

Dwarfism of Lymantriid Moths of *Ivela auripes* (Lepidoptera) Breaking out in the Garden of the Institute for Nature Study, Tokyo, in 2007

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自然教育園で大発生したキアシドクガ(鱗翅目, ドクガ科)
成虫の小型化について, 2007年

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Abstract: Dwarfism of lymantriid moths of *Ivela auripes* in the Institute for Nature Study, Tokyo, in 2007 is investigated and compared with the results in 2005 and 2006. The length of male forewing was significantly larger than in 2006, and was identical with that in 2005. The length of female forewing did not change during the three years. In 2007, defoliation of *Swida controversa* caused by larvae of *I. auripes* was not so serious as in 2006, and the population density of *I. auripes* in 2007 was evidently smaller than in 2006. It is surmised that the increase of the male forewing length will be derived from decrease of the population density, that is, in 2007 larvae of *I. auripes* were able to take more food than those of 2006. On the contrary, the size of female moths did not change in three years. This phenomenon suggests that the survival strategies against shortage of food may be different between the two sexes.

Introduction

The occurrence of the lymantriid moth *Ivela auripes* was observed first in 2001 (Owada *et al.*, 2001) at the Institute for Nature Study (INS), Tokyo. In the urban area of Tokyo, this moth was not recorded at the end of the 20th Century (Owada *et al.*, 2000). At the Imperial Palace, Tokyo, two females were collected by a light trap in 2001 (Owada *et al.*, 2006), and several moths were collected in the Akasaka Imperial gardens in 2002 (Owada *et al.*, 2005).

In the garden of INS, the population size of the moth was kept rather small in 2002 and 2003, and the outbreak started in 2004 (Yano & Kuwahara, 2006). In 2005, defoliation of the host-plant, *Swida controversa*, Cornaceae, by *I. auripes* was so serious that investigations of this outbreak were carried out on the damage of

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host-plant (Yano & Kuwahara, 2006, 2007) and on the population size and dwarfism of *I. auripes* (Owada *et al.*, 2007).

In 2007, the outbreak of *I. auripes* in the forest of INS was still observed. The population size of this lymantriid moth seemed a little smaller than that in 2006, but the dwarfism of moths was still maintained. For a comparison of the population size and dwarfism of moths with those in 2006 and 2007, moths were collected by the same way and time as in 2006. In this paper, we are going to record this sampling result, and to discuss the population dynamics of *I. auripes* at INS, Tokyo.

Before going into further details, we express our sincere thanks to the following scientists for their kind aid to this investigation in many ways: Dr Shoji Hamao, Dr Hideho Hara, Dr Lutz W. R. Kobes, Dr Masao Ohno, Dr Paul W. Schaefer, and Dr Shun-Ichi Uéno.

Sampling and metrical methods

The sampling day, May 26, 2007, was fine, and Yano considered it the peak of occurrence of *I. auripes*. Owada used a pole (6 m in length) with a net (60 cm in diameter), and collected moths as many as possible from 10:00 to 12:00. This sampling method, interval and condition of occurrence are equivalent to those in the investigation of INS 2006, but different from those in INS 2005 and the Imperial Palace, Tokyo (IPT 2005) (Table 1) (see Owada *et al.*, 2007).

The forewing length is a distance from the basal hinge to the apex. Moths collected in this research were set in paper pouches, dried, and measured in millimeters with rounding to the nearest whole number. All the specimens investigated in this study are preserved in the National Museum of Nature and Science, Tokyo.

Results

A total of 189 males and 86 females were collected during two hours in 2007 survey (INS 2007). The 2006 survey (INS 2006) was conducted in the same way as in INS 2007, and a total of 522 males and 132 females were collected. The population size of *I. auripes* in INS 2007 is reduced to ca. 42% of that in INS 2006 (Table 1). The dwarfism of moths is as obvious in INS 2007 as those in INS 2005 and INS 2006 (Owada *et al.*, 2007), and variance of their forewing length and the mean length with SD are shown in Figs. 1-2 and Table 1.

