The Progress of Invasion of Insect Pest, the Mexican Been Beetle, *Epilachna varivestis* in Nagano Prefecture

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Abstract The investigation on defoliation of *Phaseolus* vegetables by the Mexican bean beetle *Epilachna varivestis* Mulsant was carried out at Guatemala high land in September, 2004. *E. varivestis* density is low and ratio of parasitism was 46.7%. From our survey in Guatemala, is not a serious pest because of natural enemies. From the investigation data of *E. varivestis* for 8 years, we can make the database of distribution and injury index in Nagano Prefecture. From the analysis of the database, distribution areas of this insect were expanding during 8 years, and speed of expansion was not so fast. Two species of parasitic wasps, *Pediobius foveolatus* and *Nothoserphus afissae,* were identified from *E. varivestis*. It was founded from the high percentage of parasitism that these wasps might be the cause of decreasing injury by this insect, and these native natural enemies may suppress the density of *E. varivestis*.

Key word: *Epilachna varivestis,* invasion, expansion, Nagano Prefecture

Introduction

The Mexican bean beetle *Epilachna varivestis* Mulsant is one of the leaf-eating beetles of the family Coccinellidae (Coleoptera). The adult *E. varivestis* has eight black spots on each yellow elytron and is 6 to 8 mm long and 4 to 6 mm wide. The adult, the 4th instar larva and egg mass are shown in Fig. 1.

Native region of *E. varivestis* is the plateau of southern Mexico and Guatemala. This beetle invaded into USA and expanded its distribution area rapidly. It was first identified in the state of Colorado in 1883, and soon became a serious pest in southern Colorado (Biddle *et al.,* 1992). In 1920, this beetle was identified in northern Alabama. From 1920 to 1970, the range of *E. varivestis* extended from Alabama to southern Ontario in Canada (Turnipseed and Kogan, 1976).

The distance from Alabama to Ontario is over at least 1300 km. *E. varivestis* achieved this expansion over a period of about 56 years, which means that it spread at a speed of 23 km/year. Moreover, Howard (1922) reported that *E. varivestis* is capable of moving up to 200 km per year.

There had been no report to find this insect pest in Japan. However, this insect was found at kidney bean fields in early August, 1997 in Yamanashi and Nagano prefectures (Sasaji, 1997 ;

Fig. 1 *Epilachna varivestis* in Chimaltenango Village, Guatemala (September 24, 2004).
A : Adult, B : The 4th instar larva, C : Egg mass.

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Fujiyama *et al.,* 1998). It is unknown when and how this insect pest invaded into Nagano Prefecture.

In this paper, we report the investigation on defoliation by *E. varivestis* in Guatemala high land, the analysis result on the progress of invasion of *E. varivestis* in Nagano Prefecture using the geographical information system (GIS) and the relation between *E. varivestis* and native parasites.

E. varivestis in Guatemala

The investigation on *E. varivestis* defoliation of *Phaseolus* vegetables was carried out at Guatemala high land in September, 2004. Fig. 2 shows *Phaseolus* vegetable field in Chimaltenango Village, Guatemala.

Table 1 shows the survey result of *E. varivestis* defoliation was 3～10.4％ at *Phaseolus* farm fields in Chimaltenango (Nakamura and Guevara, 2007). From Table 1, it can be said that *E. varivestis* density is low and ratio of parasitism in field A is calculated to be 46.7%, which is very high.

Pupa of the tachinid fly was found from mummy collected in Chimaltenango. Fig. 3 shows a larva (mummy) of *E. varivestis* attacked by a parasitic wasps and a cocoon of the tachinid fly from a mummy of *E. varivestis* collected in Guatemala. Schaefer (1983) listed 22 species, including 13 tachinid flies and 8 parasitic wasps as parasites of *E. varivestis,* 65 species as predators and 12 diseases.

From our survey in Guatemala, *E. varivestis* is not a serious pest because of natural enemies. In Japan, the injury levels calculated by the degree of defoliation of kidney bean, *Phaseolus vulgaris* leaves were 87.9％ in Suwa City, 56.3％ in Okaya City and 50％ in Chino City in 2000.

