EVALUATION OF SURVEY METHODS FOR ESTIMATING SORGHUM MIDGE (DIPTERA: CECIDOMYIIDAE) DENSITIES IN GRAIN SORGHUM

V. B. Steward, T. J. Kring, and W. C. Yearian
Department of Entomology
University of Arkansas
Fayetteville, AR 72701
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ABSTRACT

Six methods for sampling field populations of ovipositing sorghum midge, *Contarinia sorghicola*, in grain sorghum panicles were compared to an absolute sampling method. The methods evaluated were the visual, tap, remove, shake, beat-bucket, and grab. Population estimates obtained by visual examination were similar to absolute estimates when population density was low but significantly differed at mean midge densities above 9.2/panicle. The remaining sampling method density estimates were significantly less than the absolute method estimates. The visual examination method was relatively time efficient taking ca. one minute per panicle to complete. The effect of panicle compactness (open, medium, and compact) on the precision of the visual examination was investigated. Accuracy of the visual examination method significantly decreased as panicle compactness increased. This may be a result of either obstructed vision or increased density of midges with compactness or a combination of both.

Key Words: Sorghum midge, *Contarinia sorghicola*, panicle compactness, sampling methods, sorghum.

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INTRODUCTION

The sorghum midge, *Contarinia sorghicola* (Coquillett), is a key pest of grain sorghum in the United States (Young and Teetes 1977). Sorghum midge females oviposit in flowering spikelets, where larval feeding prevents kernel development. Sorghum midge economic thresholds have been developed for susceptible (Bottrell 1971; Hallman et al. 1984) and resistant grain sorghum hybrids (Hallman et al. 1984) as one to three and five adult midges per flowering panicle, respectively. Reseach methods for estimating field populations of sorghum midge adults have typically been quantified by using the absolute method (Waquil et al. 1985; Teetes et al. 1986; Waquil et al. 1986), in which a plastic bag is placed over the panicle, and the panicle is excised and returned to the laboratory for inspection; and the visual method (Huddleston et al. 1972) in which the sampler visually examines the panicle in the field. Field scouts commonly use the plastic bag method (Griffin et al. 1984; Johnson et al. 1984; Turney et al. 1987) to estimate adult midge densities. Standardized and calibrated sampling methods are necessary to properly utilize economic thresholds. Little or no research has been conducted that describes the precision and efficiency of these methods for estimating ovipositing sorghum midge densities on grain sorghum panicles. An understanding of the efficiency of sampling methods for sorghum midge is fundamental to sound integrated pest management programs in grain sorghum. This study was undertaken to evaluate

selected survey methods and the influence of panicle compactness in estimating ovipositing sorghum midge populations.

MATERIALS AND METHODS

Tests were conducted in two fields of commercial grain sorghum naturally infested with sorghum midges. Field I was located in Little River Co. in southwestern Arkansas, and Field II was in McCurtain Co. in southeastern Oklahoma. Field I was planted with Northrup King 2660 hybrid sorghum on 20 April 1987, and Field II was planted with Northrup King 9750 hybrid sorghum on 1 May 1987. Varying soil moisture conditions in Field II resulted in spotty and extended plant emergence. As a result, sizeable blocks of blooming grain sorghum were available to evaluate sampling methods over a three - week period.

Survey Methods

The absolute method (Waquil et al. 1985; Teetes et al. 1986; Waquil et al. 1986) was performed by quickly placing a clear 1 mil plastic bag (20.3 × 7.6 × 38.1 cm) over the panicle and holding it firm around the peduncle. The peduncle was cut, and the bag was tied and returned to the laboratory where the panicle and bag contents were thoroughly inspected for midges.

Results of six survey methods for estimating adult sorghum midge densities were compared to the absolute density estimates. These were the visual, plastic bag - tap, plastic bag - shake, plastic bag - remove, beat - bucket, and grab methods. The plastic bag - tap, - shake, and - remove methods will be referred to hereafter as tap, shake, and remove, respectively. Sampled panicles were carefully approached to minimize disrupting ovipositing midges.

The visual method was conducted by visually dividing the panicle into quadrants and counting the number of midges while making one complete pass around the panicle. Adult midges flying around the panicle were not included in the visual count. The tap method was performed by placing a clear plastic bag over the panicles, and gently tapping the panicle through the bag (similar to methods described by Griffin et al. 1984; Johnson et al. 1984; and Turney et al. 1987). The number of sorghum midges on the panicle and on the inside wall of the bag was counted. The shake method was similar to the tap method except that instead of tapping, the panicle was vigorously shaken. The remove method was the same as the shake method except that after shaking the panicle, the bag was slipped off while gently but firmly holding the bottom of the bag against the panicle. The bag was expanded slightly by exhaling into it or holding the open end of the bag towards the prevailing wind. The closed bag was then examined at eye level, and the number of adult midges were counted.