In the male forewing length in INS 2007, the minimum size has been advanced to 16 mm, while it is 17 mm in 2005 and 2006, and the maximum size is 27 mm, which is equal in INS 2005 and is 1 mm longer than that of INS 2006. The mean length (22.5 mm, SD=2.2) was larger than that of INS 2006 (mean=21.4 mm, SD=1.8), was equal to that of INS 2005 (mean=22.5 mm, SD=2.3). The difference between the three years was statistically significant (one-way ANOVA, $F_{2, 891}=28.92$, $P<0.001$). In comparison with two groups, we found statistically significant difference between INS 2006 and INS 2007, and between INS 2005 and INS 2006 (both Turkey, $P<0.01$).

On the other hand, among the female forewing lengths of INS 2007 (mean=23.4 mm, SD=2.6), INS 2006 (mean=23.5 mm, SD=2.5) and INS 2005 (mean=22.8 mm, SD=2.7), we found no significant difference (one-way ANOVA, $F_{2, 243}=0.859$, $P=0.41$).

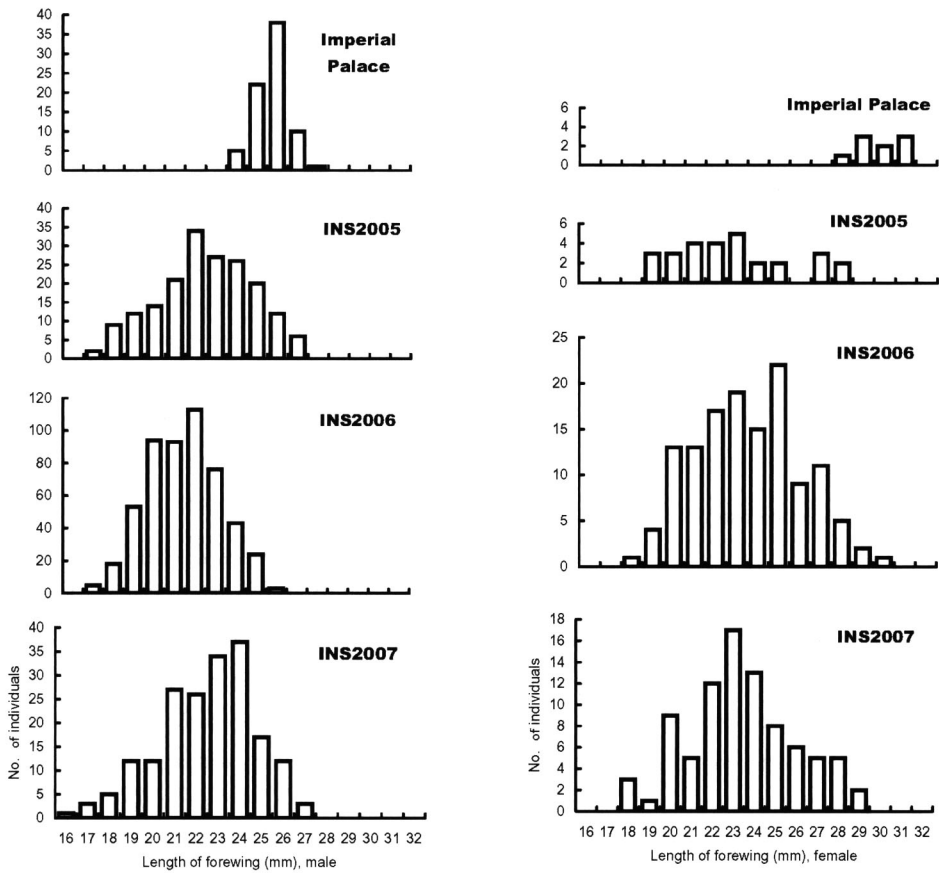


Fig. 1. Length of forewing of male (left) and female (right) *I. auripes*. Imperial Palace, Tokyo, 2005, control, larvae grown under enough leaves, and INS 2005, INS 2006 and INS 2007.

