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Nakahira, Kengo
Laboratory of Insect Natural Enemies, Institute of Biological Control, Faculty of Agriculture, Kyushu University

Iwase, Shun-ichiro
Laboratory of Insect Natural Enemies, Division of Biological Control, Department of Applied Genetics and Pest Management, Graduate School of Bioresource and Bioenvironmental Sciences, Kyushu University

Takagi, Masami
Laboratory of Insect Natural Enemies, Division of Biological Control, Department of Applied Genetics and Pest Management, Graduate School of Bioresource and Bioenvironmental Sciences, Kyushu University

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# Seasonal Abundance and Oviposition Preference of the Alfalfa Weevil *Hypera postica* on *Vicia sativa* subsp. *nigra*

**Kengo NAKAHIRA[1]*, Shun–ichiro IWASE[2] and Masami TAKAGI[2]**

Laboratory of Insect Natural Enemies, Institute of Biological Control, Faculty of Agriculture, Kyushu University, Fukuoka 812–8581, Japan

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The alfalfa weevil *Hypera postica* (Gyllenhal) is the most serious invasive pest of Chinese milk vetch, *Astragalus sinicus* L. *H. postica* also feeds on the leguminous plant *Vicia sativa* subsp. *nigra* (L.), an important host as a source of *H. postica* infections. We investigated the seasonal abundance and oviposition preference of *H. postica* on *V. sativa* subsp. *nigra* in Hisayama town, Fukuoka Prefecture, Japan. *H. postica* eggs were observed on *V. sativa* subsp. *nigra* throughout the study from January 11 to May 11, 2011 and the peak density of *H. postica* larvae was observed in April 11. Rapid growth of *V. sativa* subsp. *nigra* from March 27 to April 11 corresponded with the increasing population density of *H. postica* larvae. The numbers of *H. postica* eggs positively correlated with the diameter of *V. sativa* subsp. *nigra* stems in the results of January 11 to April 11. We investigated the oviposition preference using field samples. To investigate oviposition preference behavior, an additional study should be performed in the laboratory.

**Key words**: classical biological control, green manure, honey source, oviposition restraint, population dynamics

## INTRODUCTION

The alfalfa weevil *Hypera postica* (Gyllenhal) is the most destructive pest of alfalfa, *Medicago sativa* (L.), worldwide (Radcliffe and Flanders, 1998; Moradi–Vajargah *et al*., 2011), and also infests the leguminous plants *Medicago polymorpha* L., *Vicia sativa* subsp. *nigra* (L.), and *V. villosa* Roch etc. (Byrne and Blickenstaff, 1968; Shobu *et al*., 2005; Nakahira *et al*., 2013). In Japan, *H. postica* is the most damaging invasive pest of Chinese milk vetch, *Astragalus sinicus* L., an important secondary crop in rice paddy fields from autumn to spring (Shobu *et al*., 2005; Kuwata *et al*., 2005). Heavy infestation of *H. postica* larvae severely damages the growth and honey production of Chinese milk vetch (Shobu *et al*., 2005; Kuwata *et al*., 2005). Thus, the population dynamics of immature *H. postica* in Japan is well studied on *A. sinicus* in paddy fields (Haitsuka *et al*., 1990; Mori *et al*., 1991; Teramoto *et al*., 1993; Suenaga *et al*., 2001). *H. postica* can also occur on *V. sativa* subsp. *nigra* (Hashimoto *et al*., 1987; Yamaguchi *et al*., 1991), but the population dynamics of immature *H. postica* on *V. sativa* subsp. *nigra* have not been studied (Yamaguchi *et al*., 1991).

*H. postica* enter summer diapause after the emergence of adults (Hashimoto *et al*., 1987; Yamaguchi *et al*. 2006). In this season, the adults of *H. postica* aggregate under the bark of several species of trees (Hashimoto *et al*., 1987; Yamaguchi *et al*., 2006). In autumn, *H. postica* breaks the summer diapause and immigrates into paddy fields and weedy lands to start oviposition (Hashimoto *et al*., 1987). Dring the period from winter to spring, the immigrated *H. postica* adults oviposit their eggs into the interiors of stems of the host plants *A. sinicus* and *V. sativa* subsp. *nigra* (Hashimoto *et al*., 1987), but the size–dependent oviposition preference has not been confirmed in *V. sativa* subsp. *nigra*. In the present study, we investigated the seasonal abundance of *H. postica* eggs and larvae on *V. sativa* subsp. *nigra* on weedy land from January to May and the size–dependent oviposition preference of *H. postica* on *V. sativa* subsp. *nigra*.

