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## SHOOTFLY SPECIES AND THEIR GRAMINACEOUS HOSTS IN ANDHRA PRADESH, INDIA\*

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(Received 14 January 1981)

**Abstract**—This paper describes the results of extensive rearing of shootfly species of the genera *Atherigona* and *Acritochaeta* from cultivated and wild Gramineae in Andhra Pradesh, India. Nineteen fly species were recorded from 41 graminaceous species including cultivated sorghum. *Atherigona soccata*, an important pest of sorghums in the Old World tropics, was reared from 22 host plants. Only cultivated and wild species of sorghum were important as hosts of this pest species. It was observed that alternative host Gramineae were of minor importance in the 'carryover' of *Atherigona soccata* through the off season, but the irrigated sorghum grown for fodder could be an important source of flies.

In general, shootflies of a particular species usually favored one graminaceous host above others. The numerically dominant fly reared from wild Gramineae was *Atherigona falcata*, which was recorded on 17 hosts, including sorghum. Other common species in Gramineae were *Atherigona pulla*, *Atherigona oryzae*, *Atherigona punctata* and *Atherigona atripalpis*, all of which were also reared in very low numbers from sorghum. Five new species of *Atherigona* were reared; three of these will be described shortly.

**Key Words:** Shootfly species, *Atherigona*, graminaceous hosts, sorghum

### INTRODUCTION

SHOOTFLIES of the genus *Atherigona* are known to cause 'dead hearts' in a number of tropical grass species (DEEMING, 1971; PONT, 1972). Two species, *Atherigona soccata* Rond. and *Atherigona approximata* Mall., are pests of two of the world's major cereals, sorghum (*Sorghum bicolor* [L.] Moench) and pearl millet (*Pennisetum americanum* [L.] Leeke), respectively. *Atherigona soccata* is a widespread and damaging pest in practically all the sorghum-growing areas in the semi-arid tropics (SWAINE and WYATT, 1954; LANGHAM, 1968; JOTWANI *et al.*, 1970; DEEMING, 1971). The species is, however, absent from the Americas and Australia. Damage is caused to sorghum in the first 6 weeks of growth. This leads to: low plant populations, as seedlings are often killed; profuse tillering, particularly of improved cultivars; and failure to form harvestable heads. Currently *Atherigona approximata* appears to be increasing in importance on pearl millet in some parts of India (JOTWANI and BUTANI, 1978; JOTWANI *et al.*, 1969).

As part of a detailed investigation of the biology of the major cereal shootfly species, the local grasses that were likely to serve as alternative hosts were examined. Collections were made particularly in the dry summer season (April-June), when high temperatures, little or no rainfall, and drying out of vegetation including grasses, except in favored sites, are characteristic of central India, and between sorghum crop seasons. Out-of-season sorghum and pearl millet, grown by farmers as fodder, were also examined.

### MATERIALS AND METHODS

Flies were reared from sorghum, pearl millet and other Gramineae that showed 'dead heart' symptoms, by placing the shoots, collected from the field, in small screened cages. The plant material was obtained by regular collections at the ICRISAT Center, Hyderabad, and in farmers' fields both around the Center and some distance away. Both cropped and uncropped areas were sampled. Crops grown in the environs of the Center include irrigated vegetables and grapes, as well as the typical dry and wet land crops of the area, rice, sorghum, pearl millet, maize, pigeon pea, chilli and safflower.

Flies that emerged were identified. In the instance of the sorghum and millet collections both males and females were identified (CLEARWATER and OTHIENO, 1977). Only males were identified from other Gramineae, as the taxonomy of the females is not established with certainty (PONT, 1972).

### RESULTS

#### *Shootflies reared from sorghum*

The results obtained from sorghum fully confirmed the observations reported by SESHU REDDY and DAVIES (1977). Over 99% were *Atherigona soccata*, but 11 other species of *Atherigona* and one species of *Acritochaeta* were also reared (Table 1). Female flies outnumbered males, confirming previous observations that the sex ratio is around 1.28:1. Two species, occurring in very low numbers, remain unidentified. Of the 12 other species reared, only *Acritochaeta orientalis* was present in sorghum in any appreciable numbers.