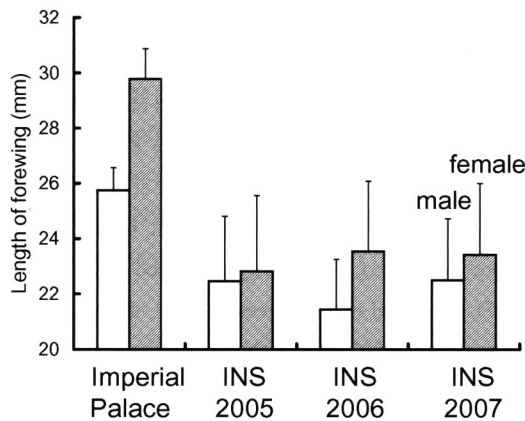


Fig. 2. Mean lengths and SD of forewing of *I. auripes* at the Imperial Palace, Tokyo, 2005, INS 2005, INS 2006 and INS 2007.

Table 1. Forewing length (mm) of *I. auripes* at Imperial Palace, Tokyo (IPT 2005), and Institute for Nature Study (INS 2005, INS 2006, INS 2007).

	IPT 2005		INS 2005		INS 2006		INS 2007	
	Male	Female	Male	Female	Male	Female	Male	Female
Mean	25.7	29.8	22.5	22.8	21.4	23.5	22.5	23.4
SD	0.8	1.1	2.3	2.7	1.8	2.5	2.2	2.6
<i>N</i>	76	9	183	28	522	132	189	86

IPT 2005: June 1st, 2005, 10:00-11:00; INS 2005: May 29th, 2005, 9:00-12:00;

INS 2006: May 26th, 2006, 10:00-12:00; INS 2007: May 26th, 2007, 10:00-12:00.

Discussion

Flight activity and forewing length of *I. auripes*

In the experimental sampling in 2007, the outbreak of *I. auripes* was obvious in comparison with the occurrence in 2005 at the Imperial Palace, Tokyo. Owada felt that moths in 2007 were fewer than those in 2006. The total of moths collected were 654 in 2006 and 275 (42 %) in 2007, though the sampling method, time and weather were almost the same. In 2006, many males were resting or flying from the ground to 2-3 m high, but in 2007, such moths were rather few. In 2006, 522 male moths were collected, and 189 male moths (36 %) were collected in 2007. In addition to this, flight activity of males in 2007 advanced clearly with significant increase of the forewing length. We noted that small males fly as active as larger males, and sometimes we observed copulations of smaller males (Owada *et al.*, 2007). However, it is clear that the excessive dwarfism of males decreases their flight activity.

On the other hand, sizes of the female forewing were not changed in 2005, 2006 and 2007. In 2006, 132 female moths were collected, and 86 female moths (65 %) were collected in 2007. It can be surmised that the actual decrease of moths in 2007 may be near to the female decrease, 65 %.

Relationship between defoliation degree and forewing length of *I. auripes*

The heavy defoliation of the host-plant, *Swida controversa*, and outbreak of *I. auripes* occurred in 2004, and monitoring survey of the defoliation was started from 2005 (Yano & Kuwahara, 2006). The garden of INS is ca. 20 ha, and all the trees of *Swida controversa* (10 cm over in diameter at breast height) are recorded. In 2006, 1,285 trees of *S. controversa* were recognized in the garden. Among them, the most heavily defoliated trees, in which leaves were completely lost, were 787 (61%), and heavily defoliated trees, most of leaves damaged, were 185 (14%) (Yano & Kuwahara, 2007). Of a total of 1208 trees in 2007, the most heavily defoliated trees were 457 (38%), and heavily defoliated trees were 397 (33%) (Yano & Kuwahara, 2008). In 2007, defoliation of *S. controversa* by larvae of *I. auripes* was not so serious as in 2006, and the population density of *I. auripes* in 2007 was evidently smaller than in 2006. It is surmised that the increase of the male forewing length in 2007 may be derived from decrease of the population density, that is, larvae of *I. auripes* in 2007 were able to take more food

than those in 2006. On the contrary, the size of female moths did not change in three years. This phenomenon suggests that the survival strategies against shortage of food may be different between the two sexes.