## MATERIALS AND METHODS

The population densities of *H. postica* larvae were recorded from January 11 to May11, 2011, at 12 sites in Hisayama town, Fukuoka Prefecture, Japan, but were not recorded on May 11 only in Kubaru 1 because *V. sativa* subsp. *nigra* plants had been cut in the place from April 26 to May 11 (Table 1). At each site, nine or ten *V. sativa* subsp. *nigra* plants with *H. postica* larvae were cut off at their bases, individually placed into plastic bags, and transported to the laboratory in an interval of 15 days from January 11. The length of *V. sativa* subsp. *nigra* was measured with a ruler and the stem diameter was measured at the half–length position. The *H. postica* larvae on each plant were counted. The stem was dissected, and the *H. postica* eggs within the stem were counted. Further, the damaged leaves and total leaves (≥ 1 cm) were counted to determine the damaged leaf ratio (damaged leaves / total leaves). The relationship between *H. postica* egg density and plant stem diameter for each plant and study date was analyzed by a generalized linear mixed model (GLMM) with Poisson (log–link) error. In this model, density of *H. postica* eggs was treated as the response variable, stem diameter as the explanatory

[1] Laboratory of Insect Natural Enemies, Institute of Biological Control, Faculty of Agriculture, Kyushu University, Fukuoka 812–8581, Japan

[2] Laboratory of Insect Natural Enemies, Division of Biological Control, Department of Applied Genetics and Pest Management, Graduate School of Bioresource and Bioenvironmental Sciences, Kyushu University

* Corresponding author (E–mail: nakahira@agr.kyushu–u.ac.jp)

variable, and the study site as a random effect. The generalized linear mixed model was performed using Package lme4 version 1.1–5 (Bates *et al.*, 2014) of R 3.0.2 for Windows (R Development Core Team, 2013).

## RESULTS AND DISCUSSION

*H. postica* eggs were observed on *V. sativa* subsp. *nigra* in Hisayama town, Fukuoka prefecture, Japan, from January 11 to May 11, 2011 (Fig. 1). In this period, the number of *H. postica* eggs was 0.57–0.89 per plant from January 11 to February 25, but decreased to 0.05 per plant on March 12 (Fig. 1). This decrease in the number of *H. postica* eggs in mid–March was also observed on *A. sinicus* (Haitsuka *et al.*, 1990). The number of *H. postica* eggs was 0.57–1.30 per plant from March 27 to May 11 (Fig. 1). *H. postica* larvae were first observed on February 10 only in Yamada 5 (Table 1), at a density of 0.20 larvae per plant. The mean density across sites was only 0.02 larvae per plant on February 10, and 0 on February 25 (Fig. 2). These low densities of *H. postica* larvae were cobstant until 27 March, but sharply increased from March 27 to April 11 (Fig. 2). The peak density of *H. postica* larvae was 1.83±0.42 (mean ± standard error) on April 11 among the study dates from January 11 to May 11 (Fig. 2). This season of peak density in Fukuoka Prefecture in 2011 was similar to the season of peak densities on vegetation with mixed *V. sativa* subsp. *nigra* and *M. polymorpha* in Izumi City, Kagoshima Prefecture in 1989 and 1990 (Yamaguchi *et al.*, 1991).

