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Report on the Occurrence and Control of the Asian Gypsy Moth (AGM), *Lymantria dispar* (Linnaeus) (Lepidoptera: Lymantriidae) in Port Areas of Japan

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Abstract: The occurrence and distribution of the Asian Gypsy Moth (AGM) within the 32 port areas of Japan was investigated from 2004 to 2008 in a trapping survey using a pheromone attractant (disparlure). AGM occurrence shifted later in the year with the increasing latitude of ports, from mid June to late July in southwestern regions, and from early August to mid September in Hokkaido. The trapping periods at each port varied from one locality to another, but the average was approximately 40 days. The relationship between the location of each trapping site and the numbers of AGM trapped indicated that the distribution of AGM within port areas was concentrated in green belts where hosts were abundant. Next, in order to evaluate the effectiveness of control actions, the numbers of AGM trapped at four ports where various control methods were used in 2007 and 2008 were compared with those of previous years or at other ports. The results indicated that control actions were effective to some extent in the cases of four of the ports.

Keywords: *Lymantria dispar*, occurrence, distribution, control, Lymantriidae

Introduction

The gypsy moth, *Lymantria dispar* (Linnaeus, 1758) is distributed widely in the Holarctic region and attacks a wide variety of trees, making it the most notorious pest of forests and ornamental trees in the world (LEONARD, 1974). It is classified into two groups or types: the European Gypsy Moth (EGM) and the Asian Gypsy Moth (AGM). The biological differences between the two groups (e.g. host range, female behavior) as well as genetic differences examined through DNA analysis have been reported by various authors (BOGDANOWICZ *et al.*, 1993; PFEIFER *et al.*, 1995; BOGDANOWICZ *et al.*, 1997; SCHREIBER *et al.*, 1997; REINEKE and ZEBITZ, 1999).

At the request of the United States and Canadian governments, a program to certify the absence of AGM on vessels heading for those countries from so-called high-risk ports (hereinafter referred to as designated ports) was initiated from 2007. It is believed that AGM is likely to lay its egg masses on vessels at those ports. The intention is to prevent AGM invasion through AGM egg masses on vessels as a pest pathway.

The Ministry of Agriculture, Forestry and Fisheries has conducted trapping surveys for AGM in the port areas where any vessel bound for North America has anchored since 2004, and control measures such as egg-mass destruction, chemical spraying, and larval trapping with burlap bands were conducted by the organization concerned with the AGM program from 2007 (YOKOCHI, 2007).

Based on the survey and control measures, this report was prepared to clarify AGM occurrence and distribution within the port areas of Japan, and to evaluate the effectiveness of controls taken mainly at designated ports.

Materials and Methods

1. Trapping survey and egg mass collecting survey

AGM traps using disparlure were set up within port areas at 32 ports. Five to 10 traps were set up in each port

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within a radius of 1 km of berths where vessels destined for North America were docked. Trap density was about two traps per square kilometer. The traps were placed on the trunks of trees, etc., 1.2–1.5 meters above the ground. The trapping period was from May to October, and collection of AGM captured in traps was conducted once per week or once per two weeks by plant quarantine inspectors at each port. Disparlure offered by the USDA was used during the trapping period.

In addition, the distribution of egg masses was investigated in 2005 and 2006 to obtain more information on the occurrence of AGM within the port areas.

2. Control measures

Control measures conducted in some ports were as follows. Some of these measures were taken at each port, with consideration for the circumstances or location of target areas (e.g. residential or industrial zones, roadside trees).

a) Egg-mass destruction

Possible oviposition sites such as tree trunks and walls were checked visually, and egg masses discovered were removed and destroyed.

b) Chemical control

For the control of larvae, some insecticides such as Trebon, Dipterex and DDVP were sprayed on the trees where larvae were discovered.

c) Larval trapping with burlap bands

Burlap bands were placed on the lower part of tree trunks, and larvae (after 4th instar) resting beneath them in the daytime were removed and destroyed.

d) Cleaning up surroundings (cutting branches, weeds, etc.)

The branches of roadside trees and weeds on the ground were cut to create circumstances in which larvae would have difficulty surviving.

