stages, which together accounted for 76 % of all eggs laid. The proportion of infested plants was however highest (79.9 %) among plants in the 6th stage. Plants with only one or two leaves were never egg-infested, but some old plants (with nine to fourteen leaves) did receive eggs, although never more than one. The preferred leaf was usually the one immediately under the last expanded leaf (fig. 2); as the plants grew older, *A. soccata* females tended to lay their eggs on leaves of higher rank.

The proportion of caged plants in each size class showing a „dead heart" symptom and in which a first instar larva was actively feeding is shown in fig. 3. There was no dead heart in very small plants (0 to 4 cm in height).

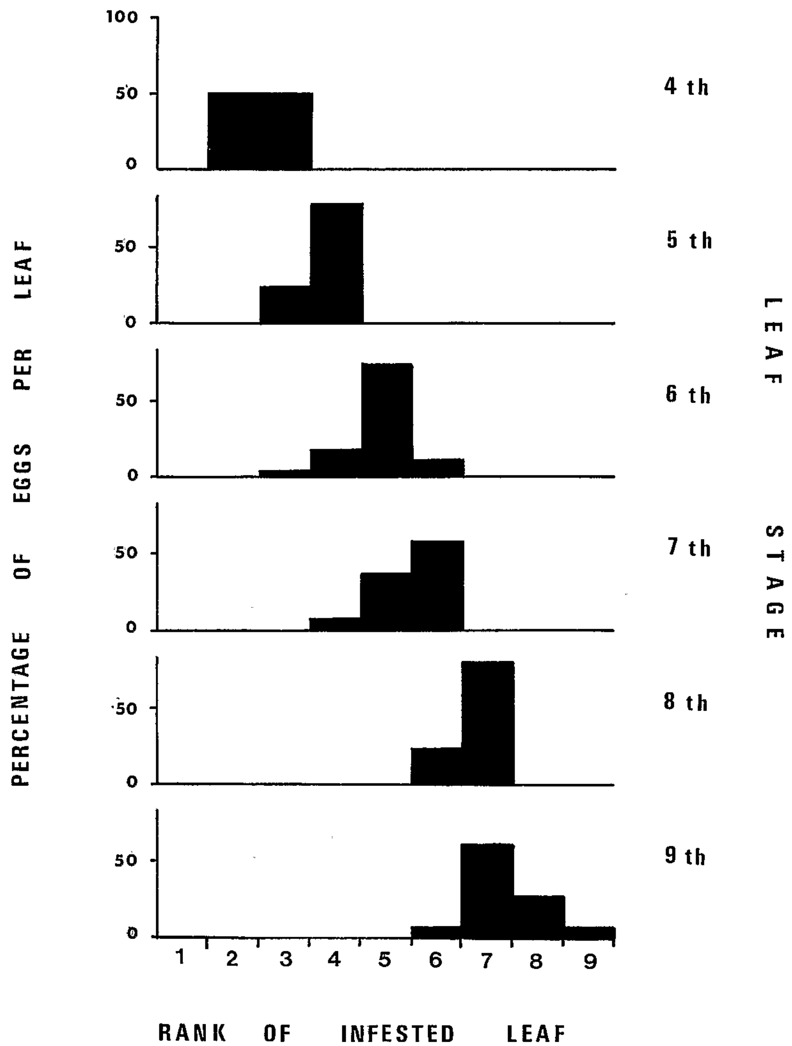

Fig. 2. Distribution of shoot fly eggs among leaves of increasing rank on plants of increasing stage

64.4 % of the dead hearts occurred in plants measuring 8 to 12 cm, and the percentage decreased in taller stems. In none of the plants with stems longer than 28 cm did a first instar larva survive and cause a dead heart. In laboratory experiments, the infestation site significantly affected the survival of larvae (table 3). The proportion of larvae which survived and moulted into the second instar, or larvae which managed to penetrate the stem but died afterwards increased as larvae were deposited on leaves higher up the plant. Among the larvae which managed to pierce the outer layer of leaf sheaths, those which were deposited at the base of the third leaf blade started feeding very near the growing point (at a mean distance of 16.8 mm from stem base). Larvae deposited at the base of the 4th leaf blade stopped their downward movement and started feeding before reaching the growing point, at a mean distance of 29.8 mm from stem base. This latter situation is not suitable for larval development (RAINA 1981). When infestation occurred at the base of the 5th leaf, larvae entered the folds of the cental leaf at a mean distance of 57.9 mm from stem base, but started feeding near the growing point (mean distance from stem base: 20.6 mm).

