SHOOT FLY SPECIES AND THEIR GRAMINACEOUS HOSTS IN ANDHRA PRADESH, INDIA

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ABSTRACT

The paper describes the results of extensive rearing of shoot fly species of the genera Atherigona and Acritochaeta from cultivated and wild gramineae in Andhra Pradesh, India. Twenty-two 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 "carryover" of A. soccata through the off season, but the irrigated sorghum grown for fodder could be an important source of flies.

In general, shoot flies 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

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Atherigona pulla, Atherigona oryzae, Atherigona punctata, and Atherigona atripalpis, all of which except for A. oryzae, were also reared in very low numbers from sorghum. Four species of Atherigona and one species of Acritochaeta in our collections are as yet unidentified. Another three species of Atherigona have been found to be new by the British Museum, London, and their discriptions will be published elsewhere.

KEY WORDS: Shoot fly species, Atherigona, Graminaceous hosts, sorghum.

INTRODUCTION

Shoot flies 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. A. soccata is a widespread and damaging pest in practially all the sorghum growing areas in the semi-arid tropics (Swain 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, to profuse tillering, particularly of improved cultivars, and failure to form harvestable heads. Currently A. 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 shoot fly 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 ICRISAT Center, Hyderabad, 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, pigeonpea,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

SHOOT FLIES 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. Three species, all occurring in very low numbers, remain unidentified. Of the 12 other species reared, only *Acritochaeta orientalis* was present in sorghum in any appreciable numbers.

Table 1. Species of shoot flies reared from sorghum in Andhra Pradesh

1. *Atherigona soccata* Rond.
2. *Atherigona falcata* Thom.
3. *Atherigona eriochloae* Mall.
4. *Atherigona punctata* Karl
5. *Atherigona approximata* Mall.
6. *Atherigona simplex* Thom.
7. *Atherigona pulla* Wied.
8. *Atherigona reversura* Villen.
9. *Atherigona atripalpis* Mall.
10. *Atherigona* sp. XIV
11. *Atherigona* sp. X
12. *Atherigona* sp. III
13. Acritochaeta orientalis Schin

Collections made on irrigated sorghum on farmers' fields in the summer season indicated that these were a significant source of

"carryover" of A. 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.

SHOOT FLIES REARED FROM OTHER GRAMINEAE

Shoot flies were reared from 40 gramineae in the period October 1975 to September 1979. In all, 14 305 flies (8178 females and 6127 males) were obtained. The total number of shoot fly species recorded was 22. Identifications were made on the male flies reared. Details are given in Appendix 1.

A. 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 S. verticilliflorum, S. almum or S. virgatum and to a much lesser extent S. 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 Echinocloa colonum and E. crusgalli, both very common weed grasses in Andhra Pradesh. The numbers reared, however, were very low in the months of April, May, and June. No A. 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 A. 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.

A. approximata was reared far less commonly than A. soccata and was relatively insignificant as a source of crop loss at 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. Echinocloa colonum was the only other alternative host of this species, and only one male fly reared.

Atherigona falcata Thom. was the most common shoot fly 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 Echinocloa spp., particularly E. colonum, were the preferred hosts. Over 83% of the flies of this species were reared from E. colonum, and a further 13% were obtained from E. crusgalli. The species was reared in very low numbers from sorghum and extremely

rarely from Zea mays. This fly is trapped in large numbers in fish meal bait traps which are exposed at ICRISAT Center to assess daily populations of Atherigona spp. Rearing records of other Atherigona shoot fly species showed that, in most instances, one grass was the dominant host These are listed in Table 2. These data indicate that Eriochloa procera is the most important host fo several of the shoot flies, particularly for A. pulla and A eriochloae. It is also a significant host for several other species including A. oryzae, A. punctata, A. reversura, A simplex, A sigma, and the undescribed species of Acritochaeta (see Append x I) 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 shoot fly species. An exception appears to be in the instance of A. oryzae, a minor pest of rice, which was reared in considerable numbers from both Digitaria adscendens and from Eragrostis japonica. In the instance of the recently named species, Atherigona sigma sp. nov (A.C. 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 shoot fly species from graminaceous hosts are not extensive in the literature and little systematic rearing from natural situations appears to have been done. Records of the important

Table 2. Shoot flies reared from gramineae, and their dominant host grass and total number of host grasses (other than *Sorghum bicolor*)

