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# ATTRACTANTS FOR *ATHERIGONA* SPP. INCLUDING THE SORGHUM SHOOTFLY, *ATHERIGONA SOCCATA* ROND. (MUSCIDAE: DIPTERA)*

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**Abstract** The use of fish meal and detergent water has been shown to be simple, economic and reliable for sampling of shootfly populations. Various mixtures of fish meal with other ingredients were evaluated. The most potent mixture was fish meal yeast ammonium sulphide, but generally fish meal alone was adequate and the most readily available attractant. The attractance of fish meal was found to be related to its degradation; it increased from the first to the third or fourth day, and then decreased. The chemicals responsible for the attractance of fish meal have yet to be identified, but in all probability they may be the amines resulting from biodegradation of the meal.

*Key Words*: Sorghum shootfly, attractants, fish meal

## INTRODUCTION

SEVERAL species of the genus *Atherigona* are known to attack sorghum (DAVIES *et al.*, 1980); however, only *Atherigona soccata* Rond. is economically important as a pest. This species is present in most of the Old World tropics except Australia. The insect attacks seedling sorghum in the first 4–5 weeks of growth, causing typical 'dead-heart' symptoms, and in years of high incidence can cause loss of plant population and yield, since tillers produced when the main shoot is killed are also destroyed and few panicles are produced. A closely related species, *A. approximata*, is a potentially serious pest of pearl millet in India (JOTWANI and BUTANI, 1978).

The dynamics of sorghum shootfly populations have been studied, usually by growing regular plantings of sorghum throughout the year, often in small contiguous plots (KUNDU *et al.*, 1971). This results in cross-infestation and often gives an erroneous impression of insect numbers and periods of peak incidence. There was a need for a simple trapping method to overcome these problems. STARKS (1970) used fish meal to attract shootflies into sorghum plots for increasing the efficiency of selection of sorghum resistant to the pest, and BARRY (1972) noted that ammonium sulphide was also attractive to the fly.

## MATERIALS AND METHODS

During 1975–1976, several products, materials and chemicals were tested as shootfly attractants and attempts were also made to determine synergistic effects of different materials. Initial trials attempted to determine the efficacy of fish meal alone. In these, fish meal was moistened and placed in a mesh cylinder (7.5 cm dia by 12.5 cm high) in square galvanized metal pans (60 × 60 × 7.5 cm) fitted with lids which gave a gap of at least 7.5 cm between the lid and the top of the pan. The pans contained 20 l. of water plus a small amount (100 g) of detergent. The water was allowed to touch the cylinder to keep the fish meal moist. In later experiments other products such as ammonium sulphide, brewers' yeast, and 'dead hearts' were placed in the water. In the trials using ammonium sulphide, 20 ml of a 20% solution were used; brewers' yeast was used at the rate of 20 g per trap. It was also found that 'swirling' the cylinder in the water of the trap and then allowing it to stand gave the best catches with fish meal as bait. In most trials, standard randomized block layouts were used, with traps separated by at least 25 m. Traps were visited every morning and flies, which tended to sink to the bottom, were scooped out with a gauze net for examination in the laboratory to determine sex and species.

## RESULTS

In the first experiment, pans containing fish meal only were exposed at various sites at the ICRISAT Center. Results of a typical trial for 7 days' exposure are given in Table 1, together with data at one location from control traps which contained only water and detergent.

Shootflies were attracted to fish meal, but clearly the site of the trap had a considerable influence on the size of the catch. Traps at sites where sorghum was growing, in $BA_{2,5}$ and the watershed, caught far more flies than others, while, even with fish meal, catches in uncultivated grassland areas were low. It was possible to analyze data from $BA_{2,5}$ (pesticide-free black-soil area) on a paired-trap basis and this showed highly significant differences between the fish meal and the control (water + detergent) traps. Catches were heaviest in fish meal traps on the fourth day of exposure, indicating that biological degradation was a probable factor in attractance.

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Table 1. Mean total catch of shootflies, *Atherigona* spp. per trap over 7 days at the ICRISAT Center

| Site | No. of traps | Mean catch |
|---|---|---|
| Unsprayed farm ($BA_{2\times1}$ (fish meal) | 6 | 793 |
| Unsprayed farm ($BA_{2\times1}$ (control) | 6* | 27 |
| Grassland (fish meal) | 12 | 40 |
| Watershed (fish meal) | 4 | 613 |

*Traps contained water and detergent only.