The percentages of damaged leaves were also low from January 11 to March 12, and gradually increased from March 12 to May 11 (Fig. 3). The feeding behavior of *H. postica* larvae on damaged leaves of *V. sativa* subsp. *nigra* was not directly observed, but the period of increase of damaged leaves corresponded with the increase of larvae density until April 11 (Figs. 2 and 3). Thus, almost all the leaf damage was caused due to the feeds of *H. postica* larvae. The larval density decreased from April 11 to May 11 (Fig. 2). The increase of damaged leaves from April 11 to May 11 was due to the remaining *H. postica* larvae after peak density on April 12 (Figs. 2 and 3). The length of *V. sativa* subsp. *nigra* was short from January 11 to March 12, and gradually increased from March 12 to May 11 (Fig. 4). The rapid plant growth from March 27 to April 11 corresponded with the increase of the population density of *H. postica* larvae (Figs. 2 and 4) and in leaf damage from March 27 to April 11 (Figs. 3 and 4). The width of plant stems was

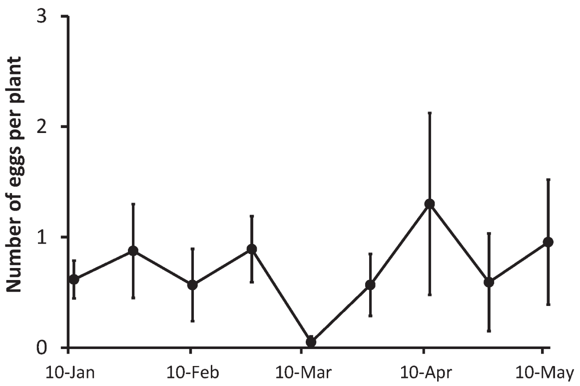


**Fig. 1.** Population density of *H. postica* eggs per *V. sativa* subsp. *nigra* plant from January 11 to May 11, 2011 (mean ± standard error).

**Table 1.** Study sites in Hisayama town, Fukuoka Prefecture, Japan

| Place name | Latitude (N) | Longitude (E) |
|---|---|---|
| Ino 1 | 33°39′45.5″ | 130°30′21.5″ |
| Kubaru 1 | 33°38′23.1″ | 130°30′13.3″ |
| Kubaru 2 | 33°38′26.9″ | 130°30′30.7″ |
| Kubaru 3 | 33°38′31.2″ | 130°30′38.8″ |
| Kubaru 4 | 33°38′46.3″ | 130°30′39.5″ |
| Kubaru 5 | 33°38′53.3″ | 130°30′18.9″ |
| Yamada 1 | 33°39′19.2″ | 130°29′32.8″ |
| Yamada 2 | 33°39′30.9″ | 130°29′31.2″ |
| Yamada 3 | 33°39′38.4″ | 130°30′11.6″ |
| Yamada 4 | 33°39′43.7″ | 130°30′12.5″ |
| Yamada 5 | 33°39′49.9″ | 130°30′02.2″ |
| Yamada 6 | 33°39′51.1″ | 130°30′04.2″ |

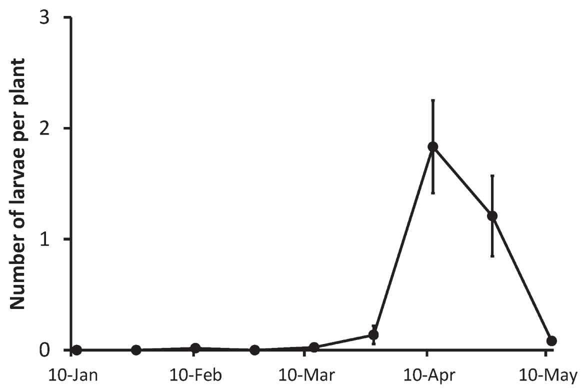


**Fig. 2.** Population density of *H. postica* larvae per *V. sativa* subsp. *nigra* plant from January 11 to May 11, 2011 (mean ± standard error).

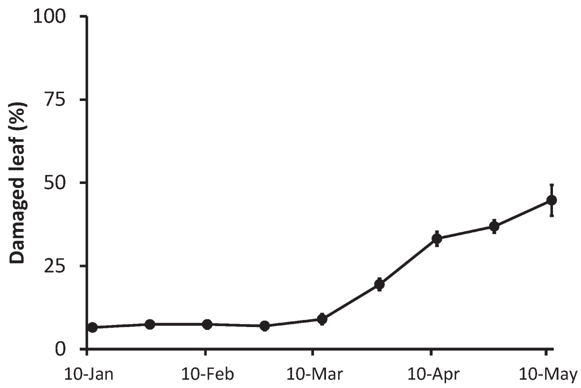


**Fig. 3.** Percentage of damaged leaves of *V. sativa* subsp. *nigra* from January 11 to May 11, 2011 (mean ± standard error).

small until March 12, and gradually increased from March 12 to April 11 (Fig. 5).

