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Research Article

Estimation of the adult Sunn Pest, *Eurygaster integriceps* Puton (Hem.: Scutelleridae) population in wheat fields using the sweeping method

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Abstract: In Iran, Sunn Pest *Eurygaster integriceps* is a major economic pest of wheat and barley. Current chemical control relies on targeting overwintering adults in wheat fields, requiring precise and efficient population assessments. While sweep-net sampling is commonly used, it lacks a strong theoretical basis. Therefore, this study was conducted to address this gap. Overwintered adults of the Sunn Pest population were sampled from wheat fields in five provinces by sweep net in early May 2005. The Menhinick model was developed to estimate overwintered adult Sunn Pest density from sweep-net catch. This method involved sweeping a known area multiple times between 9 AM and noon at half-hour intervals to establish a decreasing trend in numbers, which was then used to estimate the total population size through linear regression. This data also allowed estimating the number of sweep strokes required to cover 1 m². The number of strokes required to sample the overwintered adult Sunn Pest population density in one m² of wheat field ranged from 7.1 to 8.4, with a median of approximately eight sweeps, equivalent to one m².

Keywords: Sunn Pest, *Eurygaster integriceps*, Sampling, Sweep net, wheat

Introduction

Estimating the number of individuals in a pest population is a fundamental challenge in pest management. The approach depends on the size and distribution of the population, as well as the desired level of accuracy (Ruesink and Haynes, 1973). Sweep netting is a widely used sampling

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technique for insect populations, especially in vegetated areas. Although it provides a relative measure of population size (the population index), it is not inherently quantitative. This method does not directly assess the absolute density of insects in a specific area. Calibration methods can be used to transform sweep-net catch data into density estimates (Pruess et al., 1977; Powell and Gale, 2015). Moran (1951), Zippin (1956), Seber (1973), and Ruesink and Haynes (1973) discuss comprehensive methods for quantitative estimation using removal trapping. A key aspect of the quantitative study of the sweep-net is correlating the number of sweeps with the accuracy of the estimated density (Menhinick, 1963; Pruess *et al*., 1977).

Sunn Pest, *Eurygaster integriceps* Puton (Hem.: Scutelleridae), has long been considered a major economic pest of wheat and barley in most West and Central Asia countries (Critchley, 1998; Parker *et al*., 2002; Parker *et al*., 2011; Davari *et al*., 2018), and to prevent economic damage, management is commonly done with insecticides. For example, in Iran, about three million ha of wheat must be sprayed each year to control this insect (Anonymous, 2024).

Sunn Pest management and its ecological studies require accurate estimates of Sunn Pest population levels using reliable, economically efficient sampling techniques (Amir-Maafi *et al*., 2007). Sweep-net samples have been used for many years to estimate relative population levels of different stages of the Sunn Pest (Banks and Brown, 1962).

The objective of this study was to relate sweep-net catches to absolute density and assess their effectiveness for estimating Sunn Pest populations in wheat fields.

Materials and Methods

The research was conducted in spring 2005 across winter wheat fields in five provinces in Iran: Tehran, West Azarbaijan, Kermanshah, Lorestan, and Isfahan. The selected fields were managed according to typical agronomic practices at the experimental stations, without insecticides.

An area of 10 × 10 m (100 m²) was chosen and marked in each wheat field. One hundred strokes with an insect net were necessary to cover all parts of the area without overlapping. The net used had a diameter of 32 cm, and the handle was 110 cm long. The area (10 × 10 m) was swept seven different times in the morning (from 9 to 12). A 30-minute interval was allowed between each set of 100 strokes. The adult Sunn Pests in each sample were then counted.

Data analysis

The total number of insects collected during each sampling period (y) was graphed against the number collected in previous periods (x). According to Hayne (1949), it is possible to estimate the absolute density of overwintered adult Sunn Pest by the linear regression method:

$$y = a + bx$$

Where y is the overwintered adult Sunn Pest collected during each sampling period, and x is the number of overwintered adult Sunn Pest collected in previous periods. The absolute density was estimated by $-a/b$. When the density per unit area is known, it is possible to calibrate sweep samples for the species. The number of sweeps necessary to capture the insects on one m^2 may be found by the following formula:

$$M = \frac{S}{N} \times \frac{T}{A}$$

Where S = no. net strokes, N = no. insect caught in the S strokes, T = no. insects in the area A, A = area of field in m^2, and M = no. sweeps necessary to catch the insects on 1 m^2 (Menhinick, 1963).

Parameters for the linear regression (REG Procedure) were estimated using the Procedure in SAS ver. 9.4 (SAS Institute, 2019).