In the USA, *E. varivestis* gained pest status soon after invading Colorado in 1883. In Nebraska, this insect has been a serious problem with recent outbreaks occurring in 1994 and 1995 (Barrigossi *et al.,* 2001).

Spread of *E. varivestis* distribution in Japan

In Nagano Prefecture, survey on distribution

Fig. 2 *Phaseolus* vegetable field near ICTA (Instituto de Ciencia y Tecnologia Agricolas) in Chimaltenango Village, Guatemala. (September 23, 2004). Scarlet runner bean rounded sugarcanes of corn after harvest.

Table 1 The survey result of *E. varivestis* at *Phaseolus* fields of farms in Chimaltenango

Field surveyed	No. of plants examined	Injured plants		Numbers of *E. varivestis*			
		Number	%	Egg mass	Larva	Mummy	Adult
A	96	10	10.4%	1	8	7	10
B	100	3	3.0%	0	3	0	2
C	200	20	10.0%	0	1	0	4
Total	396	33	8.3%	1	12	7	16

(Nakamura & Guevara, 2007)

and injury of *E. varivestis* started from 1997 when this insect was found at first. Survey area is shown in Fig. 4.

A hundred leaves were sampled at random in a field cultivated kidney bean or scarlet runner bean, *Phaseolus coccineus,* infested by *E. varivestis.* The number of leaves infested by *E. varivestis* and its feeding intensity were investigated. The feeding intensity of each survey field was classified as followings ; 'null (N)' (% of infested leaves was 0%), 'light (L)' (1–20%), 'medium (M)' (21–40%), 'severe (S)' (41–70%), 'very severe (V)' (71–100%). Using these feeding intensities of survey fields in the area, injury index of the area was calculated as following.

Injury index＝
{(No. of L＋No. of M×2＋No. of S×3＋
No. of V×4)×100}/(No. of sampled fields×4)

This index ranges 0 (no injury) to 100 (more than 70% injury). Numbers of survey community and sampled field are 103 and 337 in 1997, 9 and 66 in 1998, 10 and 90 in 1999, 10 and 57 in 2000, 9 and 107 in 2001, 15 and 322 in 2002, 15 and 430 in 2003, and in 2004, respectively.

From the investigation data for 8 years, we can make the database of distribution and injury index of *E. varivestis* in Nagano Prefecture. Fig. 5 shows the expansion process of distribution and injury level from 1997 to 2004.

Two results were derived by change of distribution map, that is, from 8 communities in 1997 to

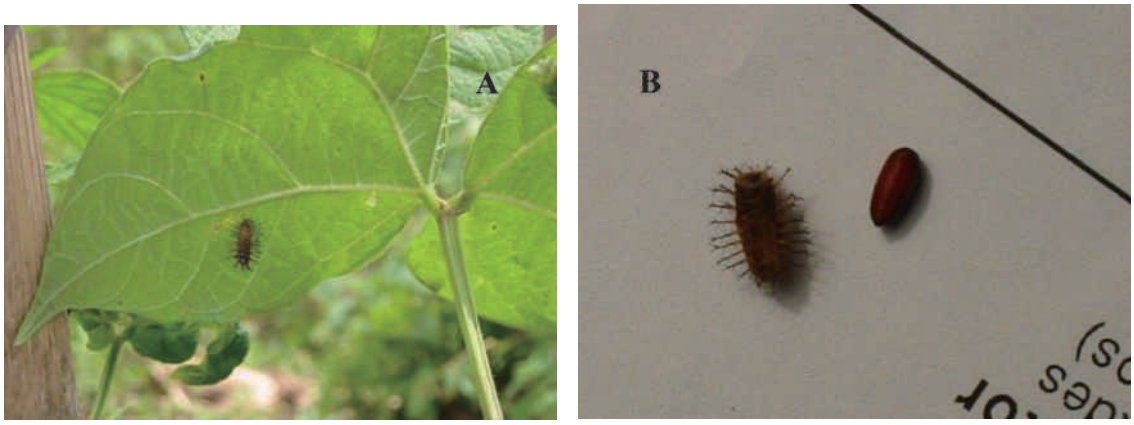

Fig. 3 Natural enemies of *E. varivestis* in Guatemala.
A : Mummy of *E. varivestis* attacked by a parasitic wasp.
B : A cocoon of tachinid fly from a mummy of *E. varivestis* collected in Chimaltenango (Nakamura and Guevara, 2007).