Yamaguchi (2009) reported that the sizes of *H. postica* egg masses showed no significant relationship with diameters of *A. sinicus* stems in February and March. In our study, the numbers of *H. postica* eggs were positively correlated with diameters of *V. sativa* subsp. *nigra* stems from January 11 to April 11 (Table 2). This result was similar to the results of positive relationship between egg mass size of *H. postica* and width of *M. sativa* stems in a laboratory experiment (Norwood *et al*., 1967). The differences in the size–dependent oviposition preference of *H. postica* must be caused by the difference of host plant species.

In this study, we described the seasonal abundance of *H. postica* on *V. sativa* subsp. *nigra*, an important plant as a source of *H. postica* occurrence, for the first time. We further investigated the size–dependent oviposition preference of *H. postica* on *V. sativa* subsp. *nigra*, based on field sampling. Further study of oviposition preference behavior should be performed in the laboratory.

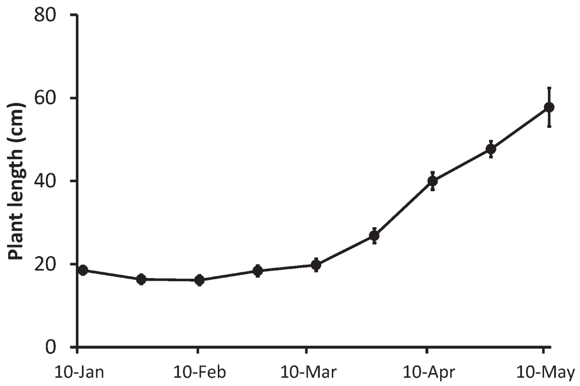


**Fig. 4.** Length of *V. sativa* subsp. nigra from January 11 to May 11, 2011 (mean ± standard error).

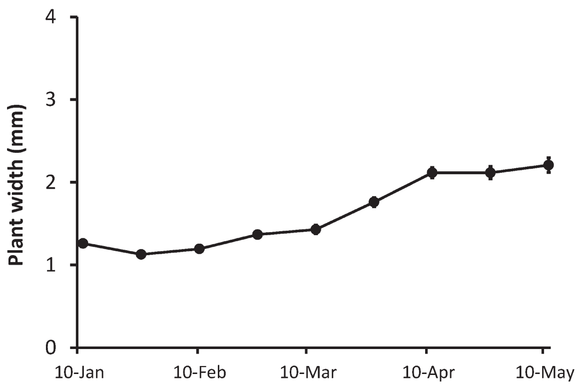


**Fig. 5.** Width of *V. sativa* subsp. *nigra* stems from January 11 to May 11, 2011 (mean ± standard error).

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**Table 2.** Results of generalized linear mixed models for numbers of *Hypera postica* eggs (response variable) in stems of *Vicia sativa* subsp. *nigra* on each study date

| Date | Estimate | Standard error | *z*–value | *p*–value |
|---|---|---|---|---|
| 11 January | 0.006096 | 0.000728 | 8.379 | <0.001 |
| 26 January | 0.012776 | 0.001266 | 10.095 | <0.001 |
| 10 February | 0.002538 | 0.000638 | 3.980 | <0.001 |
| 25 February | 0.001974 | 0.000424 | 4.656 | <0.001 |
| 12 March | 0.012405 | 0.003073 | 4.037 | <0.001 |
| 27 March | 0.003838 | 0.000661 | 5.805 | <0.001 |
| 11 April | 0.001857 | 0.000377 | 4.919 | <0.001 |
| 26 April | –0.000453 | 0.000367 | –1.235 | 0.217 |
| 11 May | –0.000270 | 0.000378 | –0.714 | 0.476 |

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