Results and Discussion

1. The occurrence and distribution of AGM within port areas of Japan, 2005–2006

To evaluate the risk of AGM egg mass attachment to vessels and to plan control measures, it is fundamentally important to clarify the prevalence and distribution of AGM within port areas. Therefore, at first, the season and period of the AGM were investigated using disparlure at each port (Fig. 1). Because Japan has a wide range of latitude, prevalence of AGM differs among ports. In southwestern regions, the season of the adult AGM started earlier and finished earlier (mid June through late July). In the northern Hokkaido and Tohoku regions, the season started about one month later than in the southwestern regions, then finished later, in late July to late September. The average trapping period in all ports was about 40 days.

Next, trapping data was analyzed by the distance from berths to each trap, trap surroundings, and distance from nearby green belts that are the main habitat of AGM. The numbers of AGM males trapped increased with distance from the berths (Fig. 2), and numbers were considerably higher in traps placed in green belts where hosts were relatively abundant (Fig. 3). The numbers decreased drastically in traps located more than 20 m from green belts (Fig. 4). The data on egg-mass collection was also analyzed by the classification of distance from green belts and the height of collection from the ground (Figs. 5, 6). The egg masses were distributed in concentration in green belts as shown in the results of the trapping survey. The height of egg-mass collection was mostly lower than 3 m above the ground. By structure where the egg masses were laid, the data was divided into two categories, host or nonhost, however, the difference between them was not obvious in this analysis.

From these results, it was suggested that AGM was not distributed evenly within port areas, but also existed in concentration in the green belts identified as their main habitat. Thus, control of AGM in green belts is key to reducing the occurrence of AGM within port areas.

