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摘　要

从 2001 年 7 月 10 日至 2001 年 8 月 29 日，在山西省应县林场一片 10 公顷杨树林中，通过释放 85 Gy 辐射不育光肩星天牛雄虫，对辐射不育法控制光肩星天牛种群繁殖的效果进行了研究。尽管平均释放比仅为 2～5，但不同方法的调查结果都显示，释放的辐射不育虫有效地抑制了林间光肩星天牛自然种群的繁殖。结果表明，当代光肩星天牛种群卵孵化率为 20％左右，F1 代存活率为 27％左右。

关键词：辐射不育　释放比　光肩星天牛

Control of *Anoplophora Glabripennis* by Releasing Sterile Insects

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ABSTRACT

An experiment to evaluate the effect of released sterile insects on reproduction of natural *A. glabripennis* population was conducted at a 30-hectare poplar tree forest in Ying County of Shanxi Province from July 10 to August 29, 2001. Though the releasing ratio was only about 2～5, results from different methods showed that the reproduction of natural *A. glabripennis* population was suppressed effectively by releasing sterile insects, and that hatch ratio of eggs laid by parent generation was about 20% and survival ratio of F1 progeny about 27%.

Key words: Sterile-insect-technique, Release ratio, *Anoplophora Glabripennis*

In recent years, *Anoplophora glabripennis* was one of most serious pests for poplar tree forests in part of Inner Mongolia and Ningxia autonomous regions and Shanxi Provinces of Three North Protection Forest of China. Currently, the most effective method of controlling them is to cut infested trees, replacing them with nonhost species. Thus, the great plenty of infested trees need to be replaced and it is really a hard work hardly to be achieved during a short period. Further more, cutting of infested trees was not the best choice because of the important role of Three North Protection Forest in protection against wind and desert. Since it was difficult to control *A. glabripennis* by the routine methods, SIT (Sterile insect technique) was tried for this goal.

1 MATERIALS AND METHODS

The beetles, *A. glabripennis*, used in the experiment, came from two sources. One was laboratory colony (Originally from the Shanxi province, China), reared with artificial diet for about 6～8 month. The other was natural colony collected directly from poplar tree forest.

A cobalt-60 source was used for irradiation. A dose rate of 1.5 Gy/min was used to administer a sterilizing dose of 85 Gy. Irradiated insects were marked with yellow paint and then transported to releasing site.

Experiment was conducted at a 30-hectare poplar tree forest in Ying County of Shanxi Province from July 10 to August 29, 2001. Irradiated *A. glabripennis* were released into a 10-hectare area and the other was set as the control area. Releasing area was isolated from the control area by empty zones.

1. 1 Investigation of release ratio

Method 1

Eight sites were distributed averagely in the releasing area, and a site included nine poplar trees. All of natural beetles and marked beetles on these trees were collected every day noontime for release ratio estimating.

Method 2

All of natural beetles and marked beetles that could be caught were collected as soon as possible in the whole releasing area every three days for release ratio estimating, and then marked beetles were released back.

1. 2 Effects of releasing irradiated male beetles on the reproduction of field population

Method 1

During the late stage of releasing, normal males (N♂), normal females from the control area (N♀) and females from the releasing area (R♀) were collected respectively and mated as follow:

N♀×N♂, R♀×S♂(irradiated male) and just R♀ which did not paired any males. Eggs laid by these females were incubated for estimating of hatch ratio, and the difference of their hatch ratio was compared to illuminate effects of releasing irradiated beetles on reproduction of natural beetle population.

Method 2

A month after releasing, 20 poplar trees were selected respectively in the releasing area and the control area, and numbers of laying marks, eggs and larvae on these trees were recorded. Then the fecundity and the survival ratio of F1 progeny were calculated for estimating of releasing effects.

2 RESULTS

2. 1 Investigation of release ratio

2630 irradiated male beetles were released from July 10 to August 29, 2001, and the results of releasing and release ratio were showed on Fig. 1 to Fig. 4.

Method 1

Form July 13 to August 25 there were 159 irradiated males, 102 normal males and 123 normal females captured from eight sites. Average release ratio was 2.47±2.61, and the maximum release ratio was 11 (Fig. 1 and Fig. 2).

Method 2

Form July 13 to August 25 there were 689 irradiated males, 513 normal males and 641 normal females captured from the whole releasing area. Average release ratio was 2.19±1.20, and the maximum release ratio was 4.14 (Fig. 3 and Fig. 4).

