tion on longevity and fertility were different in each report cited above. However, in the melon fly no evidence of influences of low temperature of 12°C during irradiation on longevity and fertility were observed.

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Colonization of *Torymus sinensis* KAMIJO
(Hymenoptera: Torymidae), a Para-
sitoid of the Chestnut Gall Wasp,
Dryocosmus kuriphilus YASUMATSU
(Hymenoptera: Cynipidae),
Introduced from China^{1,2}

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Torymus sinensis KAMIJO, which was described as a new species in 1982 (KAMIJO, 1982), has been introduced 3 times from China to Japan to control the chestnut gall wasp, *Dryocosmus kuriphilus* YASUMATSU. The first introduction, however, was not successful chiefly because the number of parasitoids introduced was too small (MURAKAMI et al., 1977). Subsequently, in 1979, Dr. Y. MURAKAMI, Kyushu University, brought approximately 2,200 galls of *D. kuriphilus* with torymid larvae which had been collected in the Hobei Province (MURAKAMI

et al., 1980). Thereafter, in 1981, M. SHIGA, one of the present authors visited the Hobei Province and sent *D. kuriphilus* galls to Japan by courtesy of the Government of China.

The galls of the second and third introductions were kept at the Fruit Tree Research Station, Yatabe, Ibaraki Prefecture, and adult parasitoids which emerged in the next spring were released in nylon-mesh bags covering branches or potted young trees of the Japanese chestnut, *Castanea crenata* SIEB. et ZUCC., on which *D. kuriphilus* galls were formed. Since the torymid has one generation a year and its life cycle is well synchronized with that of *D. kuriphilus*, the parasitoid females released were expected to immediately attack the galls in their early stage of development. Three parasitoid females were usually released with males in a bag and the bag was removed in mid-summer.

In the spring of 1980, a total of 36 parasitoid females (*fr*) were released in 11 bags, and in the next spring, 120 female adults (*fy*) emerged from galls collected on the branches and young trees that were bagged (*fy/fr*=3.33). Then, in the spring of 1981, 99 females (*fr*) were released in 29 bags and and 347 female adults (*fy*) were obtained in the next spring (*fy/fr*=3.51) (MORIYA et al., unpub-

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² Contributions from the Fruit Tree Research Station, A-160.

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Fig. 1. Map of the Fruit Tree Research Station. In sections A, B, C, . . . Q, chestnut trees naturally grow among pine and other kinds of trees and shrubs. In section X, potted young trees of chestnut were placed. Dotted area is cultivated with chestnuts.

lished data).

In the spring of 1982 we started a new project to release *T. sinensis* under natural conditions. Materials used for this purpose were selected from parasitoids propagated by the bagging method mentioned above and also from those which emerged from the galls introduced from China in 1981. First, in the laboratory, newly emerged parasitoid females were kept with males in glass tubes after they were reared for a while by supplying drops of honey. The tubes were then attached to branches of chestnut trees naturally growing in sections A and B on the grounds of the Fruit Tree Research Station (Fig. 1). The stoppers of the tubes were removed to allow the parasitoids to disperse by themselves. The trees with these tubes will hereafter be referred to as "the trees of release." One hundred females were thus released on 5 of the total of 14 trees growing in section A and 160 females on 6 of the total of 35 trees in section B.

In March, 1983, galls formed in the preceding year were collected in all the sections except C, D, G, I, and M, and kept in shelters set up outdoors. Particularly in section A the gall collection was performed on all the 14 trees and in section B, on 14 trees, or 40% of the total trees growing there. In

both sections all the galls formed in the preceding year were gathered on these trees. In each of sections Z1 and Z2 galls were obtained from 4 rows of chestnut cultivars located in the northern half of the plot. The emergence of adult *T. sinensis* took place in April. Nearly at the same time *Torymus beneficus* YASUMATSU et KAMIJO, an indigenous parasitoid of *D. kuriphilus*, also emerged in considerable numbers. Females of both species can be distinguished from one another by the difference in the length of the ovipositor, but in the males there are no clear-cut morphological differences between both species. In our study, therefore, males were counted without separating the species from one another. When *T. sinensis* and *T. beneficus* adults emerged from galls collected in sections A, B, Z1 and Z2, they were returned to the places where the galls had been collected, immediately after they were counted. This procedure was necessary for minimizing the effect of gall collection upon the parasitoid populations.

The records of emergence of adult parasitoids are summarized in Table 1. In sections A and B, data on the parasitoids are supplied in distinguishing those on the trees of release from those on the other trees investigated as in Table 2. It is evident from Table 2 that *T. sinensis* spread from the points of release to the surroundings and succeeded in colonizing these areas after they were released in 1982.