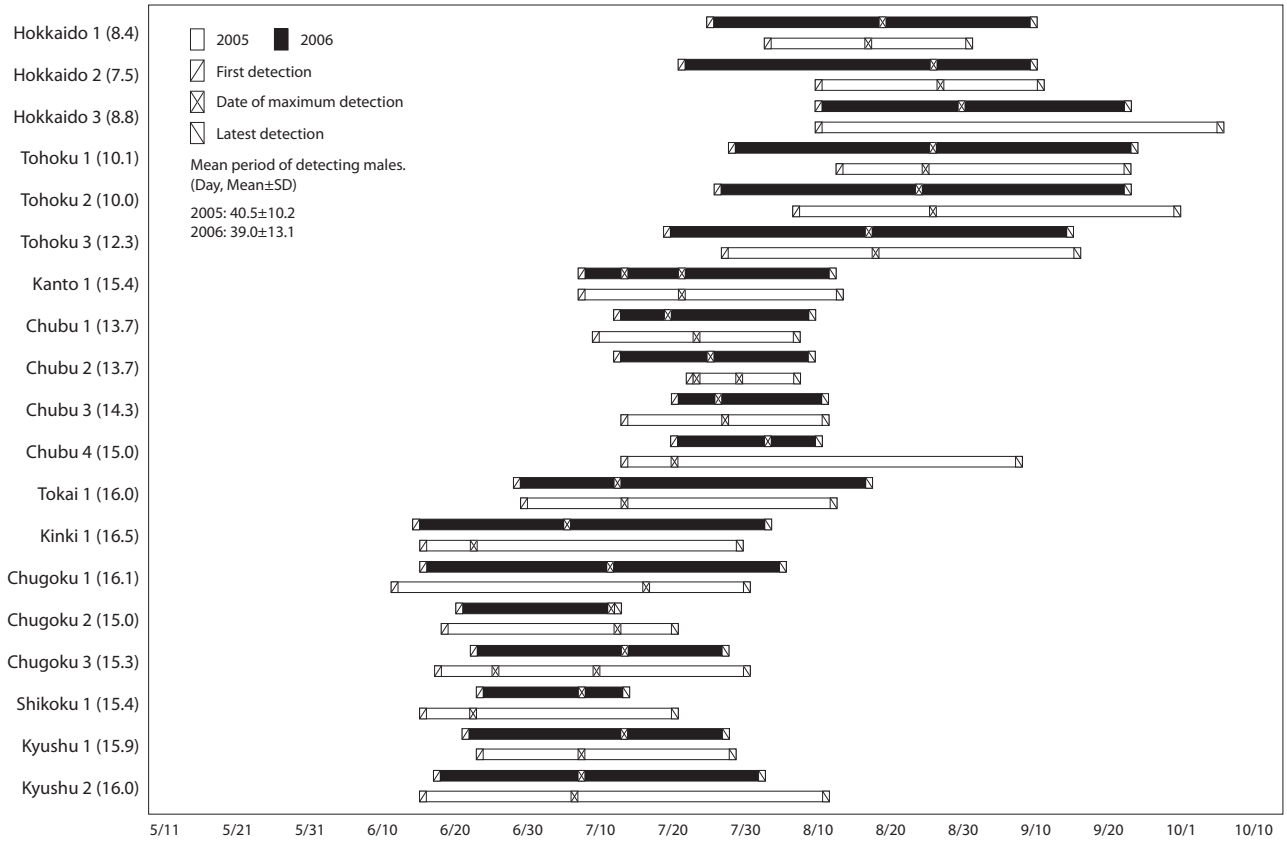

Fig. 1. Detection period of AGM males by pheromone trap in 19 ports of Japan (2005, 2006).
Ports are arranged from north to south. and the parentheses indicate the annual mean temparature (°C) of the ports (1971–2000, Japan Meteorological Agency).

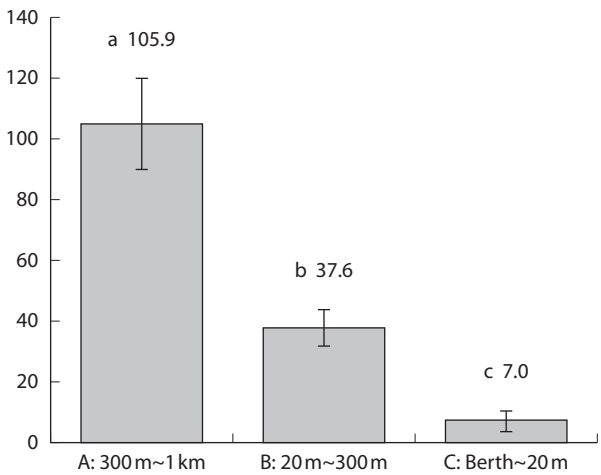

Fig. 2. The number of AGM captured per one trap, classified by the distance the berth and traps (Means ± SE).
Values with the different letter (a, b, c) are significantly different ($p < 0.05$; Tuckey-Kramer HSD test).

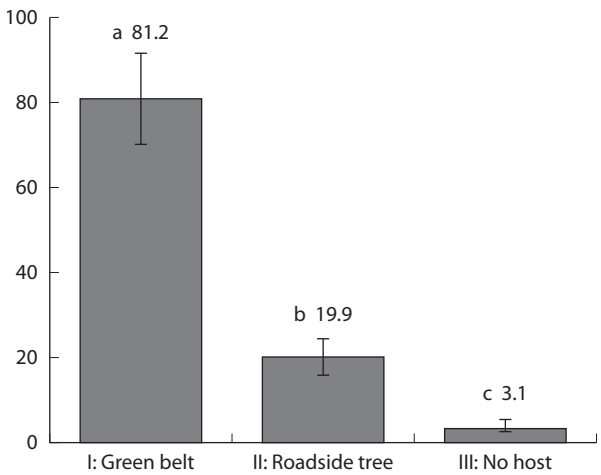

Fig. 3. The number of AGM captured per one trap, classified by the circumstances around trap (Means ± SE).
Values with the different letter (a, b, c) are significantly different ($p < 0.05$; Tuckey-Kramer HSD test).

