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# Oversight numerical density of *Nezara viridula* (L.) and its related insect predators and parasitoids on sugar beet plants: A crucial element of IPM for this insect

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**Abstract**: Sugar beet, *Beta vulgaris* L., is the main source of sugar production in Egypt, followed by sugar cane. Unfortunately, this crop is subject to several insect infestations, among which is the green stink bug, *Nezara viridula* L. The current investigation was carried out during the 2022/2023 and 2023/2024 seasons to monitor the population dynamics of *N. viridula* and associated predators and parasitoids in three sugar beet cultivation dates. Averages of the insect population density were 5.40-5.73, 8.93-9.27, and 17.93-18.74 nymphs and adults / 5 sugar beet plants in the first, second, and third cultivations, respectively. Six insect predators were collected as associated with *N. viridula*. The most dominant was *Chrysoperla carnea* (24.06-32.73%), while the least dominant was *Paederus alfierii* (5.43-7.96%). The egg parasitoid, *Trissolcus basalis*, was found parasitizing the egg masses of *N. viridula*. In the 2022/2023 season, the parasitisms of *N. viridula* eggs were 35.82, 34.59, and 36.17% in the mid-August, mid-September, and mid-October, respectively. The corresponding values of parasitism in the 2023/2024 season were 33.25, 30.15, and 32.76%, respectively. Statistical analysis revealed that the correlations among populations of *N. viridula* and populations of all predators and parasitoids were usually highly significant and positive. The current results show that the sugar beet fields are rich in biological control agents that actively regulate the population density of *N. viridula*. So, pesticide applications against this green stink bug may not be required in most cases.

**Key words**: *Beta vulgaris* L., predators, parasitoids, stink bug, plantation.

## 1. Introduction

Sugar beet, *Beta vulgais* L., is the major source of sugar production in Egypt, followed by sugar cane. Egypt's ministry of agriculture and land reclamation is highly interested in enhancing sugar production through expansion of cultivated areas and increasing the productivity of the unit area. One of the major constraints against high productivity is the insect pests, which damage sugar beet plants throughout all crop stages. The green stink bug, *Nezara viridula*, is a piercing-sucking insect pest that feeds upon the plant saps **(Bazazo *et al.* 2017; Khalifa, 2017 and 2018)**; meanwhile, it can transmit some diseases **(Hawila, 2021)**. **Abd El-Aty and Ramadan (2023)** encountered, *N. viridual* throughout the sugar beet season with notable peaks in March and April, while **El-Zoghby (2003)** detected the highest population density of this stink bug by the second week of May. Insect monitoring by **Abdel-Raheem *et al*. (2011)** revealed that this insect appeared on sugar beet plants early in the season (during November and December). **El-Dessouki (2014)** indicated that late sugar beet cultivation (sown during November) had higher population densities of *N. viridula* compared to August or October cultivations. Despite the fact that sugar beet plants are liable to infestations of several insect pests other than *N. viridula*, they have a diversity of natural enemies that regulate the populations of insect pests **(Khalifa, 2017)**. *Coccinella undecimpunctata, Scymnus syriacus, Paederus alfierii, Chrysoperla carnea*, and *Orius* spp. were usually surveyed as insect predators associated with the insect pests inhabiting sugar beet fields **(Shalaby, 2001; Talha, 2001; Youssef and Abou-Attia 2001, and Khalifa, 2017)**. **Bazazo (2005)** surveyed 42 predators belonging to six orders and 10 families, with distinguished populations of spiders that proved to efficiently regulate the insect pest populations. **El-Dessouki (2014)** observed that, eggs and early nymphal stages of *N. viridula* were usually fed upon by *C. undecimpunctata*, *Scymnus* spp., *P. alfierii*, and *C. carnea*. In addition to insect predators, the parasitoids were found to play an important role against the eggs of *N. viridula*. *Trissolcus basalis*, the egg-parasitoid, was recorded attacking egg-masses of the green stink bug **(Tawfik, 2007; Abd El-Aty and Ramadan, 2023)**. **Ademokoya *et al.* (2022)** review that the natural enemies of stink bugs in the US, noting that the egg and the late nymphal and adult stages of stink bugs are the most commonly attacked by parasitoids, whereas eggs and young nymphs are the stages most commonly attacked by predators. The current investigation was conducted to find out the population fluctuation of the green stink bug, *N. viridula*, on three cultivation dates of sugar beet. Also, the population densities of the main insect predators, as well as the egg-parasitoid, *Tirssolcus basalis*, were monitored. The correlations among *N. viridula* population densities and those of natural enemies were calculated.