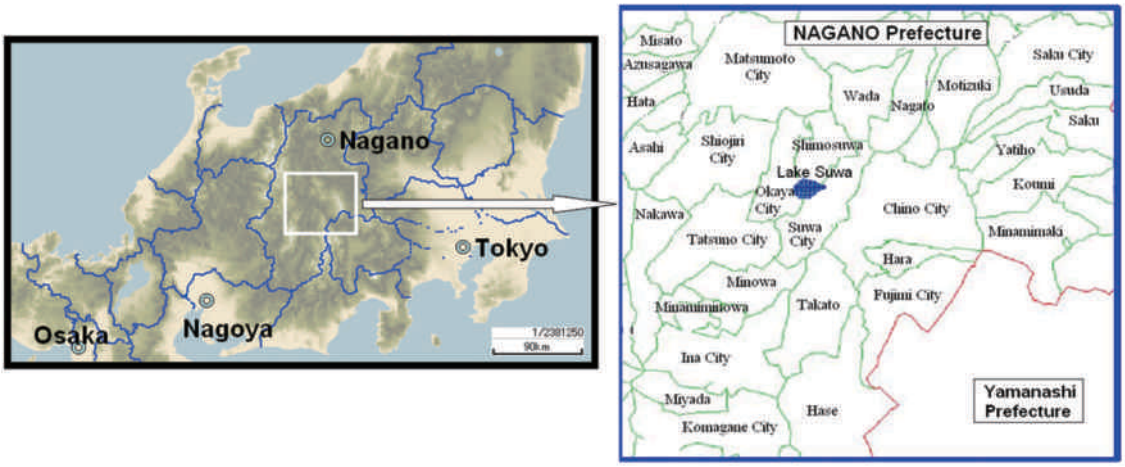

Fig. 4 Survey area on distribution and injury of *E. varivestis* in Nagano Prefecture.