Species of shoot fly	Total No. of grass hosts	Dominant host grass
Atherigona pulla Weld.	13	*Eriochloa procera* (60%)
A. oryzae Mall.	13	(*Digitaria adscendens* (50%) (*Eragrostis japonica* (43%)
A. punctata Karl	13	*Brachiaria* 4 spp. *B. reptans* (52%)
A. atripalpis Mall.	7	*Setaria glauca* (87%)
A. eriochloae Mall.	8	*Eriochloa procera* (92%)
A. reversura Villen.	4	*Cynodon dactylon* (92%)
A. bidens Hennig	4	*Bothriochloa pertusa* (87%)
A. simplex Thom.	3	*Eriochloa procera* (82%)
A. bella Frey	2	*Digitaria longiflora* (87%)
A. millaceae Mall.	1	*Eleusine coracana*
A. zeta sp. nov.	1	*Cynodon dactylon* (100%)
A. sigma sp. nov.	4	(*Eriochloa procera* (37%) (*Panicum psilopodium* (31%)
A. reddyi sp. nov.	1	*Brachiaria distachya*
A. sp. I	1	*Cymbopogon caesius*
A. sp. III	3	*Eragrostis japonica* (78%)
A. sp. VIII	1	*Brachiaria reptans*
A. sp. XIV	2	*Thelepogon elegans* (82%)
Acritochaeta orientalis Schin.	3	*Echinocloa colonum*
Acritochaeta sp. XXII	4	*Eriochloa procera*

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.

pest species, A. soccata, are available (Nye 1960; Deeming 1971; Pont 1972). Datailed 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 A. 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 sorghum shoot fly, all other host gramineae forming an insignificant source of population increase. Wild sorghums do carry low numbers of sorghum shoot fly 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 species. 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 E. indica exposed in these artificial conditions. He observed that flies reared from D. adscendens in the field were not A. soccata, but the species was not determined. In the current work it was clear that the dominant fly from Digitaria longiflora was A. bella and from D. adscendens was A. oryzae, although several other species including A. falcata, A. pulla, and A. punctata were reared occasionally from these hosts. Ogwaro (1978 a, b) carried out similar experiments with Digitaria scallarum, Rottboellia exaltata,

Setaria verticillata, and Panicum maximum; rearing A. soccata from S. verticillata and D. scallarum; and very few from the other two hosts. In his experiments he observed no oviposition on P. maximum in screen house conditions, and very little on the other three grasses, thus supporting our observations that shoot flies, including A. 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. A. excisa) of sorghum (Meksongsee et al. 1968). In the present study it was recovered only from four hosts and in very low numbers, Sorghum bicolor, Echinocloa colonum, Zea mays and Eragrostis japonica. 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 year and the apparent underrepresentation 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 shoot fly species present in the dry parts of the year were A. falcata, A. pulla, and A. eriochloae.

It is concluded from this survey that not much breeding of sorghum shoot fly occurs in gramineae other than sorghum and its wild host relatives. A significant source of "carryover" in the environs of

ICRISAT Center is sorghum grown under irrigation for fodder. No large upsurge in A. soccata occurred in wild gramineae at the onset of the monsoon in any of the 3 to 4 years of the survey. Work described elsewhere, in which populations of Atherigona spp. were monitored using fish meal baited traps, confirmed that shoot fly populations were low in the summer season, but in 3 years' observations a small rise in shoot fly catches, mainly of A. soccata, appeared just after the onset of the rains. The main increase in sorghum shoot fly 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., A. punctata was bred from 13 host gramineae. Three new species of Atherigona, A. zeta sp. nov. from Cynodon dactylon, A. reddyi sp. nov. from Brachiaria distachya, and A. sigma sp. nov. from four grass hosts have been described (A.C. Pont 1980, personal communication).

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APPENDIX 1. Species of shoot flies reared and their host plant records (other than Sorghum bicolor) from Andhra Pradesh, India - October 1975 to September 1979

Total number of Graminaceous hosts : 40

Total flies reared : 14,305

Females : 8,178

Males . 6,127

Total number of species of shoot fly . 22

1. Atherigona soccata Rond (313 flies)

Host plants: Brachiaria distachya (15), B reptans (2), Cymbopogon caesius (1), Cynodon dactylon (3), Dichanthium annulatum (3), Echinocloa colonum (21), E crusgalli (6), Eragrostis japonica (7), Eriochloa procera (3), Panicum repens (2), Paspalum scrobiculatum (2), Pennisetum americanum (8), Setaria glauca (1), S intermedia (1), Sorghum almum (34), S. halepense (122), S. sudanense (7), S. verticilliflorum (40), S. virgatum (30), Triticum aestivum (3), and Zea mays (2)

2. Atherigona falcata Thom. (3675 flies)

Host plants: Brachiaria ramosa (9), B. reptans (8), Chloris barbata (1), Cynodon dactylon (1), Dichanthium annulatum (1), Digitaria adscendens (20), Echinocloa colonum (3070), E. crusgalli (482), Eragrostis japonica (34), Eriochloa

procera (22), Ischaemum pilosum (1), Panicum psilopodium (1), P. repens (6), Setaria glauca (8), Thimeda quadrivalvis (10), and Zea mays (1).