Occurrence of *I. auripes* was first observed in 2001 at INS, and one pair of moths were collected by Yano for identification (Owada *et al.*, 2001). Forewing lengths of the male and female specimens are 27.0 mm and 30.0 mm, respectively, and are longer than the mean lengths of the control population, the Imperial Palace, Tokyo, 2005 (male: 25.5 mm, n=76; female: 29.8 mm, n=9) (Table 1). It can be presumed that moths of *I. auripes* were normally sized, when they settled at the forest of INS.

In our previous paper (Owada *et al.*, 2007), it was surmised that “the high variance in the forewing length of moths from INS would be brought from variable larvae, whether they faced starvation or not, and many larvae would die before pupation, and some moths would be fully grown without starvation like those in the Imperial Palace, Tokyo”.

Kobes (1995) noted the occurrence of dwarf and/or brachypterous imagines of the gypsy moth, *Lymantria dispar*, an univoltine lymantriid species, by inbreeding of F17-19 offspring. On the other hand, moths of *I. auripes* in the forest of INS, Tokyo, were dwarfed within five years, from 2001 to 2005. This phenomenon is apparently caused by larval starvation. Food-plants of *Swida controversa* extraordinarily defoliated by the outbreak of *I. auripes*, and the shortage of food yielded dwarfed larvae. This is one of the survival strategies in *I. auripes*, of which larvae can survive against shortage of food, making very small pupae, and the small adults can leave their offspring (Owada *et al.*, 2007).

Outbreak continuation in *I. auripes* and death of *Swida controversa* in INS

Under the natural condition of the outbreak of *Ivela auripes*, most of seriously damaged food-plants, *Swida controversa* and *Cornus brachypoda* (Cornaceae), never perish (Togashi, 1994). During the three years, 2002-2005, however, ca. 100 trees (7 %) within 1,369 individuals of *S. controversa* died in the garden of the Institute for Nature Study, Tokyo (Yano & Kuwahara, 2006). During one year, 2005-2006, 86 trees (6.7 %) within 1,285 trees died, and as many as 162 trees (13.4%) within 1,208 trees died during 2006-2007 (Yano & Kuwahara, 2008).

Trichogramma sp. is known as an egg parasitoid wasp of *I. auripes* (Schaefer, 1983), and also some wasps and dipteran parasitoids of larvae are listed by Yasumatsu and Watanabe (1965). In INS, however, parasitoids and predators might not be able to control the population size of *I. auripes* during 2004-2007.

As was discussed in our previous paper (Owada *et al.*, 2007), since the Institute for Nature Study, Tokyo, is completely surrounded by urban buildings and roads, females, which are going to fly outside INS, may return to INS, and have to lay eggs to trees in INS. Trees of *W. controversa* might continue to perish until this extraordinary outbreak of *I. auripes* comes to an end.

摘 要

2004年から開始された継続的なキアシドクガの大発生によって、発生した成虫が小型化していることが明らかになったが、2006年に行ったサンプリング調査とまったく同じ調査を2007年にも行ない、個体数とサイズの変化を調べた。

樹冠部を飛翔する雄の個体数は、2006年に比べて少し減ったと感じたが、皇居の2005年の観察と比べると、大量に発生していることは間違いなかった。雌雄の合計サンプリング数では2006年が654頭であったが、2007年は275頭で前年の42%である。2007年の発生状況が2006年のものと大きく異なる点は、地上付近から2-3mの高さを飛ぶ雄の個体数が減少したことで、サンプリング個体数の522頭から189頭への36%であった。また、樹冠を飛ぶ雄の飛翔力も増加していたようで、前翅長も2006年のものに比べて有意に長くなっており、2005年の平均値と等しくなった。