Based on this work, a series of trials was carried out in late 1975 in which various components were added to fish meal. In the first trial, there were eight treatments replicated three times. Flies were collected at 2-day intervals for 14 days (Table 2).

Analysis of the data showed that catches with a combination of ammonium sulphide, yeast and fish meal were significantly better than all other treatments, and that, in general, treatments containing fish meal were attractive. Yeast and ammonium sulphide used alone were only slightly attractive, but when combined there was a marked synergistic effect. The treatment containing ammonium sulphide, yeast and fish meal was adopted as a standard attractant mixture for shootfly population studies at the ICRISAT Center.

Since there had been reports (Pradhan, 1971) that shootfly attack was heavier in fertilized fields, trials were also carried out in which ammonia, ammonium nitrate and urea were added to the standard treatment. All combinations reduced the catch compared with the standard mixture. The best of these treatments, ammonia plus the standard, caught only half as many flies as the standard alone. Treatments containing ammonium nitrate, either alone or in combination, were particularly poor.

As sorghum 'dead hearts' produce a characteristic odor, their attractance to the shootfly was tested. A chi-square analysis of catch over 7 days in March 1976 showed that a given volume of 'dead hearts' was not as attractive to the shootfly as an equivalent volume of moist meal. 'Dead hearts' were, however, attractive and on the day of maximum attractance took 99 flies compared with 207 taken by fish meal traps in the experiment.

Table 2. Mean 2-day catch per trap of *Atherigona* spp. over 14 days at the ICRISAT Center (three replicates)

| Treatment | | Mean catch |
|---|---|---|
| Water | | 2.44 |
| Water + yeast | | 4.00 |
| Water + AS | | 4.00 |
| Water + AS + FM | | 43.52 |
| Water + FM | | 96.76 |
| Water + yeast + FM | | 97.43 |
| Water + AS + yeast | | 178.05 |
| Water + AS + yeast + FM | | 241.76 |
| | S. Em. ± | 31.47 |
| | L.S.D. (0.001) | 184.21 |

AS = ammonium sulphide.
FM = fish meal.

As a follow-up to the work on addition of fertilizer to the meal, an experiment was conducted in which dead hearts and bullock dung, alone and in combination, were added to fish meal over a 14-day period in a three replicate randomized block trial in late March 1976. Dung was used, as flies had been observed to visit and apparently feed on dung pats in the field, and also because it is a commonly used fertilizer. Overall catches in the experiment were low and the 'dead heart' plus fish meal combination was slightly inferior to fish meal alone (Table 3).

Catches were greatest in the first 4 days over all treatments. The attractant traps including fish meal were highly productive on the third and fourth days. Dung appeared to have a depressing effect on the catches and there appears to be no other rational explanation for the very low catches in the fish meal dung 'dead-heart' treatment, which caught very few flies over the first 4 or 5 days. There was an interaction between treatments and days, which was largely explained by the very high attractance of the 'dead-heart' plus fish meal treatments in all replicates over the first 3 days. Later, this treatment became less attractive than the fish meal treatment alone.

*Nature of the attractant in fish meal*

A preliminary effort was made to determine the basic characteristics of the chemicals responsible for the attractance of fish meal. Traps were baited with water, detergent powder, and a concentrate made from boiled and unboiled fish meal. The concentrat was aged and filtered for the different treatment Results showed that traps in which the meal was not treated in any way and in which the minute pieces of fish meal were allowed to remain in the water were the most attractive and that when this solution was aged for 10 days it was less attractive and became even less so over the next 10 days of trapping. Solutions made from boiled meal were not very attractive either immediately or with aging, filtered or unfiltered (Table 4).

It appears likely that the attractance of fish meal is due to biodegradation. A latin-square experiment was therefore carried out in which four treatments replicated four times were compared over 4 days, the period when fish meal had been shown to be most active. The treatments were fish meal alone, fish meal plus a biocide (aureofungin), water plus biocide, and water alone. It was demonstrated conclusively that addition of the biocide reduced the catches drastically. The possibility that biocide itself might repel flies was not tested (Table 5).

Table 3. Mean daily catch per trap of *Atherigona* spp. over 14 days at the ICRISAT Center on eight treatments (three replicates)

| Treatment | | Mean catch |
|---|---|---|
| Dung + dead hearts | | 1.74 |
| Water | | 1.76 |
| Dung | | 2.31 |
| Dead hearts | | 4.57 |
| Dung + dead hearts + fish meal | | 5.60 |
| Dung + fish meal | | 12.55 |
| Dead hearts + fish meal | | 17.26 |
| Fish meal | | 19.93 |
| | S. Em. ± | 1.85 |
| | L.S.D. (0.05) | 9.56 |

The catch was highest on the third day in fish meal traps and the analysis of data showed that all treatments were markedly inferior to fish meal alone. The addition of biocide appeared to affect production of the chemical attractant.