## 2. Materials and Methods

### 2.1. Experimental site and seasons of study

The current investigation was conducted at the experimental farm of Sakha Agricultural Research Station during the 2022/2023 and 2023/2024 seasons on *Nezara viridula* and associated predators and parasitoids in sugar beet fields.

### 2.2. Experimental design and sowing

The experimental area was divided into three sections, each measuring 500 $m^2$. The sections were assigned to be sown by multi-germ sugar beet variety (Husam) on August $20^{th}$, September $20^{th}$, and October $15^{th}$. All agricultural practices were followed according to the recommendations of the Ministry of Agriculture, but without any pesticides.

### 2.3. Sampling and examination

Biweekly samples were taken as 15 random plants (5 plants × 3 replicates) per sample. The sampling began one month after the sowing of each cultivation date. At sampling, the sugar beet plant was confined completely into a clear plastic bag and cut at the soil surface to be obtained carefully in the bag. The samples were transferred to the laboratory for examination.

### 2.4. Examination

A piece of cotton, saturated with diethyl ether, was introduced into each plastic bag and tightly closed for two minutes to anesthetize the collected arthropods. Then, the contents of the bag were dropped onto a white paper sheet, and a fine, soft brush was used to exclude the arthropods attached with sugar beet plants. The collected arthropods were individually introduced into glass vials containing 70% ethyl alcohol with a few drops of glycerin. The specimens were initially sorted and counted in the lab and later were thoroughly identified by the "Survey and Classification Unit," Plant Protection Research Institute, Agricultural Research Center, Egypt. The considered insect stages were as follows: *Coccinella undecimpunctata* (larvae and adults), *Paederus alfierii* (adults), *Orius* spp. (adults), *Chrysoperla carnea* (larvae and adults), Carabids (adults) and *Anthicus* spp. (adults). Meanwhile, the sugar beet plants were examined for collecting egg-masses of *Nezara viridula*. The egg-masses were kept individually in glass containers and monitored for the egg hatch to nymphs of the green stink bug or emergence of parasitoid. Parasitism was calculated according to the following equation:

$$\text{Parasitism \%} = \frac{\text{No.of emerging parasitoids}}{\text{Total no.colleted eggs}} \times 100$$

### 2.5. Statistical analysis

Analysis of variance (ANOVA) at P = 0.05 was adopted using Minitab V:16 software **(Duncan, 1955)**. Also, correlation coefficient values were calculated according to **Snedecor and Cochran (1989)**.

## 3. Results

### 3.1. Population dynamics of *N. viridula*

**Season of 2022/2023**

Data presented in Table (1) show the population dynamics of *N. viridula* nymphs and adults on sugar beet plants through three sowing date in the 2022/2023 season. Mid-August cultivation date received the initial *N. viridula* infestation on December 13$^{th}$, with 3.33 nymphs and adults/5 plants, increased progressively to reach maximum on February 13$^{th}$ with 8.67 individuals/5 plants. However, the mean of *N. viridula* nymphs and adults was 5.40 nymphs and adults/5 plants on mid-August planation. The mid-September and mid-October time had the first infestation on January 13$^{th}$ and February 12$^{th}$, respectively. Averages of infestations throughout the season were 9.27 and 17.93 nymphs and adults/5 plants for mid-September and October cultivations, respectively.

**Season of 2023/2024**

Population dynamics of *N. viridula* nymphs and adults in the 2023/2024 season (Table 2) were similar to those in the 2022/2023 season. Mid-October cultivation harbored the highest Overall averages of *N. viridula* were 5.73 and 8.93 nymphs and adults/5plants in mid-August and mid-September cultivation, respectively. The insect density (18.74 nymphs and adults/5 plants) throughout the season, particularly during April.