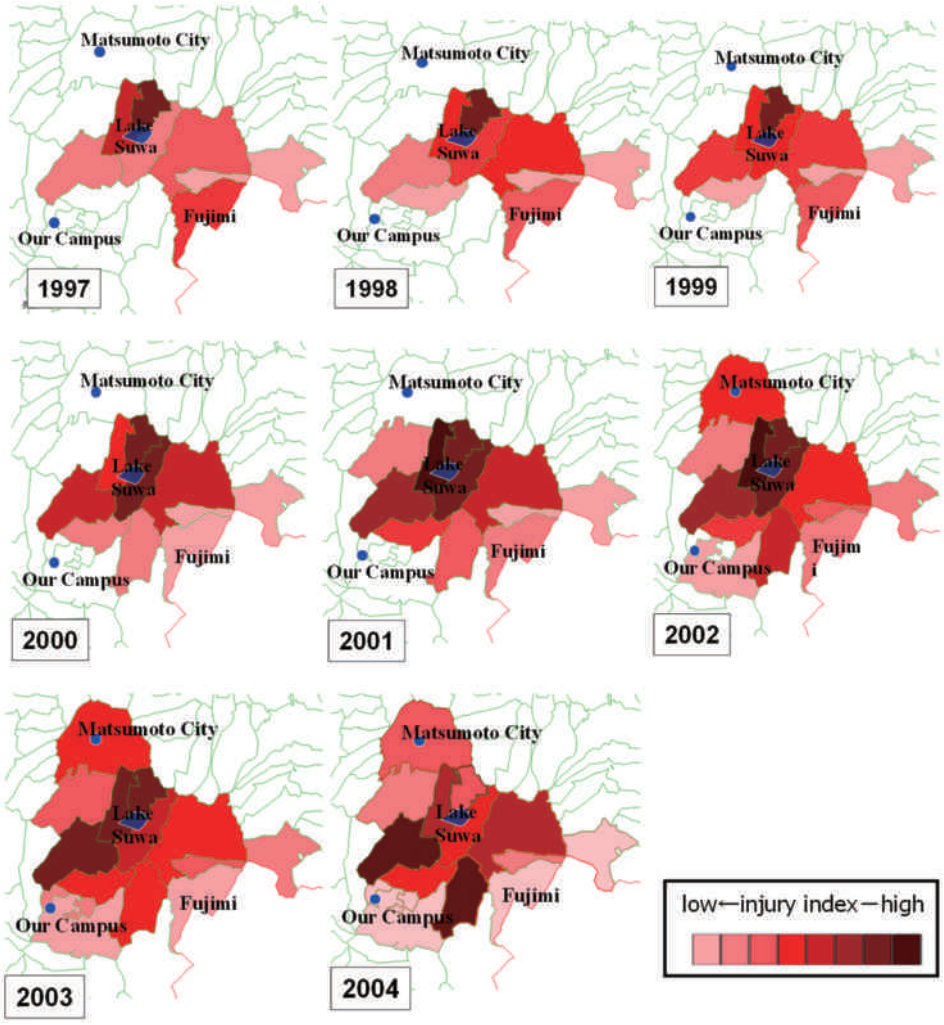

Fig. 5 Expansion process of distribution and injury index by *E. varivestis* from 1997 to 2004.

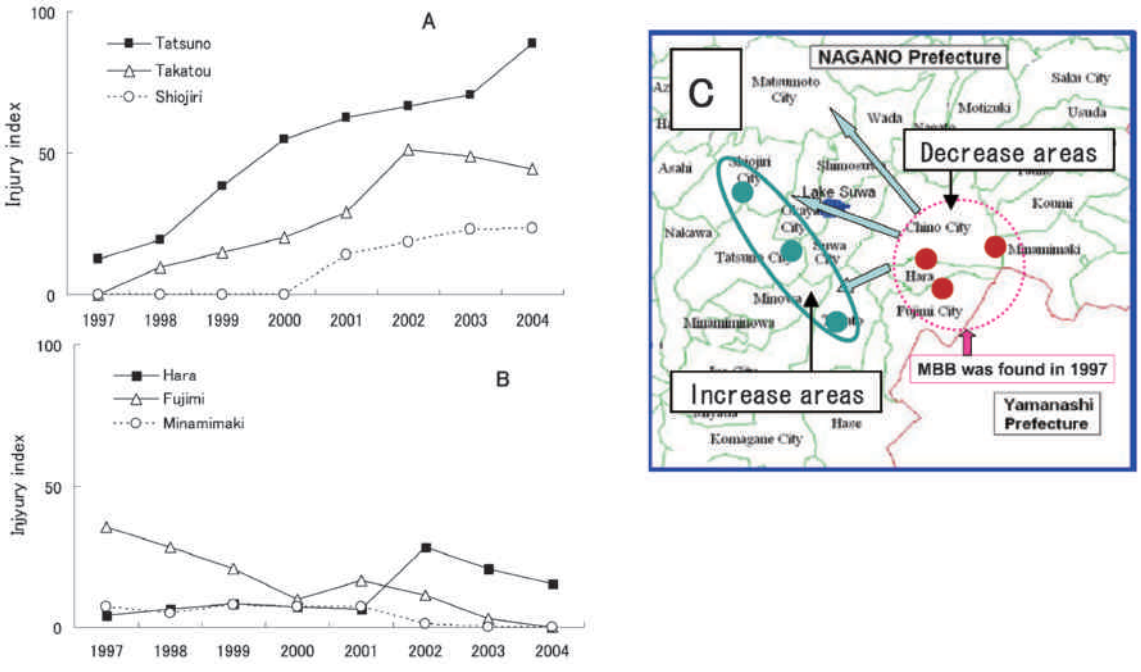

Fig. 6 Two patterns of annual change of injury index by *E. varivestis*
A : Increase areas of injury, B : Decrease areas of injury, C : Map of increase and decrease areas.

13 communities in 2004 (Fig. 5). First, distribution areas of *E. varivestis* were expanding during 8 years. Second, speed of expansion was not so fast. It took 10 years to expand from Fujimi Town to Ina City (about 45 km), that is, speed of 4.5 km/year.