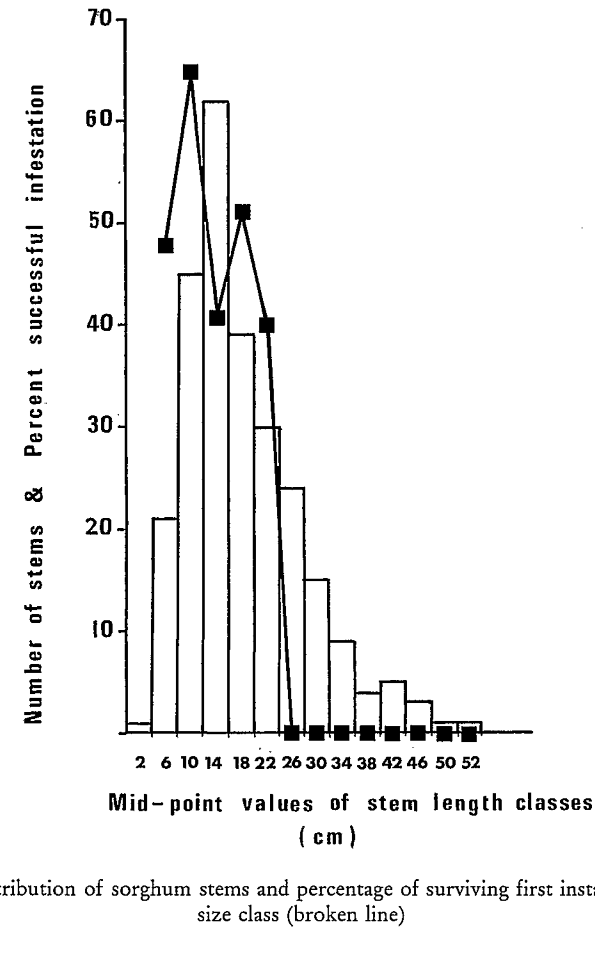

Fig. 3. Size distribution of sorghum stems and percentage of surviving first instar larvae in each size class (broken line)

4 Discussion

The preference of *A. soccata* females for small sorghum plants was indicated by a higher proportion of infested shoots among younger plants and a greater number of eggs on these plants. The discrepancy observed between field and cage data expresses the fact that, in a limited choice situation, flies tend to lay eggs on plants which would normally not be selected in the field.

Oviposition site selection in phytophagous insects is often determined by the chemical composition of the host. In the case of the sorghum shoot fly, OGWARO (1978) showed that females were able to select precisely their oviposition sites through a succession of probing movements of the anterior tarsae and of the ovipositor. Chemical analysis of sorghum plants (COOPER 1973; CULVENOR 1973; RETI 1969) revealed that such compounds as hordenine (β-p-hydroxyphenethyl dimethylamine, an alkaloid), and durrhin, a cyanogenic glucoside, were present at very significant levels in younger plants and disappeared completely as the plants grew older. These compounds are probably involved in the recognition of the host by *A. soccata* females.

If one agrees with PROKOPY and OWENS' (1978) assumption that vision tends to play a more important part in host plant recognition in monophagous than in polyphagous insects, physical and morphological characteristics of the host are likely to play a major role in oviposition site selection by the sorghum shoot fly, which is almost strictly monophagous. Important physical modifications are incurred by the ageing sorghum plant: change in leaf colour from a greenish yellow to a deep green, increased leaf rigidity due to a lower water content and to an increase in the structural carbohydrate content, attack by fungi, etc. Such modifications are partly responsible for the rapidly declining attractivity of older stems. This phenomenon is very similar to the differencial attractivity of cabbage varieties of different colours and tendernesses to cabbage root flies (FINCH and SKINNER 1974; HARDMAN and ELLIS 1978).

The survival of the first instar larva largely depends on its ability to pierce the leaf sheaths before reaching the tender tissues surrounding the growing point. As deposition of silica bodies and lignification of the cell walls increase with age, the leaf sheaths become more and more difficult to pierce, which results in a higher mortality of the newly hatched larvae. At the same time, eggs being laid on leaves of increasing rank, the survival of larvae hatching from these eggs increases: the higher the oviposition site, the smaller is the number of sheaths the larva has to pierce and the weaker is their resistance to penetration. On the other hand, when a larva has to pierce one or several sheaths, its survival decreases as the distance it has to travel inside the stem increases. Larvae hatching from eggs laid on newly expanded leaves often crawl between two adjacent leaves without piercing them, and the softness of the tissues makes their progression all the more easier.