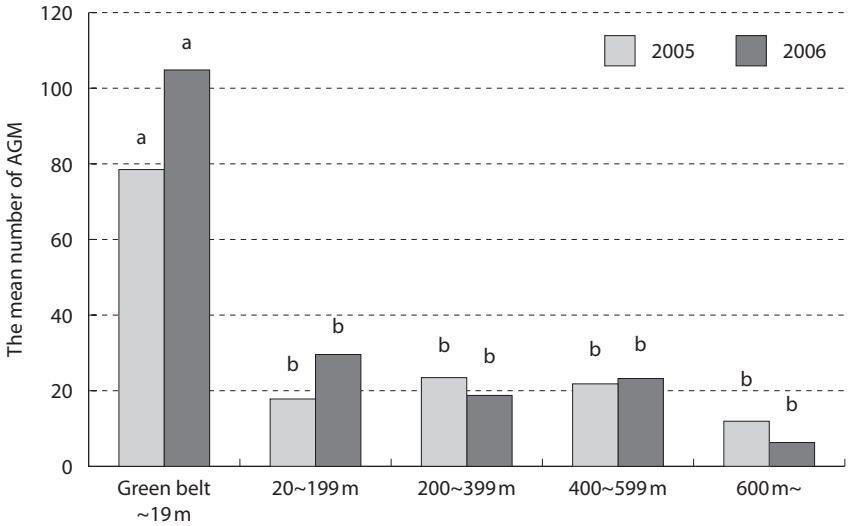

Fig. 4. The mean number of AGM captured per one trap,classified by the distance from trap and nearest green belt (11 ports). Values with the different letter (a, b) within the same year are significantly different ($p < 0.05$; Williams test).

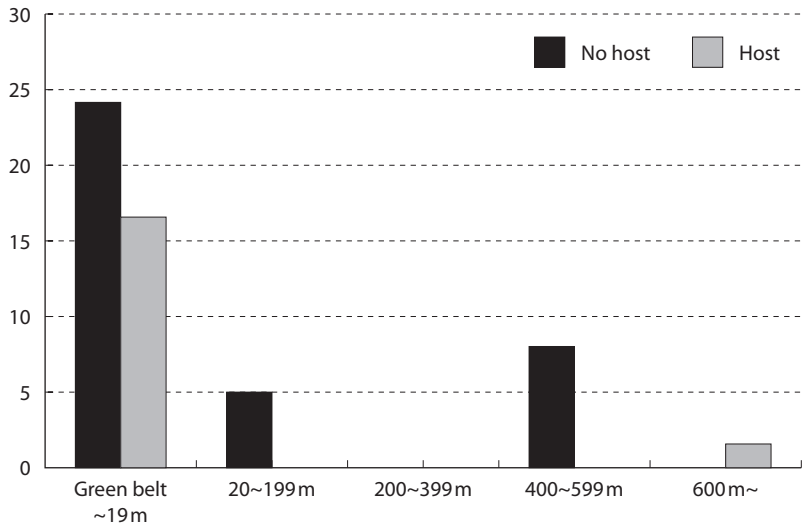

Fig. 5. The number of AGM egg mass discovered, classfied by the distance from green belts nearby (11 ports).

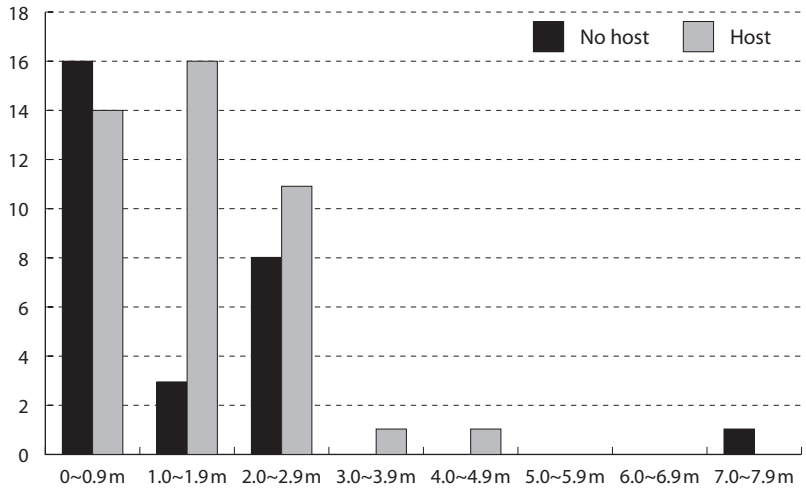

Fig. 6. The number of AGM egg mass discovered, classfied by the height from the ground (19 ports).