\*Submitted as C.P. No. 7 by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

Table 1. Species of shootflies reared from sorghum in Andhra Pradesh

1. <i>Atherigona soccata</i> Rond.
2. <i>Atherigona falcata</i> Thom.
3. <i>Atherigona eriochloae</i> Mall.
4. <i>Atherigona punctata</i> Karl
5. <i>Atherigona approximata</i> Mall
6. <i>Atherigona simplex</i> Thom.
7. <i>Atherigona pulla</i> Wied.
8. <i>Atherigona reversura</i> Villen.
9. <i>Atherigona atripalpis</i> Mall
10. <i>Atherigona oryzae</i> Mall.
11. <i>Atherigona</i> sp. X
12. <i>Atherigona</i> sp. XIV
13. <i>Acrutochaeta orientalis</i> Schin.

Collections made on irrigated sorghum on farmers' fields in the summer season indicated that these were a significant source of 'carryover' of *Atherigona soccata*. Surveys showed that in some fields up to 30% of the tillers were attacked and 99.8% of the flies reared were of this species.

#### Shootflies reared from other gramineae

Shootflies were reared from 40 Gramineae in the period October 1975–September 1979. In all, 14,301 (8178 females and 6123 males) were obtained. The total number of shootfly species recorded was 19. Identifications were made on the male flies reared. Details are given in Table 2.

*Atherigona soccata* was reared from 21 species of gramineae, but was rare from species other than the wild sorghums; *Sorghum halepense* was by far the most important alternative host with *Sorghum verticilliflorum*, *Sorghum ulmum* or *Sorghum virgatum* and to a lesser extent *Sorghum sudanense*, being significant hosts. Of 313 flies of this species reared from alternative hosts, well over 70% were obtained from these five host plants. The only other Gramineae members that appeared to be potential sources of carryover in the summer season were *Echinochloa colona* and *Echinochloa crusgalli*, both very common weed grasses in Andhra Pradesh. The numbers reared, however, were very low in the months of April–June. No *Atherigona soccata* were reared from *Cynodon dactylon* in these months, but this grass, which grows commonly in sorghum fields after the cultivation initiated by the arrival of the monsoon, did generally harbor a few in July. *Brachiaria distachya* was fairly regularly recorded as a host. Very small numbers of *Atherigona soccata* were reared from *Pennisetum americanum* in June, but an early-sown millet crop did not lead to an early build up of the species. A rapid increase in population appears to occur only when the main sorghum crop is sown. The insect was reared very rarely from *Zea mays*, *Triticum aestivum* and minor millets. There is thus evidence that cereals, other than sorghum, are unimportant as hosts of this fly. This has implications with regard to mixed cropping of the cereals which is being increasingly encouraged in the semi-arid tropics as a risk-averting measure.

*Atherigona approximata* was reared far less commonly than *Atherigona soccata* and was relatively insignificant as a source of crop loss at the ICRISAT. It was found in large numbers only when a millet crop

was growing. Surveys showed that up to 12.7% of the millet plants grown for fodder, irrigated from wells, had 'dead hearts'—almost all of them caused by this species. *Echinochloa colona* was the only other alternative host of this species, and only one male fly reared.

*Atherigona falcata* Thom. was the most common shootfly reared from host grasses and was recovered from a total of 16 species. Of the total flies reared in this study, 60% were of this species. It was clear that *Echinochloa* spp., particularly *Echinochloa colona*, were the preferred hosts. Over 83% of the flies of this species were reared from *Echinochloa colona*, and a further 13% were obtained from *Echinochloa crusgalli*. The species was reared in very low numbers from sorghum and extremely rarely from *Z. mays*. This fly is trapped in large numbers in fish-meal bait traps which are exposed at the ICRISAT Center to assess daily populations of *Atherigona* spp. Rearing records of other *Atherigona* shootfly species showed that, in most instances, one grass was the dominant host. These are listed in Table 3. These data indicate that *Eriochloa procerca* is the most important host for several of the shootflies, particularly for *Atherigona pulla* and *Atherigona eriochloae*. It is also a significant host for several other species including *Atherigona oryzae*, *Atherigona punctata*, *Atherigona reversura*, *Atherigona simplex* and *Atherigona* sp. XIII (see Table 2). A significant feature of these data, collected over several seasons, is that usually one grass genus, or even a species within a genus, dominates as the host of a particular shootfly species. An exception appears to be in the instance of *Atherigona oryzae*, a minor pest of rice, which was reared in considerable numbers from both *Digitaria adscendens* and from *Eragrostis japonica*. In the instance of *Atherigona* sp. XIII, which has been recently named (PONT, 1980, personal communication), the number of flies reared was small and more extensive collections are required to ascertain the dominant host.