Results

In early May 2005, when the population of overwintered adult Sunn Pest, *E. integriceps*, peaked, a study on sampling procedures was conducted in a single wheat field in each

province. Table 1 presents the total number of overwintered adult Sunn Pests for each province during different intervals, as measured by the sweeping method (Table 1). A regression analysis was conducted with *y* representing the number of overwintered adult Sunn Pest caught in successive sweeping periods and *x* indicating the numbers collected in previous periods, with results also displayed in Table 2. The probability of capturing Sunn Pests, indicated by the slope of the line, remained relatively constant throughout the collection period, as shown by the straight-line relationship between individual data points (Fig. 1, Table 2). The x-axis intercept (-a/b) estimates the total population size to be between 172.9 and 1038.8 adult Sunn Pest per 100 m^2 (Table 2). The gradual decline observed suggests that only a small percentage of the insects are captured at any given sampling, potentially because they primarily occupy the lower parts of the wheat. This finding may be due to Sunn Pests dropping to the ground after initial sampling and subsequently crawling back up, or to many being on the ground due to cooler temperatures. Nonetheless, the capture probability between successive periods is not always linear (Menhinick, 1963). Various hypotheses may account for fluctuations in capture probability, but understanding the species' behavior and microhabitat is essential to identifying the correct explanation (Ruesink and Haynes, 1973; Pruess *et al*., 1977; Elliott *et al*., 1991). The M-equivalent sweeps on the seven sampling times of day were quite constant for overwintered adult Sunn Pest, and ranged from 7.1 to 8.4 strokes necessary to sample one m^2 of wheat field (Table 2). This study had two interrelated goals. First, it aimed to relate sweep-net catches to absolute Sunn Pest density, specifically predicting the number of overwintered adult Sunn Pests per square meter based on sweep-net samples. Since Sunn Pest is not uniformly distributed in wheat fields (Amir-Maafi *et al*., 2007), multiple samples from each field are required to estimate density accurately, and several fields must be sampled to estimate regional density effectively (Pedigo and Buntin, 1994). The second goal was to establish a method for assessing the accuracy of the estimated field and regional densities after data collection.

Table 1 Number of overwintered adult Sunn Pest *Eurygaster integriceps* caught in successive sweeping period.

Sampling Time (hours)	West Azarbaijan		Isfahan		Kermanshah		Lorestan		Tehran	
	No. captured	No. removed previously	No. captured	No. removed previously	No. captured	No. removed previously	No. captured	No. removed previously	No. captured	No. removed previously
9.00	85	-	74	-	54	-	44		530	-
9:30	37	85	31	74	58	54	30	44	256	530
10.00	26	122	23	105	45	112	43	74	103	786
10:30	21	148	14	128	47	157	20	117	91	889
11.00	11	169	9	142	37	204	13	137	36	980
11:30	16	180	8	151	11	241	10	150	8	1016
12.00	10	196	4	159	8	252	8	160	3	1024

Table 2 Parameters (mean ± S. E.) obtained by fitting linear regression models to overwintered adult Sunn Pest, *Eurygaster integriceps* caught in successive sweeping period in wheat field in four provinces of IRAN.

Province	Parameters		r^2	*P*-value	Total Population per 100 m^2	Sweep net equal to 1 m^2
	Intercept (*a*) mean ± SE	Slope (*b*) mean ± SE				
West Azarbayjan	56.388 ± 4.891	-0.242 ± 0.032	0.936	*P* = 0.0010	233.514	7.9
Isfahan	55.261 ± 1.847	-0.319 ± 0.014	0.990	*P* = 0.00002	172.914	7.4
Kermanshah	75.564 ± 9.521	-0.243 ± 0.052	0.846	*P* = 0.0090	311.565	8.4
Lorestan	49.946 ± 8.903	-0.258 ± 0.074	0.754	*P* = 0.0250	193.897	8.1
Tehran	512.037 ± 30.794	-0.493 ± 0.035	0.981	*P* = 0.0001	1038.898	7.1