Acknowledgements

The work reported here was carried out at the International Centre of Insect Physiology and Ecology, Nairobi, Kenya, and was supported by a grant (n° 78 7 0896) from the Direction Générale de la Recherche Scientifique et Technique (France). I am indebted to Prof. ODHIAMBO for providing facilities and to Dr. A. K. RAINA for critical comments on the manuscript. J. G. KIBUKA, P. OLLIMO and M. LUBEGA are thanked for their help in the field and the laboratory.

Zusammenfassung

Über Eiablage und Überleben der Sorghum-Schößlingsfliege Atherigona soccata Rond. (Dipt., Muscidae) in Abhängigkeit von der Wirtspflanzengröße

Die Weibchen von *A. soccata* belegten Sorghum-Pflanzen von 4–8 cm Höhe mit einer größeren Zahl Eier als höhere Pflanzen. Frisch geschlüpfte Larven überlebten nur an Pflanzen, die niedriger als 24 cm waren. Das Überleben der L_1 war vom Stadium der Wirtspflanze abhängig. Es wurde beeinflußt durch die Resistenz der Pflanze gegen das Eindringen sowie durch die Distanz zwischen Eindringungs- und Wachstumspunkt. Das Überleben hängt somit von der Fähigkeit des Weibchens ab, den geeigneten Eiablageort zu finden.

References

Blum, A., 1967: Varietal resistance of sorghum to the sorghum shoot fly (*Atherigona varia* var. *soccata*). Crop Sci. *7*, 461–462.

— 1968: Anatomical phenomena in seedlings of sorghum varieties resistant to the sorghum shoot fly (*Atherigona varia soccata*). Crop. Sci. *8*, 388–391.

Cooper, J. P., 1973: Genetic variation in herbage constituents. In: Butler, G. W.; Bailey, R. W. (eds.), Chemistry and biochemistry of herbage. London and New York: Academic Press.

Culvenor, C. C., 1973: Alkaloids. In: Butler, G. W.; Bailey, R. W. (eds.), Chemistry and biochemistry of herbage. London and New York: Academic Press.

Finch, S.; Skinner, G., 1974: Some factors affecting efficiency of water traps for capturing cabbage root flies. Ann. appl. Biol. *77*, 213–226.

Hardman, J. A.; Ellis, P. R., 1978: Host plant factors influencing the susceptibility of cruciferous crops to cabbage root fly attack. Ent. exp. appl. *24*, 193–197.

Jotwani, M. G.; Marwaha, K. K.; Srivastava, K. M.; Young, W. R., 1970: Seasonal incidence of shoot fly (*Atherigona soccata* Rond.) in jowar hybrids at Dehli. Ind. J. Entomol. *32*, 7–15.

Meksongsee, B.; Chawanapong, M.; Sangkasuwan, V.; Poonyathaworn, P., 1981: The biology and control of sorghum shoot fly *Atherigona soccata* Rondani in Thailand. Ins. Sci. Application 2 (in press).

Ogwaro, K., 1978: Ovipositional behaviour and host-plant preference of the sorghum shoot fly, *Atherigona soccata* (Diptera: Anthomyiidae). Ent. exp. appl. *23*, 189–199.

Ponnaiya, B. W. X., 1951a: Studies in the genus *Sorghum*: I. Field observations on sorghum resistance to the insect pest *Atherigona indica* M. Madras Univ. J. *21*, 96–117.

— 1951b: Studies in the genus *Sorghum*: II. The cause of resistance in sorghum to the insect pest *Atherigona indica* M. Madras Univ. J. *21*, 203–217.

Prokopy, R. J.; Owens, E. D., 1978: Visual generalist with visual specialist phytophagous insects: host selection behaviour and application to management. Ent. exp. appl. *24*, 409–420.

Raina, A. K., 1981: Movement, feeding behaviour and growth of larvae of the sorghum shoot fly, *Atherigona soccata*. Ins. Sci. Application 2 (in press).

Reti, L., 1969: β-Phenethylamines. In: Manske, R. B. R.; Holmes, H. L. (eds.), The alkaloids – Chemistry and physiology. New York: Academic Press.

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

Young, W. R., 1981: Sixty five years of research on the sorghum shoot fly. Ins. Sci. Application 2, in press.

Author's address: Alex Delobel, Research Scientist, O.R.S.T.O.M. (Office de la Recherche Scientifique et Technique Outre-Mer), 70–74 route d'Aulnay, F-93140 Bondy