## DISCUSSION

Rearing records of shootfly species from gramineae hosts are not extensive in the literature and little systematic rearing from natural situations appears to have been done. Records of the important pest species, *Atherigona soccata*, are available (NYE, 1960; DREMSING, 1971; PONT, 1972). Detailed records of this and other species occurring on sorghum and some alternative hosts are given in the works of SESHU REDDY and DAVIES (1977) and DAVIES *et al.* (1980). These reports record *Atherigona soccata* from 21 host grass species and most of the records are new. Clearly, the cultivated sorghum, *Sorghum bicolor*, is by far the most important source of the sorghum shootfly, all other host Gramineae forming an insignificant source of population increase. Wild sorghums do carry low numbers of the sorghum shootfly throughout the year and thus assist in maintenance of the species in the absence of cultivated sorghum. Attempts to breed the species from wild grasses in screen house conditions have been only partially successful. GRANADOS (1972) used three Gramineae, *Digitaria adscendens*, *Brachiaria reptans* and *Eleusine indica*, in experiments and obtained eggs on all spe-

Table 2. Species of shootflies reared and their host plant records (other than *Sorghum bicolor*) from Andhra Pradesh, India—October 1975–September 1979

Species of shootfly	Host plants	No. of flies reared
<i>Atherigona succata</i> Rond.	<i>Brachiaria distachya</i> (15), <i>Brachiaria reptans</i> (2), <i>Cymbopogon caesius</i> (1), <i>Echinochloa colona</i> (21), <i>Echinochloa crusgalli</i> (6), <i>Eragrostis japonica</i> (7), <i>Eriochloa procerca</i> (3), <i>Panicum repens</i> (2), <i>Paspalum scrobiculatum</i> (2), <i>Pennisetum americanum</i> (8), <i>Setaria glauca</i> (1), <i>Setaria intermedia</i> (1), <i>Sorghum almum</i> (34), <i>Sorghum halepense</i> (122), <i>Sorghum sudanense</i> (7), <i>Sorghum verticilliflorum</i> (40), <i>Sorghum virgatum</i> (30), <i>Triticum aestivum</i> (3) and <i>Z. mays</i> (2)	313
<i>Atherigona falcata</i> Thom.	<i>Brachiaria ramosa</i> (9), <i>Brachiaria reptans</i> (8), <i>Chloris barbata</i> , (1), <i>Cynodon dactylon</i> (1), <i>Dichanthium annulatum</i> (1), <i>Digitaria adscendens</i> (20), <i>Echinochloa colona</i> (3070), <i>Echinochloa crusgalli</i> (482), <i>Eragrostis japonica</i> (34), <i>Eriochloa procerca</i> (22), <i>Ischaemum pilosum</i> (1), <i>Panicum psilopodium</i> (1), <i>Panicum repens</i> (6), <i>Setaria glauca</i> (8), <i>Themeda quadrivalvis</i> (10) and <i>Z. mays</i> (1)	3675
<i>Atherigona pulla</i> Wied.	<i>Brachiaria distachya</i> (2), <i>Brachiaria ramosa</i> (2), <i>Brachiaria reptans</i> (3), <i>Digitaria adscendens</i> (1), <i>Echinochloa colona</i> (5), <i>Echinochloa crusgalli</i> (4), <i>Eriochloa procerca</i> (260), <i>Panicum miliaceum</i> (2), <i>Panicum miliare</i> (55), <i>Panicum psilopodium</i> (83), <i>Panicum repens</i> (11), <i>Paspalum scrobiculatum</i> (1) and <i>Setaria glauca</i> (1)	430
<i>Atherigona oryzae</i> Mall.	<i>Brachiaria distachya</i> (1), <i>Brachiaria ramosa</i> (2), <i>Brachiaria reptans</i> (2), <i>Cymbopogon caesius</i> (1), <i>Cynodon dactylon</i> (5), <i>Digitaria adscendens</i> (147), <i>Digitaria longiflora</i> (3), <i>Echinochloa colona</i> (15), <i>Eragrostis japonica</i> (153), <i>Eriochloa procerca</i> (6), <i>Panicum psilopodium</i> (1), <i>Setaria glauca</i> (1), <i>Setaria intermedia</i> (1), <i>Sorghum halepense</i> (3) and <i>Themeda quadrivalvis</i> (1)	352
<i>Atherigona punctata</i> Karl	<i>Brachiaria distachya</i> (12), <i>Brachiaria eruciformis</i> (46), <i>Brachiaria ramosa</i> (22), <i>Brachiaria reptans</i> (163), <i>Dichanthium annulatum</i> (1), <i>Digitaria adscendens</i> (1), <i>Echinochloa colona</i> (11), <i>Eragrostis ciliatensis</i> (1), <i>Eriochloa procerca</i> (19), <i>Paspalum fluitans</i> (1), <i>Pennisetum americanum</i> (1), <i>Setaria glauca</i> (29) and <i>Setaria italica</i> (5)	312
<i>Atherigona atripalpis</i> Mall.	<i>Dactyloctenium aegyptium</i> (2), <i>Echinochloa colona</i> (12), <i>Panicum psilopodium</i> (3), <i>Eragrostis japonica</i> (1), <i>Setaria glauca</i> (267), <i>Setaria intermedia</i> (19) and <i>Setaria italica</i> (1)	305
<i>Atherigona eriochloae</i> Mall.	<i>Brachiaria reptans</i> (1), <i>Cynodon dactylon</i> (6), <i>Echinochloa colona</i> (4), <i>Echinochloa crusgalli</i> (1), <i>Eriochloa procerca</i> (229), <i>Panicum psilopodium</i> (4), <i>Panicum repens</i> (3) and <i>Themeda quadrivalvis</i> (1)	249
<i>Atherigona reversura</i> Villen.	<i>Cynodon dactylon</i> (119), <i>Echinochloa colona</i> (6), <i>Eriochloa procerca</i> (3) and <i>Setaria nervosum</i> (1)	129
<i>Atherigona approximata</i> Mall.	<i>Echinochloa colona</i> (1) and <i>Pennisetum americanum</i> (127)	128
<i>Atherigona hidens</i> Hennig	<i>Bothriochloa pertusa</i> (20), <i>Panicum psilopodium</i> (1), <i>Sorghum almum</i> (1) and <i>Z. mays</i> (1)	23
<i>Atherigona simplex</i> Thom.	<i>Echinochloa colona</i> (1), <i>Eriochloa procerca</i> (14) and <i>Paspalum scrobiculatum</i> (2)	17
<i>Atherigona hella</i> Frey	<i>Brachiaria ramosa</i> (2) and <i>Digitaria longiflora</i> (13)	15
<i>Atherigona miliaceae</i> Mall.	<i>Eleusine coracana</i> (1)	1
<i>Atherigona</i> sp. XIV*	<i>Brachiaria distachya</i> (24) and <i>Thelepogon elegans</i> (109)	133
<i>Atherigona</i> sp. VI*	<i>Cynodon dactylon</i> (23)	23
<i>Atherigona</i> sp. XIII*	<i>Brachiaria distachya</i> (4), <i>Eriochloa procerca</i> (7), <i>Panicum psilopodium</i> (6) and <i>Panicum repens</i> (2)	19
<i>Atherigona</i> sp. VII*	<i>Brachiaria distachya</i> (1)	1
<i>Atherigona</i> sp. VIII*	<i>Brachiaria reptans</i> (1)	1
<i>Aeritochueta orientalis</i> Schin.	<i>Echinochloa colona</i> (5), <i>Eragrostis japonica</i> (1) and <i>Z. mays</i> (1)	7