The beat - bucket method (coined by Hall et al. 1983; modified from Sinodis et al. 1979) was performed by shaking the panicle vigorously in a 19 - liter white plastic bucket and counting the number of midges in the bucket. The grab method was performed by quickly grasping the lower portion of the panicle and pulling upward through the top of the panicle. The number of orange markings left on one's hand by crushed orange - colored female midges were counted.

Evaluation I

Midges on panicles in Field I were sampled on 17 and 18 June by each method except for the beat - bucket and tap methods. Midges were sampled in Field II

using all six methods on 6, 8, and 9 July. Twenty - five panicles were sampled each sampling date by each method except on 9 July when only eighteen panicles per method were sampled. Typical sized panicles for the field were sampled while at ca. 2/3 bloom. Panicles were randomly selected ensuring a minimum of 1 m separation between panicles. Samples were taken in an ordered sequence (visual, absolute, tap, shake, remove, beat - bucket, grab) until the desired number of panicles were sampled per method. Samples were taken between 1000 to 1400 hrs during peak ovipositional activity (Fisher et al. 1982, Summers 1975). Time required to perform each sampling method was recorded. Data were analyzed using regression and analysis of variance. Duncan's (1955) new multiple range test was used to separate means.

Evaluation II

Preliminary examination of the data suggested that the visual and absolute methods were comparable in their estimate of adult midge densities. Thus, additional paired comparisons were made in Field II with each panicle being sampled twice, first visually followed by one of the other methods.

Twenty - five panicles were selected (as previously described) for each paired comparison. Panicles were sampled in succession for a particular comparison until all samples had been taken. Visual - absolute, - bucket, - tap, and - grab comparisons were made on 10 July. Visual - remove and - shake comparisons were made 22 and 26 July, respectively. The differences between the visual midge density estimates to estimates by the other sampling methods were compared using a paired t - test, and regression analysis was conducted on the paired comparisons.

Panicle Compactness

Various degrees of panicle compactness were evident. Thus, the effect of panicle compactness on estimating sorghum midge density with the visual method was examined. Panicles were classified into three panicle types: 1) open, 2) medium, 3) and 4) compact depending upon compactness of the panicle (Huddleston et al. 1972). Sixteen panicles of each compactness class were first sampled visually and then by the absolute method on 23, 24, 28, and 30 July between 1000 and 1400 hrs. Panicles in the 2/3 bloom stage were sampled in an ordered sequence based on panicle compactness (open, medium, compact) until the desired number of samples per compactness class had been taken. Data were subjected to regression and analysis of variance, with differences among means separated by Duncan's new multiple range test (Duncan 1955).

RESULTS AND DISCUSSION

Evaluation I

Mean sorghum midge densities, as estimated by the absolute sampling method were ca. 3× higher in Field II than in Field I (Table 1). Visual examination provided estimates of sorghum midge densities that were not statistically different from the absolute sampling method densities in both Fields I and II. The mean number of midges per panicle was estimated to be 2.0 by visual examination and was slightly higher than the absolute estimate of 1.8 in Field I. The visual method estimate of 4.9 midges per panicle was slightly lower than the absolute method estimate of 5.5 in Field II. Density estimates of the remaining sampling methods in both fields were significantly lower ($P < 0.05$) than estimates using either the absolute or visual methods. In Field I, the lowest midge density estimate of 0.5 per

Table 1. Evaluation of survey methods in sampling *Contarinia sorghicola* in sorghum panicles in southwestern Arkansas and southeastern Oklahoma during 1987.

Survey Method	Midge/Panicle* ($\bar{x} \pm$ SE)		Time Required/Panicle (sec.) ($\bar{x} \pm$ SE)	
	Field I	Field II	Field I	Field II
Absolute	1.8 ± 0.3a**	5.5 ± 0.7a	NA	NA
Visual	2.0 ± 0.3a	4.9 ± 0.5a	43.8 ± 1.5c	62.2 ± 1.1a
Beat - Bucket	———	3.6 ± 0.4b	———	41.5 ± 1.0b
Tap	———	3.3 ± 0.4b	———	61.2 ± 1.2a
Shake	0.8 ± 0.1b	3.1 ± 0.4bc	57.1 ± 1.4a	63.6 ± 1.4a
Remove	0.9 ± 0.2b	3.1 ± 0.4bc	52.8 ± 1.3b	61.0 ± 1.1a
Grab	0.5 ± 0.1b	1.9 ± 0.2c	11.5 ± 0.4d	11.7 ± 0.3c

* Field I, n = 50; Field II, n = 68.