The most likely breakdown product from fish meal protein appeared to be an amine, and since skatole ($C_9H_9N$) was available locally it was tested. It proved to be attractive to the shootfly, but inferior to fish meal in traps in adjacent experiments. In 12 traps, 339 shootflies were caught on the first day of exposure of the skatole. The number fell to 122 on the second day and 60 on the third; by the fifth day, the catch in the skatole traps was no greater than that in the control traps containing detergent and water alone. A chi-square analysis confirmed that skatole gave significantly higher catches of shootflies than detergent water.

*Specificity of the fish meal attractant*

In these trials, over 70,000 shootflies were collected and representative samples of 2580 individuals were examined from the catches of December 1975 and March-April 1976 when most of the work was carried out. It was clear that most of the flies attracted were from the genus *Atherigona*, but that several species were represented. Of the flies taken in December, 77% were female, compared to 68% of those taken in April. Male *A. soccata* made up to 22% of the sample taken in December and almost 24% of that in April. A significant proportion of the males trapped in April were *A. falcata*. The overall mean trap catch was over 4 times higher in December than in April.

## DISCUSSION

The data show that fish meal is a powerful attractant for Muscid shootflies of the genus *Atherigona*. The effectiveness of the fish meal can be greatly enhanced by addition of brewers' yeast and ammonium sulphide, but generally the use of fish meal alone would enable a simple and reliable assessment of shootfly populations. While square galvanized pans were used in these experiments almost any receptacle with a large surface area could be used. It was found in the course of the work that a lid was advantageous, as removal of the lid resulted in lower catches. The attractance of the medium increased to a peak on the third or fourth day and the medium was predominantly attractive to females. There are indications from the report of CHARWATER (1977) that there is also some selectivity within the females. It appears that young females are more attracted than older ones, and the work currently in progress (SESHU REDDY *et al.*, 1980; UNNITHAN, personal communication) indicates that the medium is most attractive to females about to lay eggs and that receptivity possibly varies with the stage of the female ovarian cycle. The males may blunder while in pursuit of females. While other products, notably 'dead hearts' and skatole, were shown to be attractive for short periods they did not compare favorably with fish meal. The chemicals associated with the attractance of fish meal have not yet been identified, but they appear to be breakdown products from biodegradation of protein. This hypothesis received support from the fact that when a small frog died by chance in a water-and-detergent trap an apparently anomalous result of high catches

Table 4. Mean daily catch of *Atherigona* spp. per trap over 14 days (three replicates) on eight treatments

| Treatment | | |
|---|---|---|
| 1 10-day-old meal + unboiled + unfiltered | | 15.36 |
| 1 10-day-old meal + boiled + unfiltered | | 5.95 |
| 1 10-day-old meal + boiled + filtered | | 4.62 |
| 1 10-day-old meal + unboiled + filtered | | 2.71 |
| 11 20-day-old meal + unboiled + unfiltered | | 3.71 |
| 11 20-day-old meal + boiled + unfiltered | | 2.90 |
| 11 20-day-old meal + boiled + filtered | | 2.62 |
| 11 20-day-old meal + unboiled + filtered | | 1.86 |
| | S. Em. ± | 1.27 |
| | L.S.D. (0.05) | 6.58 |

Table 5. The effect of biocide on catch of *Atherigona* spp. in fish meal traps over 4 days (four replicates)

| Treatment | Mean catch per trap |
|---|---|
| Fish meal | 254.75 |
| Fish meal + biocide | 32.50 |
| Water + biocide | 4.00 |
| Water | 1.25 |
| S. Em. ± | 18.22 |
| L.S.D. (0.001) | 179.17 |

in this trap was obtained. The chemicals were not particularly persistent as was indicated by the experiments carried out on stored extract solutions. The use of a biocide resulted in far lower catches however, the possible effects of the biocide itself cannot be completely ignored. Boiling fish meal had a marked effect on the effectiveness of solutions subsequently made up, and this again indicates that the substances are probably associated with biodegradation.

Fish meal has now been used for several years at the ICRISAT Center as a sampling tool and results from routine collections from traps will be compared with those obtained from small plots planted with sorghum at fortnightly intervals.

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