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Relative abundance of English grain aphid *Sitobion avenae* (Homoptera: Aphididae) on wheat fields in Najaf province-Iraq

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ABSTRACT

The English grain aphid, Sitobion avenae (Fabricius), is a major sucking pest of wheat, causing direct yield loss and acting as a vector for plant viruses, thereby threatening both grain quantity and quality. Comprehensive field data on its population ecology in Middle Eastern agroecosystems, particularly Iraq, remains scarce. This study investigated the relative abundance, seasonal dynamics, and key influencing factors of S. avenae in wheat fields across Najaf province, Iraq, during the 2022-2023 growing season. Weekly sampling from five representative fields was conducted, with aphids collected from tillers and identified morphologically. Population density (individuals per tiller) was quantified and analyzed against spatiotemporal and climatic variables. Results revealed a distinct unimodal population trend, with initial colonization in early March and a peak abundance (52% of the seasonal total) occurring in mid-March, coinciding with the wheat ear formation stage. A sharp decline ensued from late March, with populations falling to minimal levels (13% of total) by May. Significant spatial variation was observed, with the highest mean density recorded at Al-Mishkhab (924 aphids/plant) and the lowest at Al-Haideria (466 aphids/plant). The population composition was consistently dominated by apterous viviparous females. Statistical analysis identified strong correlations between aphid density and climatic factors: a significant negative correlation with mean temperature ($r = -0.943$) and a significant positive correlation with relative humidity ($r = 0.997$). The population collapse in late spring was attributed to the combined effects of host plant maturation and abiotic stress from rising temperatures and aridity. This study concludes that the population dynamics of S. avenae in Najaf are critically synchronized with wheat phenology and local climate. The mid-March peak defines a key period for targeted monitoring. These findings provide essential baseline data for developing integrated pest management (IPM) strategies, including the determination of economic thresholds and the timing of interventions, to safeguard wheat yield and quality in Iraqi agroecosystems and similar regions.

1.Introduction

Wheat (Triticum aestivum L.) plays an undeniable role in the human food basket as one of the most vital cereals in ensuring global food security [1]. However, the yield and quality of this strategic crop are constantly threatened by a wide range of biological pests. Among them, aphids, especially the English grain aphid with the scientific name Sitobion avenae (Fabricius) (Homoptera: Aphididae), are among the most destructive sucking insects in wheat fields [2].

This pest causes both direct and indirect damage. Direct damage through sucking plant sap leads to general plant weakness, a decrease in thousand-grain weight and a quantitative loss in yield [3]. At a qualitative level, this feeding can negatively affect the protein content and nutritional composition of wheat grain, an issue that is directly related to the food industry and the final quality of products such as flour, bread and other cereal products. On the other hand, indirect and perhaps more dangerous damage is the role of this aphid as an important vector of plant pathogenic viruses such as Barley Yellow Mosaic Virus (BYDV), which causes irreparable losses [4].

Although the distribution and biology of S.*avenae* have been well studied in many parts of the world, including Europe and North America, there is a lack of comprehensive information on the status of this pest in many parts of the Middle East, including Iraq. Najaf province is considered one of the important centers of agriculture and wheat production in Iraq. Due to climate change, cropping patterns and, consequently, differences in farm management in this region, the population dynamics of this pest can show different patterns [5]. The lack of accurate and quantitative field data on the density and relative abundance of this pest in Iraqi agroecosystems is a clear knowledge gap. This deficiency has made it challenging to develop integrated pest management (IPM) programs based on economic loss thresholds [6].

Sustainable pest management emphasizes not only increasing yield but also maintaining the quality and safety of the food produced. Any disruption in the production of wheat of desired quality affects the supply chain up to the food industry and the final consumer. Therefore, monitoring and accurately understanding the demographics of key pests is an initial and essential step to protect this food asset and ensure the quality of the final products [7].

Accordingly, the main objectives of this study are defined as follows: To determine the relative abundance of the English grain aphid (Sitobion avenae) in wheat fields in Najaf province, Iraq. To monitor population changes of this pest during the wheat growing season. To determine the plant growth stage that accounts for the highest density of the pest population [8].

The results of this study provide essential and fundamental data for agricultural experts and food industry researchers to better understand the epidemiology of the pest and design more accurate and less risky management strategies. This will ultimately contribute to the production of superior quality and greater quantity of wheat as a primary raw material for the food industry.