2. 2 Effects of releasing irradiated male beetles on the reproduction of field population

Method 1

Eggs collected from three different mating types and their hatch ratios were listed in Table 1.

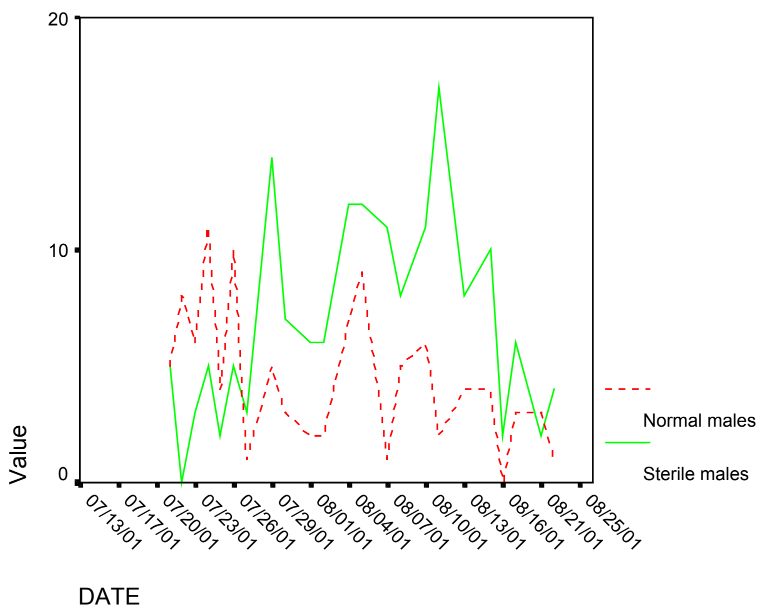

Fig. 1　Captured normal males and irradiated males from eight sites set in the releasing area