**Table (1). Average of *N. viridula* nymphs and adults / 5 plants during, 2022/2023 season**

| Examination date | Cultivation dates | | |
|---|---|---|---|
| | August 20th | September 20th | October 15th |
| Dec. 13 | 3.33 | 0.00 | 0.00 |
| Dec. 27 | 4.00 | 0.00 | 0.00 |
| Jan. 13 | 4.33 | 4.67 | 0.00 |
| Jan. 27 | 6.67 | 7.33 | 0.00 |
| Feb. 13 | 8.67 | 9.33 | 0.00 |
| Feb. 28 | 0.00 | 11.00 | 12.00 |
| Mar. 13 | 0.00 | 14.00 | 16.33 |
| Mar. 28 | 0.00 | 0.00 | 16.67 |
| Apr. 13 | 0.00 | 0.00 | 20.33 |
| Apr. 28 | 0.00 | 0.00 | 24.33 |
| Total | 27.00 | 46.33 | 89.66 |
| Mean ± SE | 5.40 ± 1.21 a | 9.27 ± 2.10 b | 17.93 ± 3.13 c |

**Table (2). Average of *N. viridula* nymphs and adults / 5 plants during, 2023/2024 season**

| Examination date | Cultivation dates | | |
|---|---|---|---|
| | August 20th | September 20th | October 15th |
| Dec. 12 | 3.00 | 0.00 | 0.00 |
| Dec. 26 | 4.33 | 0.00 | 0.00 |
| Jan. 12 | 4.67 | 5.33 | 0.00 |
| Jan. 26 | 7.67 | 6.67 | 0.00 |
| Feb. 12 | 9.00 | 8.67 | 0.00 |
| Feb. 27 | 0.00 | 10.67 | 11.67 |
| Mar. 12 | 0.00 | 13.33 | 16.67 |
| Mar. 27 | 0.00 | 0.00 | 17.67 |
| Apr. 12 | 0.00 | 0.00 | 22.00 |
| Apr. 27 | 0.00 | 0.00 | 25.67 |
| Total | 21.00 | 44.67 | 94.35 |
| Mean ± SE | 5.73 ± 2.34 a | 8.93 ± 3.45 b | 18.74 7.01 c |

### 3.2. Population density of insect predators inhabiting sugar beet plants

**Season of 2022/2023**

Six insect predatory species were monitored in the three sugar beet sowing dates, Table (3). *C. carnea* larvae and adults were the most dominant as compared with the other predators. The *chrysopids* were found at 28.97, 29.31, and 24.57% (out of the total predator population.) in mid-August, mid-September, and mid-October, respectively. The second rank of dominant predators was occupied by the carabids, which were represented by 20.15% in the first cultivation date, 21.35% in the second cultivation date, and 20.10% in the third one. However, the last dominant predators were *P. alfierii* and *Anthicus* spp.

**Table (3). Relative dominance of insect predators as affected by cultivation date of sugar beet during, 2022/2023 season**

| Predator | No. of predators / 5 plants | | | | | |
|---|---|---|---|---|---|---|
| | August 20th | | September 20th | | October 15th | |
| | No. | % | No. | % | No. | % |
| *C. undecimpunctata* (A-L) | 7.13 | 14.15 | 12.73 | 15.51 | 25.73 | 20.06 |
| *Paederus alfierii* (A-N) | 3.79 | 7.53 | 4.46 | 5.43 | 8.79 | 6.85 |
| *Orius spp* (A-N) | 6.73 | 13.34 | 12.59 | 15.33 | 18.86 | 14.70 |
| *Chrysoperla carnea* (L) | 14.39 | 28.57 | 24.06 | 29.31 | 31.52 | 24.57 |
| Carabids (A) | 11.66 | 23.15 | 17.53 | 21.35 | 25.79 | 20.10 |
| *Anthicus spp* (A) | 6.66 | 13.22 | 10. 73 | 13.07 | 17.59 | 13.71 |
| Total | 50.36 | | 82.10 | | 128.28 | |

**Season of 2023/2024**

The same above mentioned predators were considered in the second season 2023/2024 as shown in Table (4). Also, *C. carnea* and Carabids were the most dominant, while *P. alfierii* was the least encountered one.