2-Materials and Methods

Study Site and Period

This study was conducted over the 2022-2023 wheat growing season (from 2022-2023 growing season) in the southern region of

Najaf province, Iraq. Monitoring and sampling were carried out in five distinct local wheat fields, selected to represent the prevailing agricultural practices in the area.

Aphid Sampling and Collection

Weekly sampling of the English grain aphid, *Sitobion avenae*, was performed from randomly selected wheat tillers within each field. Aphids were carefully collected from the leaves, stems, and ears using a fine, soft-bristled brush and placed into labeled vials containing 70% ethanol for preservation and transport to the laboratory.

Identification and Population Assessment

In the laboratory, all aphid specimens were examined and identified. The immature stages (nymphs) were differentiated into their respective instars (1st to 4th) based on morphological characteristics such as body size, antennal segment number, and cauda development, observed under a binocular dissecting microscope at 4X magnification. Representative specimens from each stage were photographed using a stereomicroscope equipped with a 40X lens. Species identification for all stages was confirmed using multiple standard pictorial and morphological keys [9-12]. The aphid population on each sampled tiller was quantified by directly counting all individuals, including both apterous (wingless) and alate (winged) adults, as well as the nymphal instars.

Data Analysis

Aphid density was quantified as the mean number of individuals per tiller. The data were analyzed using a two-factorial experimental design arranged in a Completely Randomized Design (CRD). The studied factors were Farm Location (with five levels: Site A, Site B, Site C, Site D, and Site E) and Sampling Week (with seven levels: Weeks 1, 2, 3, 4, 5, 6, and 7 during the sampling month). Analysis of Variance (ANOVA) was conducted to assess the significance of the main effects and their interaction. Where the ANOVA indicated significant differences ($p < 0.05$), treatment means were compared using the Least Significant Difference (LSD) post-hoc test. All statistical analyses were performed with SPSS software, Version 21 [13].

3-Results

3.1 Infestation Pattern and Seasonal Population Dynamics

Field observations confirmed that *Sitobion avenae* infests wheat crops during the early reproductive stages, primarily colonizing wheat ears and developing grains (Fig. 1). The aphid population exhibited a distinct unimodal seasonal trend. Initial colonization was observed in early March, with aphids constituting 52% of the total population recorded for the entire study period. The population increased progressively, reaching its zenith in mid-March (Fig. 2). A marked decline commenced thereafter, with the proportion falling to 35% by the first week of April. The lowest population level was recorded in May, representing only 13% of the total seasonal count. This population dynamics pattern demonstrates a clear peak abundance during March, followed by a sharp decline as the season progressed into hotter and drier months.

Fig. (1) Wheat ears infestation by *S. avenae*

3.2 Spatial Variation in Population Density

A total of 3,458 aphids were recorded across all study sites during the sampling period (Table 1). Significant spatial variation in population density was observed (LSD_{0.05} = 2.8). The Al-Mishkhab site sustained the highest infestation, with a total of 924 aphids per plant, followed by Al-Manathira (827 aphids per plant). In contrast, Al-Haideria recorded the lowest population density (466 aphids per plant). Statistical analysis revealed significant differences in total aphid abundance between the Al-Mishkhab and Al-Haideria sites and the other locations. The population structure across all sites was consistently dominated by females (1,611 individuals), followed by males (1,013 individuals) and nymphal instars (1st instar: 340; 2nd instar: 494).

3.3 Morphological Identification

Specimens were identified as Sitobion avenae based on key morphological characteristics. Apterous viviparous females (Fig. 3) were characterized by:

- Antennae that are predominantly black and longer than the body.
- Long, black siphuncle.
- A pale, elongated cauda without a sup acaudal process.

The nymphal instars were differentiated by their developing morphology, including antennal segmentation and the proportional size of cauda and siphuncle (Fig. 4). Alate males (Fig. 5) were distinguished by the presence of conspicuous dark dorsal intersegmental markings, in addition to black antennae, siphuncle, and legs.

3.4 .Relationship with Abiotic Factors

The climatic data for the study period is summarized in Table 2. March was the coolest and most humid month (Mean Temp: 31°C, RH: 85.2%), while May was the hottest and driest (Mean Temp: 36.2°C, RH: 58.4%). Correlation analysis revealed a strong negative relationship between mean temperature and aphid population density (r = -0.943). Conversely, a strong positive correlation was found between relative humidity and aphid density (r = 0.997).