\*Undescribed species.

Figures in parentheses show totals of male flies reared.

Table 3. Shootflies reared from Gramineae, and their dominant host grass and total number of host grasses (other than *Sorghum bicolor*)

Species of shootfly	Total No. of grass hosts	Dominant host grass
<i>Atherigona oryzae</i> Mall.	15	{ <i>Digitaria adscendens</i> (42)* <i>Eragrostis japonica</i> (43) <i>Eriochloa procer</i> (60)
<i>Atherigona pulla</i> Weid.	13	{ <i>Brachiaria</i> 4 spp. <i>Brachiaria reptans</i> (52)
<i>Atherigona punctata</i> Karl	13	{ <i>Eriochloa procer</i> (92) <i>Setaria glauca</i> (87)
<i>Atherigona eriochloae</i> Mall.	8	<i>Cynodon dactylon</i> (92)
<i>Atherigona atripalpis</i> Mall.	7	<i>Bothriochloa pertusa</i> (87)
<i>Atherigona retersura</i> Villen.	4	<i>Eriochloa procer</i> (82)
<i>Atherigona hidens</i> Hennig	4	<i>Digitaria longiflora</i> (87)
<i>Atherigona simplex</i> Thom.	3	<i>Eleusine coracana</i>
<i>Atherigona bella</i> Frey	2	<i>Cynodon dactylon</i> (100)
<i>Atherigona miluaceae</i> Mall.	1	<i>Brachiaria distachya</i>
<i>Atherigona</i> sp. VI	1	<i>Brachiaria reptans</i>
<i>Atherigona</i> sp. VII	1	<i>Eriochloa procer</i> (37)
<i>Atherigona</i> sp. VIII	1	<i>Panicum psilopodium</i> (31)
<i>Atherigona</i> sp. XIII	4	{ <i>Theleposyon elegans</i> (82) <i>Echinochloa colona</i>
<i>Atherigona</i> sp. XIV	2	
<i>Acritochaeta orientalis</i> Schin.	3	