**Table (4). Relative dominance of insect predators as affected by cultivation date of sugar beet during, 2023/2024 season**

| Predator | No. of predators / 5 plants | | | | | |
|---|---|---|---|---|---|---|
| | August 20th | | September 20th | | October 15th | |
| | No. | % | No. | % | No. | % |
| *C.undecimpunctata* (A-L) | 7. 39 | 13.97 | 14.39 | 16.27 | 27.73 | 21.46 |
| *Paederus alfierii* (A-N) | 3.59 | 6. 79 | 4.86 | 5.50 | 10.79 | 7.96 |
| *Orius spp* (A-N) | 7.53 | 14.24 | 13.79 | 15.60 | 19.26 | 14.21 |
| *Chrysoperla carnea* (L) | 13.99 | 26.46 | 25.26 | 29.00 | 32.73 | 24.51 |
| Carabids (A) | 12.99 | 24. 57 | 18. 39 | 20.80 | 26.59 | 19.62 |
| *Anthicus spp* (A) | 7.33 | 13.86 | 11. 73 | 13.27 | 18. 40 | 13.58 |
| Total | 52.88 | | 88.42 | | 135.50 | |

### 3.3. Parasitism *N. viridula* egg by the egg-parasitoid, *T. basalis* in sugar beet plants

**Season of 2022/2023**

Sugar beet plants sown in mid-August harbored *N. viridula* egg-parasitoid by the egg-parasitoid, *T. basalis*. Average parasitism in Table (5) was 35.82% throughout the season, compared to 34.59% in mid-September cultivation and 36.17% in mid-October. Roughly, more than one third of *N. viridula* eggs were parasitized by *T. basalis* over the three considered cultivation dates.

**Season of 2023/2024**

Almost all the results of *N. viridula* parasitism in the 2023/2024 season (Table 6) were similar to those of the 2022/2023 season. The corresponding values of parasitism in the second season were 33.25, 30.15, and 32.76%.

**Table (5). Parasitism of *N. viridula* eggs by the egg parasitoid, *T. basslis* on sugar beet plants during three cultivation dates at the 2022/2023 season**

| Sampling date | Mean No. of predators / 5 plants | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | August 20th | | | September 20th | | | October 15th | | |
| | No. of collected eggs | No. of emerging parasitoid | Parasitism % | No. of collected eggs | No. of emerging parasitoid | Parasitism % | No. of collected eggs | No. of emerging parasitoid | Parasitism % |
| Dec. 13 | 83.0 | 25.0 | 30.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dec. 27 | 79.0 | 26.0 | 32.91 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jan. 13 | 80.0 | 28.0 | 35.00 | 79.0 | 25.0 | 31.65 | 0.00 | 0.00 | 0.00 |
| Jan. 27 | 81.0 | 30.0 | 37.04 | 78.0 | 23.0 | 29.49 | 0.00 | 0.00 | 0.00 |
| Feb. 13 | 79.0 | 35.0 | 44.30 | 81.0 | 31.0 | 38.27 | 0.00 | 0.00 | 0.00 |
| Feb. 28 | 0.00 | 0.00 | 0.00 | 81.0 | 28.0 | 34.57 | 86.0 | 32.0 | 37.21 |
| Mar. 13 | 0.00 | 0.00 | 0.00 | 80.0 | 31.0 | 38.75 | 85.0 | 30.0 | 35.29 |
| Mar. 28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 83.0 | 30.0 | 36.14 |
| Apr. 13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 86.0 | 31.0 | 36.05 |
| Apr. 28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 83.0 | 30.0 | 36.14 |
| Total | 402 | 144 | 35.82 | 399 | 138 | 34.59 | 423 | 153 | 36.17 |

