Fig. 1. Correlation between gramine contents of fresh barley leaves (X) and density of aphid complex (Y).

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The Stimulation of Oviposition in *Athalia japonica* (Tenthredinidae, Hym.) by Tethered Flight¹

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Unlike its close relatives, *Athalia rosae* and *A. infumata*, *A. japonica* lay few eggs when raised in the laboratory at a constant 20°C condition, making laboratory rearing difficult. Some behavioral or physiological obstruction for normal reproductive maturation and oviposition may exist in this species. The requirement of flight was the first characteristic to check since the stimulation of oviposition by flight has been documented in various aphids and planthoppers (JOHNSON, 1969; KENNEDY, 1956; TAKEDA, 1974).

Adult females of *A. japonica* within 24 h of emergence were tethered at the scutellum with cot-

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ton thread glued by correction fluid and forced to fly continuously by human breath. After 1, 3, 5 and 7 min of forced flight, they were placed under a Petri dish with 1 male and a piece of *Clerodendron* leaf which has been shown to stimulate mating in this group of sawflies (NISHIDA et al., 1989). When mating was observed, females were transferred into a transparent plastic container (12 cm ht. × 12 cm dia.) with 5–6 leaves of young host plant *Raphanus sativus* var *radicula*. The containers were kept at 20°C, 16L–18D and eggs laid in the plant were counted daily, when the host plant was renewed. Counting continued until the females died.

Figure 1 showed that the number of eggs laid varied depending on the period of forced flight. Due to the small sample size, individual mean values were not statistically significant. Flights of 3 min or longer significantly increased the number of eggs laid (*t* test at 5% level), compared with flights shorter than 3 min. When field-collected females were kept in the same rearing condition, the number of eggs laid was found to be comparable to that laid by females which were forced to fly for 3 min or longer.

HIGASHIMOTO (1983) has observed frequent flights of *A. japonica* and *A. infumata* in the field but not of *A. rosae*, although NAGASAKA (1989) suggested that the latter seems to be the most long range consistent flier. Of the 3 turnip sawflies *A. japonica* has the broadest range of host plants growing in the widest range of landscapes and is most widely dis-

tributed geographically. It is also the least heat resistant (UCHIMORI et al. in prep.) and probably shifts breeding sites seasonally to avoid hot weather. Dispersal flight must somehow function to start reproductive maturation or oviposition in *A. japonica*. Flight may facilitate the expansion of distribution or emigration to a novel habitat which also serves to keep diploid male production due to inbreeding at a low rate. In this species and others with haplo-diploid sex determination mechanisms, the consequences of inbreeding may be serious. Nevertheless even tethered *A. japonica* females often stopped flying in 2 min, which may rule out the possibility that flight may contribute to a long range migration like, the intercontinental flight displayed by some locusts or planthoppers, although the weak flight ability of this species does not rule out the possibility that it flies intermittently for long distances, ovipositing after each short flight. The ecological implication of the required flight for oviposition, however, awaits further study in the field.

The stimulation of oviposition by such a short period of flight has also been observed in other species (KENNEDY, 1956). In aphids, the stimulation did not seem to result from physical fatigue due to a long distance flight, but was effected via the stimulated brain-endocrine axis. KENNEDY attributed such an instantaneous stimulation to a neural feedback or reflex mechanism. His conclusion requires future neuroendocrinological study.

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Fig. 1. The number of eggs oviposited by tethered *A. japonica* females of after different periods of forced flight. Mean values and the standard deviation are given. Circles; laboratory reared females. Triangle; field-collected females without subsequent forced flight. Number in parentheses are the number of females used. Laboratory reared females were forced to fly for 0, 1, 3, 5, and 7 min.