\*Figures in parentheses are the percentages of the total flies that were reared from the dominant grass. In cases where these percentages are not shown, the number of flies that were reared was too small (less than 10) for calculation of percentages.

cies. However, flies were only reared in very small numbers from the first two, in spite of the fact that eggs were laid on all plants of *Eleusine indica* exposed in these artificial conditions. He observed that flies reared from *Digitaria adscendens* in the field were not *Atherigona soccata*, but the species was not determined. In the current work it was clear that the dominant fly from *Digitaria longiflora* was *Atherigona bella*, and from *Digitaria adscendens* it was *Atherigona oryzae*, although several other species including *Atherigona falcata*, *Atherigona pulla* and *Atherigona punctata* were reared occasionally from these hosts. OGWARO (1978a, b) carried out similar experiments with *Digitaria scallurum*, *Rottboellia exaltata*, *Setaria verticillata* and *Panicum maximum*; rearing *Atherigona soccata* from *Setaria verticillata* and *Digitaria scallurum*; and very few from the other two hosts. In his experiments he observed no oviposition on *Panicum maximum* in screen house conditions, and very little on the other three grasses, thus supporting our observations that shootflies, including *Atherigona soccata*, tend to be fairly specific in their host preferences.

Considering the large amount of collecting done, *Acritochaeta orientalis* was poorly represented in the rearing records from gramineae. This species has been variously described as a saprophytic or predacious species (DEEMING, 1971; PONT, 1972) or as a serious pest (Syn. *Acritochaeta excisa* of sorghum (MEKSONGSEE *et al.*, 1968). In the present study it was recovered only from four hosts *Sorghum bicolor*, *Echinochloa colona*, *Z. mays* and *Eragrostis japonica*, and in very low numbers. This may, however, add some weight to the supposition that it is a secondary feeder, occurring only when larvae of other fly species, or rotting material, are available as food in damaged stems. Significantly, it was never bred from samples obtained in the very dry parts of the year and the apparent under-

representation in these studies may be due to the fact that samples brought to the laboratory were generally those in which 'dead hearts' were relatively young. The commonest shootfly species present in the dry parts of the year were *Atherigona falcata*, *Atherigona pulla* and *Atherigona eriochloae*.

It is concluded from this survey that not much breeding of the sorghum shootfly occurs in Gramineae other than sorghum and its wild host relatives. A significant source of 'carryover' in the environs of the ICRISAT Center is sorghum grown under irrigation for fodder. No large upsurge in *Atherigona soccata* occurred in wild gramineae at the onset of the monsoon in any of the 3-4 years of the survey. Work described elsewhere, in which populations of *Atherigona* spp. were monitored using fish meal-baited traps, confirmed that shootfly populations were low in the summer season, but in 3-years' observations a small rise in shootfly catches, mainly of *Atherigona soccata*, appeared just after the onset of the rains. The main increase in sorghum shootfly populations occurred in July and August, and was associated with the availability of large areas of young sorghum that were in a suitable state for attack.

For several of the fly species reared the host plants were not previously recorded, e.g. *Atherigona punctata* was bred from 13 host gramineae. The species of *Atherigona*, *Atherigona* sp. VI from *Cynodon dactylon*, *Atherigona* sp. VII from *Brachiaria distachya*, and *Atherigona* sp. XIII from four grass hosts, have been described (PONT, 1980, personal communication).

*Acknowledgements*—The authors are indebted to Dr L. J. G. VAN DER MAESEN, Germplasm Botanist, ICRISAT Center, for the identification of the graminaceous host plants and Mr A. C. PONT, British Museum (Natural History), London, for the confirmation of the species of shoot-

flies. Special thanks are due to Mr Y. V. REDDY for the assistance rendered in the identification of shootflies and to Mr K. HARFENDRANATH and other staff for the collection of sorghum and other graminaceous host samples during the course of the studies.

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