On the other hand, its speed in the USA was 23 km/year. Why *E. varivestis* could not expand its range in Japan as quickly as in the USA ?

Annual change of injury index

To find the answer of above question, we analyzed these distribution maps in detail and there found two patterns on annual change of injury index. One is increasing pattern (Fig. 6A) and the other is decreasing pattern (Fig. 6B). Fig. 6C shows a map of decreasing and increasing areas. *E. varivestis* was found at Hara, Fujimi and Minamimaki in 1997 at the first time. Injury indexes of these areas are decreasing. Arrows in Fig. 6C indicate the direction of dispersion. Tatsuno, Takato and Shiojiri, where *E. varivestis* invaded after 1997, are the front of distribution .Injury index of these areas are increasing.

Native parasite

We carried out life table census from 1999 to 2002 at scarlet runner bean filed in Fujimi, where *E. varivestis* invaded before 1997. Fig. 7 shows the change of population density from1999 to 2003. The number of eggs (Fig. 7A) and young larvae (Fig. 7B) decreased gradually, and *E. varivestis* did not found at this field since 2003.

Why the density of *E. varivestis* became low in Fujimi ? In this area, two species of parasitic wasps, *Pediobius foveolatus* and *Nothoserphus afissae,* were identified from *E. varivestis* (Nakamura *et al.,* 2007). Fig. 8 shows some photos (adult, oviposition, larva and pupa) of tow parasites. *P. foveolatus* is gregarious parasitism and *N. afissae* is mono and ectoparasitism. These wasps were known as parasites of native *Epilachna* beetles in Japan. And these two wasps were useful for reducing the *Epilachna* beetle population in Japan. These native natural enemies attacked the new invaded insect pest as shown in Fig. 9.

It was founded from the ratio of parasitism that these wasps might be the cause of decreasing injury index of *E. varivestis* in this area. Table 2 shows the percent of parasitism by two native

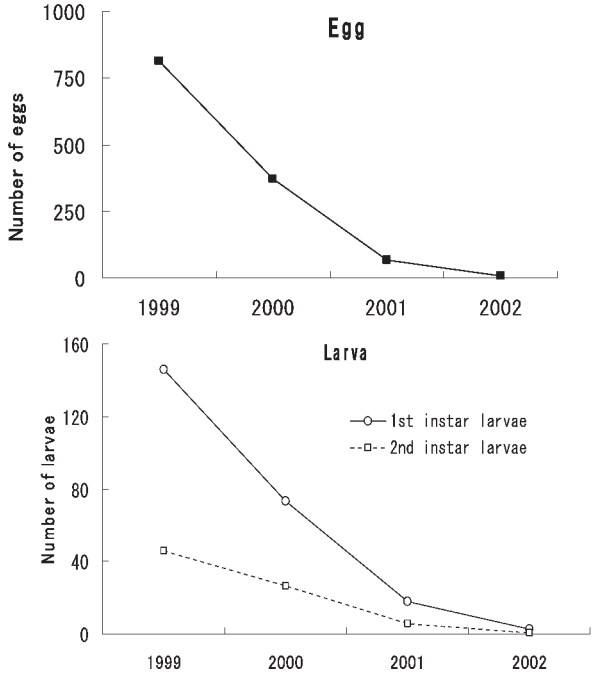

Fig. 7 Change of density of *E. varivestis* at scarlet runner bean field in Fijimi from 1999 to 2002.