Table (1): Total counts of different life stages of Sitobion avenae collected from wheat fields in Najaf Province

Collection site	1st nymph	2nd nymph	Females	Males	Total
Al-Manathira	61	128	390	248	827
Al-Mishkhab	77	138	465	244	924
Al-Abbasia	71	98	375	178	722
Al-Kufa	61	60	210	188	519

Al-Haideria	70	70	171	155	466
Total	340	494	1611	1013	3458
$L.S.D_{0.05}$	2.8	3.6	3.4	3.9	2.8

Table (2): Temperature and humidity during study period

	Mean temperature (˚C)	% Humidity
March	31	85.2
April	34.9	71.4
May	36.2	58.4

The seasonal population dynamics of *Sitobion avenae* demonstrated a distinct temporal pattern, with abundance peaking during the month of March and subsequently declining (Fig. 2). Initial colonization of wheat ears was first observed in early March, at which point aphids constituted 52% of the total population recorded over the study period. The population increased gradually, reaching its zenith in mid-March. A marked decline commenced thereafter, with the proportion of aphids falling to 35% by the first week of April. The lowest population level was recorded in May, representing only 13% of the total seasonal count.

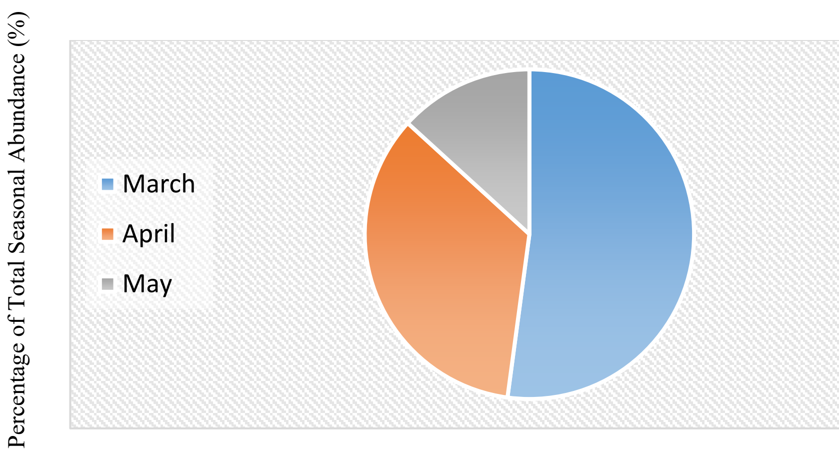

Fig. (2): Percentage of Monthly abundance for *S. avenae*

Morphological examination confirmed the identity of the aphids as *S. avenae* based on key diagnostic characteristics. Apterous viviparous females (Fig. 3) were characterized by long, black siphunculi; a pale, elongated cauda; and antennae that were predominantly black and exceeded the body length. The development of these structures across nymphal instars was documented, illustrating the differentiating features of the antennae and cauda in early and late-stage nymphs (Fig. 4). Furthermore, the study documented the presence of alate males, which were distinguished by conspicuous dark dorsal intersegmental markings (Fig. 5).

A (20 X) B (40 X) C (40 X)

Figure (3): diagnostic features of apterous females S. *avenae* (A). Adult without supracaudal process, siphunculi black long, cauda elongates, (B) Adult with black siphunculi and a pale cauda, (C) Black Antennae much longer than body.

A (40 X) B (40 X) C
(40X)

Figure (4): Diagnostic features of different instar nymphal stages S. *avenae* (A) first instar nympal stage showed has five-segment antennae. (B) First instar stage showed black siphunculi. (C)The second newly instar stage showed antennae, cauda and siphunculi.

A (40 X) B (40 X) C (40 X)

Figure (5): Diagnostic features of alate male of *S. avenae* (A) Male showed black dorsal intersegment markings. (B) Male showed black siphunculi. (C) Male with black antennae, legs and siphunculi.

4-Discussion

This study clarifies the morphology, population dynamics, and climatic influences of *Sitobion avenae* in Najaf's wheat fields. The collected specimens matched the established taxonomic profile for *S. avenae* (body length: 1.3–3.3 mm; darkened head; pale rostral segments; elongated, smooth cauda) [9-12]. The presence of darker dorsal intersegmental markings in alate forms further confirmed this species' characteristic polymorphism.