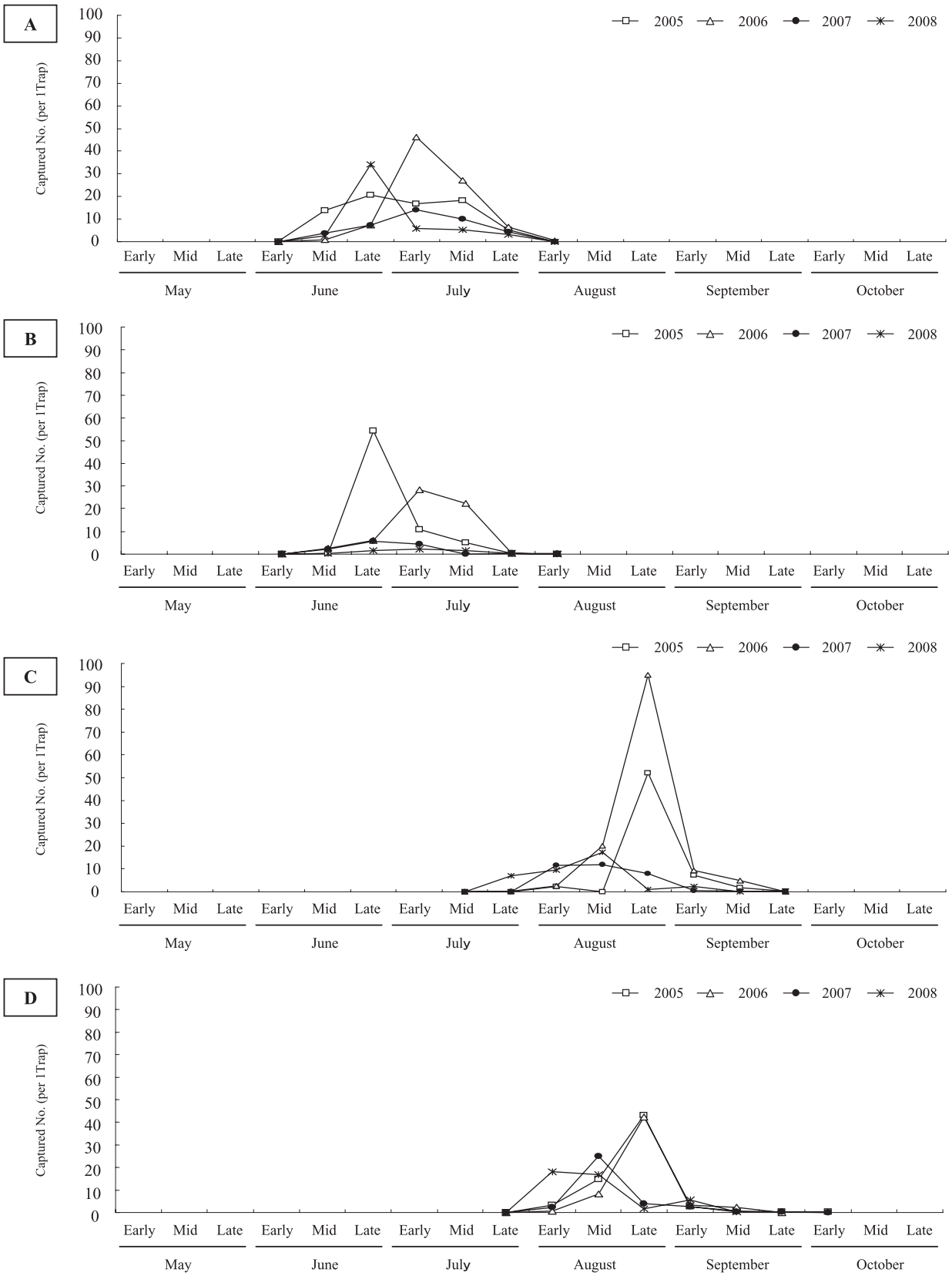

Fig. 7. Seasonal trend in the average number of AGM per trap in each designated port (2005–2008).

2. The occurrence and control of AGM in four designated ports (2005–2008)

The control actions shown in Materials and Methods were conducted from 2007, mainly at the ports where AGM was relatively abundant. In order to try to evaluate the effectiveness of the control actions, trends in trapping numbers at four designated ports were compared among years, and also compared with the data from other ports.