**Means within the same column followed by the same letter are not significantly different; Duncan's new multiple range test ($P < 0.05$).

NA = Not applicable.

panicle was obtained by using the grab method, but it was not significantly ($P < 0.05$) different from the shake and remove mehtods. The grab method also gave the lowest estimate in Field II and was significantly ($P < 0.05$) lower than the beat - bucket and tap method but not significantly ($\rho < 0.05$) lower than the shake and remove methods.

In Field I, all methods required less than one minute to perform, but mean time required to sample a panicle differed significantly ($\rho < 0.05$) between visual, shake, remove, and grab methods (Table 1). The shake and remove methods more time to perform than the visual method, which in turn required longer than the grab method. In Field II, the grab method again took the least amount of time to complete, with the beat - bucket method being intermediate between the grab and remaining methods in Field II. The visual, tap, shake, and remove methods all required ca. one minute in Field II.

Linear regression analysis revealed that a weak relationship existed between number of midges counted by a sampling method and time required to count them.

Evaluation II

In the paired comparisons, only the absolute method was not significantly ($\rho < 0.05$) different from the visual method (Table 2). A mean difference of only 0.4 midges existed between the visual and absolute sampling methods. Mean differences between the remaining methods and its visual comparison ranged from 0.7 to 3.9 fewer midges per panicle.

Panicle Compactness

Midge densities were dramatically higher (1 - 5×) during this evaluation than in Evaluation I or II (Table 3). Mean sorghum midge density per panicle increased significantly ($\rho < 0.05$) with panicle compactness, ranging from 9.2 to 25.6 in open and compact panicles, respectively. The mean difference between absolute and

Table 2. Comparison of the visual examination method to various survey methods for sampling *Contarinia sorghicola* in sorghum panicles.

Survey Method*	Mean Midge/Panicle ± SE: Visual Examination	Mean Midge/Panicle ± SE: By Survey Method	Difference ($\bar{x}$ ± SE)
Absolute	3.6 ± 0.5	4.0 ± 0.5	- 0.4 ± 0.4
Beat - Bucket	2.4 ± 0.4	1.7 ± 0.3	0.7 ± 0.2**
Tap	2.8 ± 0.4	1.7 ± 0.3	1.1 ± 0.2**
Shake	9.7 ± 0.7	5.8 ± 0.5	3.9 ± 0.5**
Remove	5.3 ± 0.8	3.8 ± 0.7	1.5 ± 0.3**
Grab	4.6 ± 0.7	1.6 ± 0.3	3.0 ± 0.4**

* Visual - absolute, - bucket, - tap, and - grab comparisons were made on 10 July; visual - remove and - shake comparisons were made 22 and 26 July, respectively.

**Paired means significantly different at the P = 0.01 level, paired t - test, n = 25.

visual sampling estimates became significantly larger as panicle compactness increased (Table 3). The confounding effect of increased midge density and panicle compactness appeared to cause precision of the visual examination method to be reduced. However, the visual method is efficient in estimation midge densities that are near the economic threshold (1 to 3 and 5 for susceptible and resistant hybrids, respectively), the area in which precision is critical in decision making.

In summary, the visual sampling method more closely estimated sorghum midge densities in grain sorghum as determined by the absolute method than any of the sampling methods tested. The visual method is not only a reliable sampling method for estimating midge densities in grain sorghum panicles but is also time efficient, taking ca. one minute per panicle.

Table 3. Effect of panicle compactness in estimating *Contarinia sorghicola* densities by visual examination.

Compactness Class (n = 64)	Mean Midge/Panicle ± SE*: Absolute Method	Mean Midge/Panicle ± SE*: Visual Examination	Difference ($\bar{x}$ ± SE)
Open	9.2 ± 0.5a	7.9 ± 0.5a	1.3 ± 0.2**
Medium	18.9 ± 1.2b	14.1 ± 0.9b	4.8 ± 0.5**
Compact	25.6 ± 1.3c	17.0 ± 1.0c	8.6 ± 0.8**

* Means within the same column followed by same letter are not significantly different ; Duncan's new multiple reange test ($P < 0.05$).

**Means significantly different at the P = 0.01 level, paired t - test.

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