The population dynamics of *S. avenae* demonstrated a distinct seasonal pattern, with abundance peaking in March followed by a sharp decline commencing in early May. This pattern underscores a strong correlation between aphid density and the phenological stage of the wheat crop. The peak abundance coincided with the ear head formation stage (typically in March), a period characterized by the availability of tender, nutrient-rich tissues, which are highly favorable for aphid colonization and reproduction [19, 21]. This is consistent with findings from the region, where Hussain et al. [16] and Amin et al. [23] also reported maximal aphid populations in late March. The subsequent population collapse in May is likely attributable to a combination of factors: the maturation of the wheat crop, leading to grain hardening and a reduction in the quality and accessibility of phloem sap [19, 20], and the onset of elevated temperatures characteristic of the Iraqi late spring.

Climatic factors, particularly temperature and relative humidity (RH), were identified as critical drivers of *S. avenae* activity. In the present study, aphid population density exhibited a negative correlation with maximum and minimum temperatures but a positive correlation with mean RH. This finding partially contrasts with other studies; for instance, Zhang et al. [18] reported a positive association between aphid density and temperature and a negative one with RH. This discrepancy may be explained by the specific climatic context of Najaf province, which is characterized by a hot, dry environment with poor rainfall. In such arid conditions, moderate temperatures coupled with higher humidity in the early spring may create a less stressful microclimate, promoting population growth. However, as temperatures rise excessively towards May, they likely induce physiological stress and exceed the optimal thermal range for *S. avenae*, contributing to the observed decline. This is supported by the work of Wains et al. [17], who noted that while aphid activity increases with rising temperatures in early spring, it subsides as the climate becomes hotter and the crop senesces.

The limited and transient abundance of *S. avenae* in this study can also be viewed through the lens of its life history strategy. As an aphid that primarily colonizes wheat ears, its window for population establishment and growth is constrained to the relatively short period of ear availability, typically 2 to 7 weeks [25]. Furthermore, the hot, dry autumns in Najaf may limit initial colonization, while the prominent drought conditions in May apply severe abiotic pressure, drastically reducing population size. The reproductive strategy of *S. avenae*, which relies heavily on parthenogenesis to rapidly exploit favorable conditions [26], allows for the observed rapid population increase in March. However, this study did not investigate interspecific competition, which can be a significant biotic factor [14]. For example, increased temperatures can alter competitive interactions, potentially favoring other species like *Rhopalosiphum padi* over *S. avenae* [26], a dynamic that warrants further investigation in the Iraqi context.

In conclusion, the relative abundance and seasonal dynamics of *S. avenae* in Najaf's wheat fields are a function of the interplay between crop phenology and the local climate. Population peaks are synchronized with the susceptible ear stage under favorable spring conditions, while population crashes are driven by a combination of host plant maturation and abiotic stress from high temperatures and drought.

4-Conclusion

This study provides the first comprehensive field assessment of the population dynamics of the English grain aphid, Sitobion avenae, in the wheat agroecosystems of Najaf province, Iraq. The findings elucidate a clear and consistent seasonal pattern, with population abundance tightly synchronized to the phenological stage of the wheat crop. The pest reaches its damaging peak density during mid-March, coinciding precisely with the critical ear formation and grain-filling period. This temporal specificity underscores the vulnerability of the crop at this reproductive stage and pinpoints a narrow, actionable window for effective monitoring and intervention within any Integrated Pest Management (IPM) program.

The strong negative correlation with rising temperature and positive correlation with relative humidity highlight the pivotal role of local climatic conditions in driving population trends. The subsequent population collapse in May is attributed to the synergistic effect of deteriorating host plant quality (grain maturation) and escalating abiotic stress from the region's characteristic heat and aridity. The significant spatial variation in aphid density among locations further emphasizes the influence of localized microclimatic or agronomic factors, warranting site-specific considerations in management strategies .In conclusion, this research fills a critical knowledge gap on the epidemiology of a key wheat pest in a significant Iraqi agricultural region. The generated data on seasonal abundance, peak activity period, and climatic drivers establish a foundational scientific basis for refining IPM frameworks. These results directly inform the development of spatially and temporally precise control strategies, including the rational determination of economic injury levels and the optimal timing of biological or chemical controls. Ultimately, such evidence-based management is essential for mitigating yield and quality losses, enhancing the sustainability of wheat production, and strengthening regional food security.

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