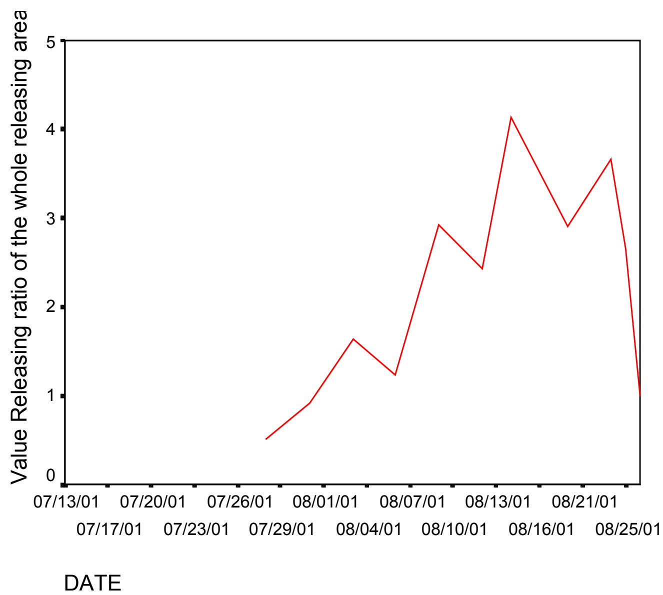

Fig. 2　Release ratio got from eight sites

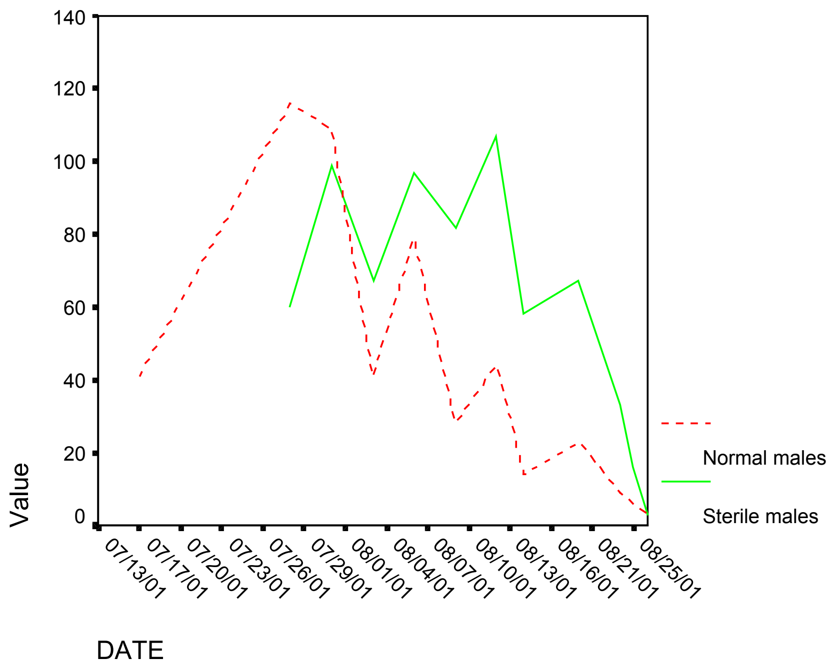

Fig. 3 Captured irradiated males and normal males from the whole releasing area

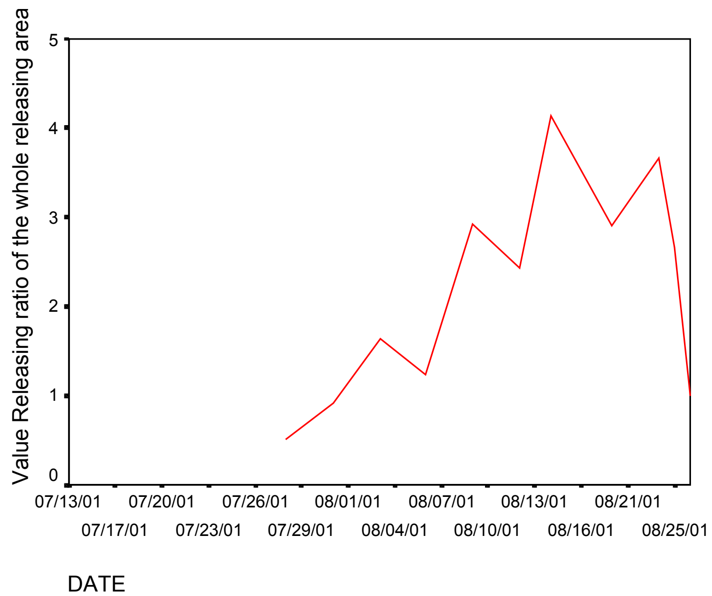

Fig. 4 Release ratio got from the whole releasing area

Table 1　Hatch ratios of eggs laid by different types of mated females

Types	Eggs	Hatched eggs	Hatch ratio
N♀×N♂	26	24	92.31%
R♀×S♂	49	10	20.41%
R♀	73	14	19.18%

The hatch ratio of females in the releasing area, which did not paired to any males, was almost same as that of females from the releasing area mated to normal males, and they were all lower than that of normal females mated with normal males significantly ($P<0.05$). In this method, the type R♀×S♂ was designed to assure mating of females with irradiated males, and meanwhile it was set as a control for females from the releasing area which freely mated with normal males or irradiated males in the releasing area. *A. Glabripennis* were polygamous, and a female could mate 27 times a day in the lab. Females in the releasing area might mate with normal or irradiated males, and logically the hatch ratio of these females should higher than that of females just mated with irradiated males. The result showed that the hatch ratio of females from the releasing area was even a little lower than that of females mated to irradiated males. This means that irradiated males prevented the mating between females and normal males in the releasing area, or sperm coming from irradiated males prevented the fertilization of sperm coming from normal males.

Method 2

Female *A. glabripennis* laid its eggs under poplar tree bark, and then a mark was left on its surface. This mark was evidently different from marks left by beetles after they fed on poplar tree bark. There might be one, two or none eggs left beneath one laying mark, and mostly only one egg. Because of difficulty of data collecting for actual eggs laid by every female beetle under the natural condition, relative fecundity was used as a parameter to indicate the oviposition ability. Results in Table 2 showed that there was no significant difference for relative fecundities between the releasing area and the control area ($P>0.05$), and F1 progeny survive ratio of the releasing area was significantly lower than that of the control area ($P<0.05$). It exhibited more dead larvae and eggs in the releasing area. Evidently, releasing of irradiated male beetles suppressed the reproduction of natural *A. glabripennis* population significantly.