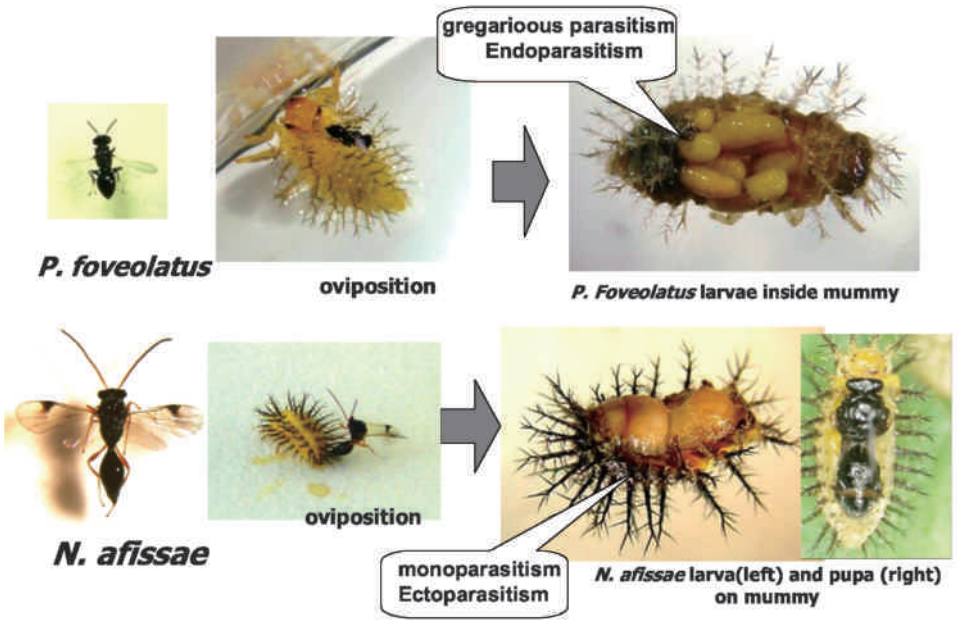

Fig. 8 Life cycle of two parasites, *Pediobius foveolatus* (Hymenoptera : Eulophidae) and *Nothoserphus affisae* (Hymenoptera : Serphidae).

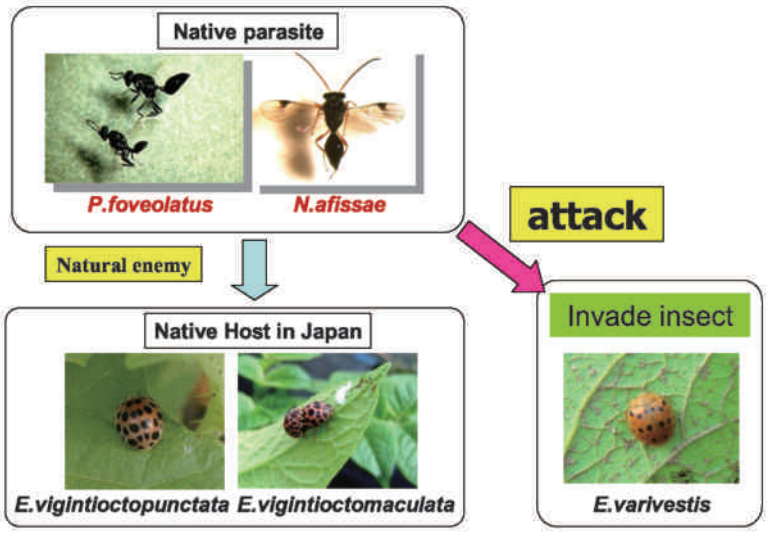

Fig. 9 Native parasites attack *E. varivestis* which invaded in Japan.

Table 2 Percent of parasitism by two native parasites to the 4th instar larvae of *E. varivestis* in Fujimi census field

Year		1999		2000	
Generation of *E. varivestis*		First	Second	First	Second
No. of the 4th instar larva		445	10	164	16
No. of mummy	by *P. foveolatus*	271	208	78	85
	by *N. affisae*	235	33	0	0
Total		951	251	242	101
% parasitism	by *P. foveolatus*	28.5%	82.9%	32.2%	84.2%
	by *N. affisae*	24.7%	13.1%	0.0%	0.0%

parasites to the fourth instar larvae of *E. varivestis* in Fujimi census field in 1999 and 2000. More than 80% of the fourth instar larvae of the second generation were parasitized by *P. foveolatus*. This high percentage of parasitism shows that these native natural enemies may suppress the density of *E. varivestis*.

On the other hand, there was no parasite in USA, when *E. varivestis* invaded into USA. So, it can be concluded that *E. varivestis* could expand so faster in USA than in Japan because of natural enemy free.

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