First, the changes in trapping numbers in the four ports from 2005 to 2008 are shown in Fig. 7.

a) Port A (Chugoku)

The results of trapping showed a fluctuation in abundance over the past four years. The trapping period was from mid June to late July, and peaks were recognized from late June to mid July in 2005 and 2006. In 2007 and 2008, larval trapping with burlap bands was conducted from June to July in the green belts, and roadside trees and weeds were cut from May to August. The numbers in 2007 and 2008 decreased compared to the previous two years. However, the difference was not so significant, thus, more intensive control actions were expected to reduce the AGM population.

b) Port B (Kinki)

The results of trapping showed a fluctuation in abundance over the past four years. The trapping periods were from mid June to late July, and peaks were recognized from late June to mid July in 2005 and 2006. In 2007 and 2008, chemical spraying was conducted on nearby parkland and the port area from April to August, and tree-branch cutting on parkland and roadsides was done from February to August. As a result, the numbers in 2007 and 2008 decreased drastically compared to the previous two years; thus chemical control in the larval stage might be effective in reducing the AGM population.

c) Port C (Tohoku)

Trapping periods in 2005 and 2006 were from early August to mid September, and peaks were recognized in late August. In 2007 and 2008, the following control measures were conducted: Egg-mass destruction was done from November to April; chemical spraying was done 2 to 3 times on green belts from May to July; larval trapping with burlap bands was done in July and August; and cleaning up by cutting tree branches and weeds was done from April to October. As a result, the numbers trapped in 2007 and 2008 decreased compared to the previous two years, and no obvious peaks were recognized through the trapping season. In some regions close to Port C, outbreaks of AGM were recorded in 2007 and 2008, so the abundance in Port C might also be elevated. Nonetheless, a decline in numbers trapped at the port was recognized in 2007 and 2008. This fact suggested that control measures taken in the port area were highly effective in reducing the AGM population.

d) Port D (Hokkaido)

The trapping periods in 2005 and 2006 were almost the same, from early August to mid September, and peaks were recognized in late August. In 2007 and 2008, chemical spraying was conducted on green belts and roadside trees from May to July. As a result, the numbers in 2007 and 2008 decreased as compared to the previous two years. However, the difference was not so significant, thus, more intensive control actions were expected to reduce the AGM population as at Port A.

To summarize the effects of control measures at the four ports, the average number of AGM per trap in each port is shown in Fig. 8. In 2007 and 2008 the numbers decreased as compared with those of 2005 and 2006, especially in the cases of ports B and C, and the differences were significant by ANOVA ($p<0.01$), indicating that control measures taken at these ports were effective in reducing AGM populations.

The effect of control measures at the above four ports was also evaluated by comparison of the numbers of AGM trapped in 2005–2006 and in 2007–2008, in conjunction with data on 15 other ports (Fig. 9). As a result, the number of AGM trapped at the four designated ports in 2007–2008 obviously decreased compared to 2005–2006. On the contrary, the numbers at 15 other ports in 2007–2008 mostly increased or did not change compared to 2005–2006. The results also suggested that control measures taken at the four designated ports were effective to some extent.

Concluding Remarks

The trapping survey indicated that AGM existed in concentration in green belts within port areas, so suppressive controls in these areas, such as chemical controls, egg-mass destruction, and larval collection might effectively reduce