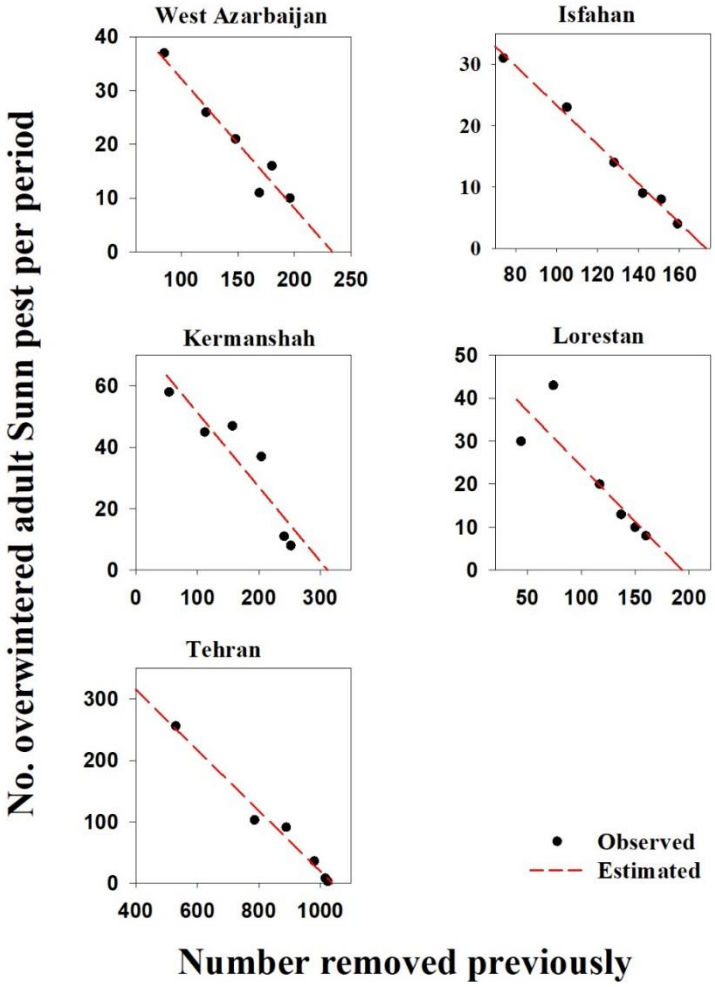

Figure 1 A progressive decrease in numbers of overwintered adult Sunn Pests caught during successive sweeping periods in 100 m2 of wheat fields in different provinces.

The principal application of the sampling methods developed here will be to measure the number of individuals in the overwintered adult Sunn Pest population. The results in this paper will provide the tools to use sweep-net sampling to estimate annual generation changes and assess the accuracy of those estimates. An application will be designed to analyze a sweep-net detection survey.

Discussion

Sunn Pest is known for its migratory behavior, with adults overwintering in mountainous regions before descending into cereal fields in spring (Brown, 1962; Arnoldi, 1995; Parker *et al*., 2011). In recent years, the management of overwintered adults in wheat fields in Iran has become increasingly critical due to their significant impact on wheat production. Chemical control of overwintering adults accounts for approximately 50% of the total area sprayed (Anonymous, 2024). But their life cycle complicates control efforts, as effective management requires precise timing of interventions to coincide with the pest's movement and reproductive stages. Estimating Sunn Pest population size is crucial for effective

management (Amir-Maafi *et al*., 2007). Sweep netting is a common sampling technique used to estimate the relative population levels of its various life stages (Banks and Brown, 1962).

Removal sampling necessitates a consistent and adequately high capture probability across samples to effectively reduce sample size (Elliot *et al*., 1991). Adult Sunn Pest sampling in wheat fields approximates these conditions (Amir-Maafi *et al*., 2007), and the model presented here estimates Sunn Pest populations more accurately than previous methods. As demonstrated by Michels Jr et al. (1997), this method yields approximately unbiased estimates of insect population size.

Overall, this study contributes to the broader field of integrated pest management by improving the methods for monitoring Sunn Pest populations. The ability to predict absolute densities from sweep-net samples and to assess the accuracy of these estimates enhances the efficiency and reliability of pest surveillance programs.

Future research could build on these findings by exploring additional factors that influence Sunn Pest distribution, such as environmental conditions or crop phenology, to refine sampling strategies further. Additionally, the methodologies developed in this study could be adapted for other pest species, extending their applicability beyond Sunn Pest management.

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Data Availability Statement

All data supporting the findings of this study are available within the paper.

Ethics approval

Insects were used in this study. All applicable international, national, and institutional guidelines for the care and use of animals were followed. This article does not contain any studies with human participants performed by the author.

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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تخمین جمعیت حشرات بالغ سن گندم *Eurygaster integriceps* Puton (Hem.: Scutelleridae) در مزارع گندم به روش تور زدن

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چکیده: سن گندم *Eurygaster integriceps* در ایران، مهم‌ترین آفت گندم و جو بوده و درحال حاضر کنترل شیمیایی علیه آن براساس هدف قرار دادن حشرات کامل زمستان‌گذران در مزارع گندم می‌باشد، که نیازمند ارزیابی دقیق و کارآمد جمعیت است. درحالی‌که معمولاً نمونه‌برداری با تور حشره‌گیری انجام می‌شود، اما این روش نمونه‌برداری، فاقد مبنای نظری قوی است. لذا، پژوهش حاضر به‌منظور رفع این خلأ انجام شده است. جمعیت سن زمستان‌گذران از مزارع گندم در پنج استان با استفاده از تور حشره‌گیری در اواسط اردیبهشت ماه سال ۱۳۸٤ نمونه‌برداری شد. از مدل Menhinick برای تخمین تعداد سن زمستان‌گذران در مزرعه گندم از داده‌های نمونه‌برداری با تور استفاده شد. در این روش با استفاده از تور حشره‌گیری از یک محدوده معین از مزرعه گندم در ساعات مختلف روز (۹ صبح تا ۱۲ ظهر) به فاصله نیم ساعت نمونه‌برداری گردید. از تجزیه‌وتحلیل رگرسیون خطی داده‌ها برای تخمین اندازه کل جمعیت استفاده شد. این داده‌ها هم‌چنین امکان تخمین تعداد تور معادل یک مترمربع را فراهم کرد. تعداد تور مورد نیاز برای نمونه‌برداری از تراکم جمعیت آفت سن بالغ زمستان‌گذران شده در یک مترمربع مزرعه گندم از ۷/۱ تا ۸/٤ تور (با میانه ۸) معادل یک مترمربع متغیر بود.

واژگان کلیدی: سن گندم، *Eurygaster integriceps*، نمونه‌برداری، تورزدن، گندم