**Table (6). Parasitism of *N. viridula* egg by the egg parasitoid, *T. basslis* on sugar beet plants during three cultivation dates at the 2023/2024 season**

| Sampling date | Mean No. of predators / 5 plants | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | August 20th | | | September 20th | | | October 15th | | |
| | No. of collected eggs | No. of emerging parasitoid | Parasitism % | No. of collected eggs | No. of emerging parasitoid | Parasitism % | No. of collected eggs | No. of emerging parasitoid | Parasitism % |
| Dec. 13 | 84.0 | 24.0 | 28.57 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dec. 27 | 80.0 | 25.0 | 31.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jan. 13 | 83.0 | 26.0 | 31.33 | 80.0 | 23.0 | 28.75 | 0.00 | 0.00 | 0.00 |
| Jan. 27 | 82.0 | 31.0 | 37.80 | 79.0 | 23.0 | 29.11 | 0.00 | 0.00 | 0.00 |
| Feb. 13 | 80.0 | 30.0 | 37.50 | 84.0 | 25.0 | 29.76 | 0.00 | 0.00 | 0.00 |
| Feb. 28 | 0.00 | 0.00 | 0.00 | 82.0 | 24.0 | 29.27 | 80.0 | 21.0 | 26.25 |
| Mar. 13 | 0.00 | 0.00 | 0.00 | 83.0 | 28.0 | 33.73 | 83.0 | 26.0 | 31.33 |
| Mar. 28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 80.0 | 26.0 | 32.50 |
| Apr. 13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 82.0 | 30.0 | 36.59 |
| Apr. 28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 84.0 | 31.0 | 36.90 |
| Total | 409 | 136 | 33.25 | 408 | 123 | 30.15 | 409 | 134 | 32. 76 |

### 3.4. Correlation coefficient values between *N. viridula* population and insect predators populations in sugar beet fields

Data presented in Tables (7 and 8) show that population density of *N. viridula* nymphs and adults correlated with highly significant values with all insect predators considered in the current research in both seasons of study. Also, there were highly significant values for the numbers of *N. viridula* eggs and population density of *T. basalis* parasitoid.

**Table (7). Correlation coefficient values between *N. viridula*, insect predators and parasitoid populations during three cultivation dates at the 2022/2023 season**

| Correlation | Cultivation date | | |
|---|---|---|---|
| | August 20th | September 20th | October 15th |
| | r | r | r |
| *N. viridula* (nymphs + adults ) × *C. undecimpunctata* (larvae + adults) | 0.600** | 0.601** | 0.607** |
| *N. viridula* (N&A) × *P. alfierii* (A) | 0.609** | 0.617** | 0.632** |
| *N. viridula* (N&A) × *Orius* ssp. (A) | 0.601** | 0.583** | 0.604** |
| *N. viridula* (N&A) × *C. carnea* (L&A) | 0.503** | 0.520** | 0.531** |
| *N. viridula* (N&A) × Carabids (A) | 0.610** | 0.613** | 0.624** |
| *N. viridula* (N&A) × *Anthicus* spp. (A) | 0.611** | 0.631** | 0.612** |
| *N. viridula* eggs × *T. basalis* (A) | 0.910** | 0.932** | 0.940** |

**Table (8). Correlation coefficient values between *N. viridula*, insect predators and parasitoid populations during three cultivation dates at the 2023/2024 season**

| Correlation | Cultivation date | | |
|---|---|---|---|
| | August 20th | September 20th | October 15th |
| | r | r | r |
| *N. viridula* (nymphs and adults ) × *C. undecimpunctata* (larvae + adults) | 0.621** | 0.611** | 0.610** |
| *N. viridula* (N&A) × *P. alfierii* (A) | 0.501** | 0.501** | 0.503** |
| *N. viridula* (N&A) × *Orius* ssp. (A) | 0.612** | 0.631** | 0.641** |
| *N. viridula* (N&A) × *C. carnea* (L&A) | 0.602** | 0.631** | 0.640** |
| *N. viridula* (N&A) × Carabids (A) | 0.502** | 0.510** | 0.531** |
| *N. viridula* (N&A) × *Anthicus* spp. (A) | 0.614** | 0.620** | 0.511** |
| *N. viridula* eggs × *T. basalis* (A) | 0.631** | 0.643** | 0.632** |