In Table 2, relative fecundity was calculated as follow: (Live larvae＋Dead larvae＋Live eggs＋Dead eggs)/Laying marks. Live F1 progeny of the releasing area was calculated as follow: Live larvae＋0.1389 Live eggs, in which the parameter 0.1389 was the hatch ratio of eggs collected from the releasing area. Live F1 progeny from the control area was calculated as follow: Live larvae＋0.9231 Live eggs, in which the parameter 0.9231 was the hatch ratio of normal eggs collected from the control area. The survive ratio was calculated as follow: Live F1 progeny/(Live larvae＋Dead larvae＋Live eggs＋Dead eggs).

Table 2 Investigation of F1 progeny in the releasing area (Means±SD)

	Laying marks	Live larvae	Dead larvae	Live eggs	Dead eggs	Relative fecundity	Live F1 progeny	Survive ratio %
Releasing area	40.37±21.33a	4.89±3.65a	2.37±2.22a	3.79±3.52a	8.63±5.96a	48.91±16.13a	5.42±3.92a	27.26±15.03a
Control area	15.67±11.70b	5.83±5.31a	0.17±0.39b	1.67±2.64a	0.08±0.29b	56.02±21.94a	7.37±4.97a	95.46±7.04b

Note: Means followed by different letters in the same column are significantly different (Multiple range tests: Duncan test with significance level 0.05)

3 DISCUSSION

Since the average dispersal distance of *A. glabripennis* population was 106.3 m (LI Youchang[1], 1996) irradiated beetles were released at several averagely distributed points at first several days of experiments. However, dispersal of beetles was not so ideal as expected that they had to be distributed artificially. In fact, these beetles even cannot fly more than 50 m. During the whole experiment it was only 4 irradiated beetles found flying across the isolating empty zone into the control area, which was only about 50 m wide. These beetles' low flying abilities and their relative biggish body-forms enable them easy to be captured. It was a basis to get the beetles for calculation of the release ratio.

There was only one generation of *A. glabripennis* emerged every year from July to August in Ying County of Shanxi Province. To get an ideal release ratio, normal beetles in the releasing area were captured to suppress the natural population level during the whole releasing. Because it was difficult to capture *A. glabripennis* with pheromone-attraction, these beetles including normal beetles and released irradiated beetles had to be collected by shaking the stem of poplar tree, and of course release ratio was not so effective and accurate as that of the other species which could be captured with pheromone. Since flying ability of new emerged beetles was significantly lower than that of full-blown beetles, and capturing of beetles was conducted everyday from the beginning of *A. glabripennis* emergency to the end of releasing experiment in the releasing area, normal beetles collected for release ratio calculation were mainly new emerged, and their flying abilities were also lower than released beetles. In fact, males were more difficult to be captured than females and released males were more difficult to be captured than new emerged natural males. Evidently, the real release ratio should higher than results calculated during experiment. Results of Table 1 showed that irradiated males almost prevented the mating between females and normal males in the releasing area. It was one of proofs for this.

In this experiment, the survive ratio of F1 progeny in the releasing area was significantly lower than that of the control area ($P < 0.05$), and releasing of irradiated beetles suppressed reproduction of natural population effectively. However, the average number of survived F1 progeny in the releasing area was no significant difference from that of the control area ($P > 0.05$). In fact, in order to get a high release ratio the low-beetle-population-leveled poplar forest was selected as the releasing area, and normal beetles had been captured to decrease the population level during the experiment in the releasing area and the control area meanwhile. Because of the great number of released male beetles, females in the releasing area got more mating chances and so that laid more eggs than females in the control area. It showed the more average laying marks in the releasing area ($P < 0.05$). This phenomenon, stimulation of mating to oviposition, was also occurred in other insect species such as cotton bollworm, *Helicoverpa armigera* (L. Noctuidae) (LIU Xiaohui[2], 1999), cabbage loopers, *Trichoplusia ni* and corn earworm, *Heliothis zea* (North D T & Holt[3], 1971) etc. The dosage 70～90 Gy can sterilize *A. glabripennis* absolutely in previous laboratory experiments by using reared beetles and so that 85 Gy was selected in this experiment. But in this experiment majority of released beetles were collected directly from field and then released after irradiation. It was plausible that natural beetles need a higher dosage to be sterilized absolutely. In fact, results from Table 1 showed that their hatch ratio was higher to 20.41% when normal females mated to 85 Gy irradiated natural males. Released beetles suppressed the reproductive of natural *A. glabripennis* population evidently. However, the effects of releasing irradiated beetles on development of F1 generation should be investigated further because it was only one generation of beetles emerging per year. A higher dosage such as 90 Gy or even 95 Gy should be tried in further experiments as well.

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