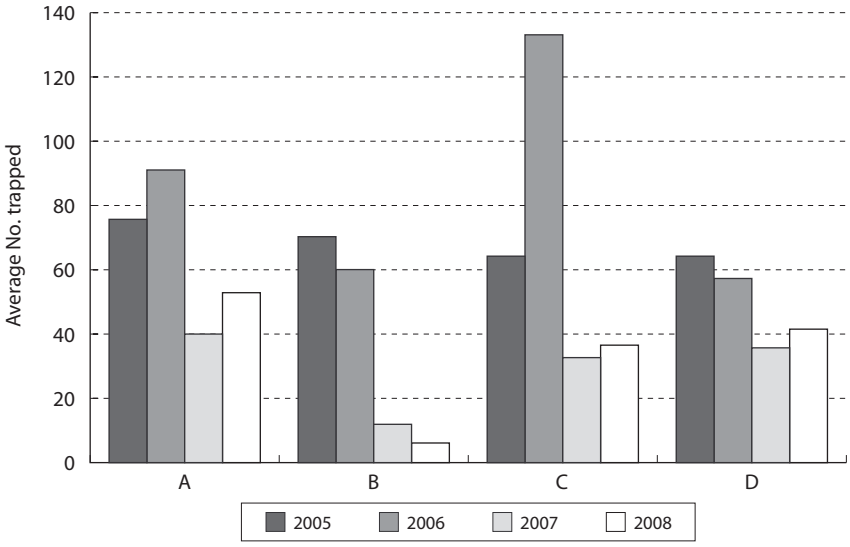

Fig. 8. Average number of AGM per one trap in each designated port (2005–2008).

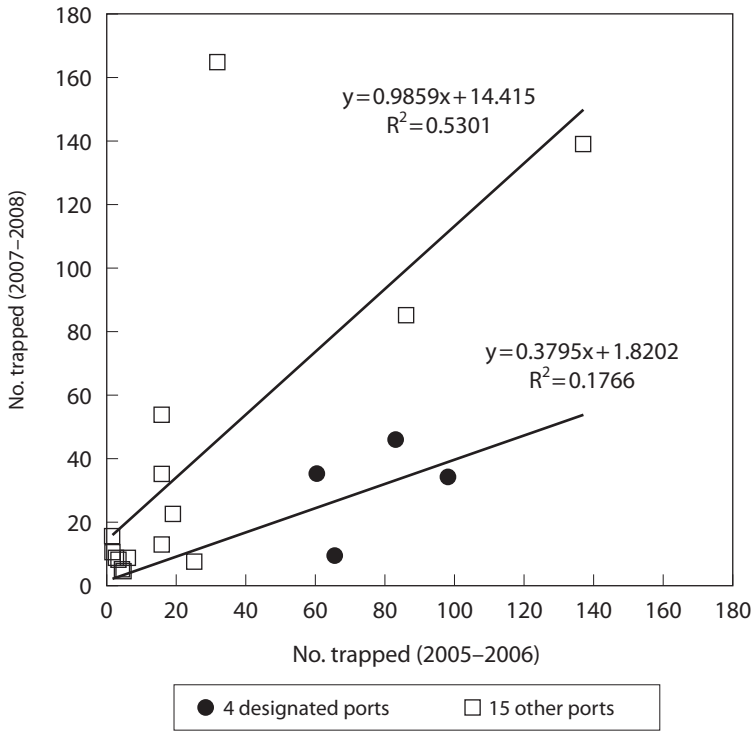

Fig. 9. Comparison between the average numbers of AGM trapped in each port (19 ports) in 2005–2006 and those in 2007–2008.

the risk of egg-mass attachment to vessels.

According to comparisons in numbers trapped at the four designated ports in 2005–2008, these ports showed a declining tendency in 2007 and 2008. Thus, control measures conducted at the four ports might be effective in reducing the AGM population.

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和 文 摘 要

日本の港湾地域におけるアジア型マイマイガ（AGM）、*Lymantria dispar*（Linnaeus）の発生と防除状況

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日本各地32港の港湾地域におけるアジア型マイマイガ（AGM）の発生と分布状況を、フェロモントラップ（Disparlure）による雄成虫の捕獲により調査した（2004–2008年）。また、2007、2008年に一部の港で実施された卵塊捕殺、殺虫剤散布、幼虫捕殺等の防除効果をトラップ捕獲数で評価した。その結果、成虫の発生時期は、各地の気候条件を反映して西南部で早く（6月中旬から7月下旬）、北上するに従って遅くなり、北海道では最も遅かった（8月上旬から9月中旬）。各地での発生期間は地域差があるものの、平均すると約40日間であった。トラップ設置場所の環境と捕獲数の関係から、港湾地域の比較的狭小な面積（半径1km）においても、AGMは一様に分布するものではなく、寄主が多いと考えられる緑地に集中して分布する傾向が認められた。次に、2007、2008年に各種の防除が実施された4港におけるトラップ捕獲数を防除実施前や他港の捕獲数と比較した結果、捕獲数に減少傾向が認められ、各種防除対策の効果が上がったものと推察された。

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