一方、雌の採集個体数は86頭で、2006年の132頭の65%であった。雌の前翅長は2006年のものと同じであるので、飛翔行動は前年並みと考えられるから、成虫全体の発生量の減少はこの数値に近いものと推定できる。また、2005-2007年の3年間で雄の前翅長がミズキの被害の多寡によって有意に変化したのに比べ、雌の前翅長に変化はなかった。幼虫の飢餓に対する抵抗性や適応性は雌雄で違っているのかもしれない。

本種の大発生が自然林や丘陵地の公園で起った場合、数年で発生は収束し、ミズキやクマノミズキが枯死に至ることはほとんどないという。しかし、都心にあつて、ビルや道路に囲まれ孤立している自然教育園においては、2002年から2005年の3年間で約100本（1,369本中の約7%）、2005年から2006年の1年間で86本（1,285本中の6.7%）、2006年から2007年では162本（1,208本中の13.4%）が枯死している。生存している個体の樹勢も弱っており、キアシドクガの大発生が収束しない限り、今後も枯死が進行していくものと予想される。

References

- Kobes, L. W. R., 1995. Erstaunliche Ergebnisse von Schmetterlingszuchten. Teil 2. Ber. Kreises Nürnberger Ent. Galathea, 11: 97-102.
- Owada, M., Y. Arita & U. Jinbo, 2001. Moths of the garden of the Institute for Nature Study, Tokyo. Rept. Inst. Nat. Stu., (33): 251-280. (In Japanese with English summary.)
- Owada, M., Y. Arita, U. Jinbo, Y. Kishida, H. Nakajima, M. Ikeda, S. Niitsu & S. Keino, 2005. Moths and butterflies of the Akasaka Imperial Gardens, Tokyo, Central Japan. Mem. natn. Sci. Mus., Tokyo, (39): 55-120. (In Japanese with English summary.)
- Owada, M., Y. Arita, U. Jinbo, Y. Kishida, H. Nakajima, M. Ikeda & N. Hirano, 2006. Monitoring survey (2000-2006) of moths (Insecta, Lepidoptera) in the garden of the Imperial Palace, Tokyo, Central Japan. Mem. natn. Sci. Mus., Tokyo, (43): 37-136. (In Japanese with English summary.)
- Owada, M., Y. Arita, Y. Kishida, M. Ikeda & U. Jinbo, 2000. Moths of the garden of the Imperial Palace, Tokyo, Central Japan. Mem. natn. Sci. Mus., Tokyo, (36): 115-168. (In Japanese with English summary.)
- Owada, M., S. Hamao, M. Yano & K. Kuwahara, 2007. Miniaturization of lymantriid moths of *Ivela auripes* (Lepidoptera) breaking out in the garden of the Institute for Nature Study, Tokyo. Rept. Inst. Nat. Stu., (38): 39-49. (In Japanese with English summary.)
- Schaefer, P. W., 1983. *Ivela auripes* Butler in Hokkaido: behavior and morphology of females; host egg defense mechanism against parasitism by *Trichogramma* sp. Kontyû, 51: 298-307.

- Togashi, K., 1994. *Ivela auripes* Butler. In Kobayashi, F. & A. Taketani (eds.), Forest Insects, pp. 288-290. Yokendo, Tokyo. (In Japanese.)
- Yano, M. & K. Kuwahara, 2006. Population explosion of *Ivela auripes* (Butler) in the Institute for Nature Study. Rept. Inst. Nat. Stu., (37): 1-8. (In Japanese.)
- Yano, M. & K. Kuwahara, 2007. Population explosion of *Ivela auripes* (Butler) in the Institute for Nature Study (Part 2). Rept. Inst. Nat. Stu., (38): 31-37. (In Japanese.)
- Yano, M. & K. Kuwahara, 2008. Population explosion of *Ivela auripes* (Butler) in the Institute for Nature Study (Part 3). Rept. Inst. Nat. Stu., (39): 29-38. (In Japanese.)
- Yasumatsu, K. & C. Watanabe, 1965. A tentative catalogue of insect natural enemies of injurious insects in Japan. Part 2. Host parasite-predator catalogue. 116 pp. Ent. Lab., Kyushu Univ., Fukuoka.