3. Atherigona pulla Wied. (430 flies)

Host plants: Brachiaria distachya (2), B. ramosa (2), B. reptans (3), Digitaria adscendens (1), Echinocloa colonum (5), E. crusgalli (4), Eriochloa procera (260), Panicum miliaceum (2), P. miliare (55), P. psilopodium (83), P. repens (11), Paspalum scrobiculatum (1), and Setaria glauca (1).

4. Atherigona oryzae Mall. (327 flies)

Host plants: Brachiaria distachya (1), B. ramosa (2), B. reptans (2), Cynodon dactylon (3), Digitaria adscendens (147), D. longiflora (3), Echinocloa colonum (15), Eragrostis japonica (142), Eriochloa procera (6), Panicum psilopodium (1), Setaria glauca (1), S. intermedia (1), and Sorghum halepense (3).

5. Atherigona punctata Karl (312 flies)

Host plants: Brachiaria distachya (12), B. cruciformis (46), B. ramosa (22), B. reptans (163), Dichanthium annulatum (1), Digitaria adscendens (1), Echinocloa colonum (11), Eragrostis cilianensis (1), Eriochloa procera (19),

Paspalidum flavidum (1), Pennisetum americanum (1), Setaria glauca (29), and S. italica (5).

6. Atherigona atripalpis Mall. (305 flies)

Host plants: Dactyloctenium aegyptium (2), Echinocloa colonum (12), Panicum psilopodium (3), Eragrostis japonica (1), Setaria glauca (267), S. intermedia (19), and S. italica (1).

7. Atherigona eriochloae Mall. (249 flies)

Host plants: Brachiaria reptans (1), Cynodon dactylon (6), Echinocloa colonum (4), E. crusgalli (1), Eriochloa procera (229), Panicum psilopodium (4), P. repens (3), and Thimeda quadrivalvis (1).

8. Atherigona reversura Villen. (129 flies)

Host plants: Cynodon dactylon (119), Echinocloa colonum (6), Eriochloa procera (3), and Sehima nervosum (1).

9. Atherigona approximata Mall. (128 flies)

Host plants: Echinochloa colonum (1), and Pennisetum americanum (127).

10. Atherigona bidens Hennig (23 flies)

Host plants: Bothriochloa pertusa (20), Panicum psilopodium (1), Sorghum almum (1), and Zea mays (1).

11. Atherigona simplex Thom. (17 flies)

Host plants: Echinocloa colonum (1), Eriochloa procera (14), and Paspalum scrobiculatum (2).

12. Atherigona bella Frey (15 flies)

Host plants: Brachiaria ramosa (2), and Digitaria longiflora (13)

13. Atherigona millaceae Mall. (1 fly)

Host plant: Eleusine coracana (1).

14. Atherigona zeta sp. nov. (23 flies)

Host plant: Cynodon dactylon (23).

15. Atherigona sigma sp. nov. (19 flies)

Host plants: Brachiaria distachya (4), Eriochloa procera (7), Panicum psilopodium (6), and P. repens (2).

16. Atherigona reddyi sp. nov. (1 fly)

Host plant: Brachiaria distachya (1).

17** Atherigona sp. I (1 fly)

Host plant: Cymbopogon caesius (1).

18** Atherigona sp. III (14 flies)

Host plants: Cynodon dactylon (2), Eragrostis japonica (11), and Thimeda quadrivalvis (1).

19** Atherigona sp. VIII (1 fly)

Host plant: Brachiaria reptans (1).

20** Atherigona sp. XIV (133 flies)

Host plants: Brachiaria distachya (24), and Thelepogon elegans (109).

21. Acritochaeta orientalis Schin. (7 flies)

Host plants: Echinocloa colonum (5), Eragrostis japonica (1), and Zea mays (1).

22** Acritochaeta sp. XXII (4 flies)

Host plants: Echinocloa colonum (1), Eriochloa procera (2)*, and Panicum psilopodium (1).

Figures in parentheses show totals of male flies reared

** Undescribed species

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