## 4. Discussion

The current study's observations of variations in *Nezara viridula* population density are consistent with other researchers' earlier findings. According to our statistics, infestation percentages differed for each of the three planting dates. The earliest infestation (mid-August) had the largest population density, followed by mid-September and mid-October. **Panizzi and Slansky (1985)** found similar findings, emphasizing that the abundance of host plants and suitable climatic circumstances cause *N. viridula* populations to peak. The mid-October cultivation had the highest infestation levels, especially in February and April when sugar beet development was at its most advanced. This pattern is in line with research by **Todd (1989)**, who hypothesized that when crops reach reproductive stages;

their better nutritional resources cause *N. viridula* populations to rise. The study identified six insect predator species that live on sugar beet plants, with carabid beetles and larvae of *C. carnea* being the most common. These results are consistent with field research **(Khalifa 2017; Youssef and Abou-Attia 2001; Talha 2001; Shalaby 2001)**. As insect predators linked to the insect pests that live in sugar beet, they discovered that, *C. undecimpunctata*, *S. syriacus*, *P. alfierii*, *C.carnea*, and *Orius* spp. were frequently surveyed. Mid-September cultivation in both seasons had the largest relative dominance of *C. carnea*, but this varied among the three planting dates. The abundance of prey, especially *N. viridula* nymphs, which peaked during this time, may be the cause of this. High prey concentrations cause *C. carnea* populations to grow, according to research by **Hagley and Allen (1988)**. Throughout the three cultivation dates, carabid beetles were consistently present and ranked as the second most prevalent predator. This result is in line with other research showing that carabids' generalist eating pattern makes them essential to integrated pest management **(Kromp, 1999)**. *Paederus alfierii* and *Anthicus* spp. were the least dominating predators in our study, indicating that their influence on suppressing *N. viridula* may be less than that of other predator species. Throughout the two seasons of study, *T. basalis* egg parasitism showed comparable patterns, with parasitism rates surpassing 30% in every cultivation date. This implies that, as previously noted by **Abd El-Aty and Ramadan (2023)**, *T. basalis* is important for the natural regulation of *N. viridula* populations. In addition to having the highest *N. viridula* population densities, the mid-October date also had the highest parasitism rates. The study showing a strong correlation between parasitoid population dynamics and host abundance lends credence to this conclusion **(Rosenheim *et al*., 1993)**. The efficacy of *T. basalis* in controlling stink bug populations is further supported by our findings, which demonstrate the plant's potential as a biocontrol agent. However, the variation in parasitism rates across planting dates raises the possibility that host availability and microclimatic variables might affect parasitoid efficiency **(Tillman, 2011)**. Insect predator concentrations and *N. viridula* populations showed substantial positive associations across all planting dates, confirming the function of natural enemies in controlling stink bug numbers. *N. viridula* egg quantities and *T. basalis* populations showed the strongest association, highlighting the parasitoid's reliance on host egg supply. **De Clercq *et al*. (2000)** found that, predator and parasitoid populations react favorably to rising prey numbers, exhibiting similar relationships. Our results support the idea that conservation biological management, which increases the number of natural enemies, may be a beneficial method for controlling *N. viridula* in sugar beet fields.

## 5. Conclusion

In sugar beet farms, the findings of this study shed important light on the population dynamics of *N. viridula*, its natural predators, and its egg parasitoid *T. basalis*. Mid-October cultivation date showed the largest numbers of *N. viridula* and the highest levels of parasitism and predation. The significance of incorporating biological control techniques into pest management systems is underscored by the robust associations seen between stink bug populations and their natural enemies. To increase the effectiveness of these natural enemies in agricultural systems, future studies should concentrate on improving conservation strategies.

## Recommendation

Using predators and parasitoids on sugar beet plants for controlling *Nezara viridula* as a biological control actively reduce the population density of this insect. As a result, chemical pesticides against the green stink bug may not be necessary in most circumstances.

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