T. sinensis were also unexpectedly recorded in sections F, J, K and X (Table 1). However, the possibility that these individuals were not the progeny of the parasitoids released in sections A and B but one of the parasitoids used for the bagging method of propagation cannot be discarded. In *D. kuriphilus*, galls are sometimes formed along the main leaf-vein (cf. Fig. 1A in ÔTAKE et al., 1982). If there were galls of this type on a bagged branch or young tree, it is unlikely that they would be collected in the spring because of leaf-shedding in the autumn of the preceding year. It is possible that *T. sinensis* emerged from galls thus fallen on the ground and naturally laid eggs in nearby galls of *D. kuriphilus*. In 1980, 4 branches in section K and 7 potted young trees in section X were covered with bags for the propagation of *T. sinensis*, and in 1981, 24 branches were used in a wider area as well as 5 potted young trees in section X. It is noteworthy, in this connection, that no *T. sinensis* females were found to emerge from galls collected on other trees than the bagged ones for the propagation of *T.*

Table 1. Emergence of *Torymus sinensis* and *Torymus beneficus* adults from *Dryocosmus kuriphilus* galls collected in the spring of 1983

Section	No. of galls collected	<i>T. sinensis</i> , <i>T. beneficus</i> males	<i>T. sinensis</i> females	<i>T. beneficus</i> females
A	5,414	1,041	132	986
B	7,789	1,380	313	1,280
Z1	513	39	7	97
Z2	471	43	7	86
E	165	2	0	10
F	265	13	2	30
H	35	5	0	4
J	327	93	12	103
K	185	21	27	11
L	77	7	0	11
N	411	94	0	156
P	100	14	0	19
Q	173	3	0	14
X	102	23	2	23
Total	16,027	2,778	502	2,830

Table 2. Details of the data on the emergence of *Torymus sinensis* females in sections A and B

Section	Group of trees	No. of trees investigated	No. of galls collected	No. of <i>T. sinensis</i> females that emerged
A	Trees of release	5	3,466	94
	Others	9	1,948	38
B	Trees of release	6	3,073	133
	Others	8	4,716	180

sinensis, in both the spring of 1981 and the spring of 1982. The 1983 emergence of *T. sinensis* in the above-mentioned sections which were comparatively distant from A and B may have taken place as a result of quantitative accumulation of leaks of parasitization in the course of repeated applications of the bagging method.

In section A, as mentioned above, all the galls were collected on the total of 14 trees growing there and 132 *T. sinensis* females emerged from them (Table 1). Assuming that the number of females (*fy*) represents the size of the female adult population originating from the 100 parasitoid females (*fr*) released in this section in the preceding year, $fy/fr=1.32$. This value is less than half of any of

the values of the same kind obtained by the bagging method in 1980–1981 and 1981–1982. It is very likely, however, that some of the released females mentioned above expanded the area of their parasitic activities out of the section and therefore the true value of *fy* was more than 132. At any rate, the fact that fy/fr exceeded 1 suggests that the *T. sinensis* population established on the grounds of the Station will grow further in the coming spring.

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Rearing of the Brown Citrus Aphid,
Toxoptera citricidus (KIRKALDY),
(Homoptera: Aphididae), on a Synthetic
Diet with Reference to pH and
Sucrose Concentration of Diet
and Rearing Density^{1,2}

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The artificial rearing method of an aphid on a chemically defined diet is applicable for studying nutritional requirement and feeding behaviour (PARRY and FORD, 1969; MITTLER, 1976; SRIVASTAVA and AUCLAIR, 1974), morph determination (SUTHERLAND and MITTLER, 1971; LECKSTEIN and LLEWELLYN, 1974; WHITE, 1972) and virus transmission (KUNKEL, 1977). Several species of aphids were reared successfully on a synthetic diet for more than several generations or almost permanently (AKEY and BECK, 1972; CHAWLA et al., 1974; DADD and KRIEGER, 1967; DADD and MITTLER, 1966; KRIEGER, 1971). In this study, *Toxoptera citricidus* which attacks citrus (FURUHASHI and NISHINO, 1968) and transmits the citrus tristeza virus (SASAKI, 1974), was reared on a synthetic diet based on that of MITTLER et al. (1970).

The apterous viviparae were collected from a citrus grove at the Okitsu Branch, Fruit Tree Research Station in Shimizu. Stock cultures of aphids were maintained on new shoots of potted *Citrus aurantium* in a growth cabinet at 20°C with natural long daylength. Before experimental use, the aphids were reared more than three generations on young shoots of the plants under an uncrowded

condition. Newly molted (within one day old) apterous adults, denoted 'parents,' were taken from cultures and individually transferred into a glass cup (3 cm in diameter and 3 cm high) after being weighed by a torsion balance. The newly deposited nymphs were individually caged in other cups except those used for testing the rearing density. Fifty aphids were used in each experiment. The diet was enclosed in Sealon film® sachets which covered the glass cup. The aphids in the cups were kept in a growth chamber at 20°C under illumination of 16 hr per day; the diet was renewed every two days. They were examined daily and aphid mortality, molting, nymph becoming adult, adult survival and fecundity were recorded, and newly matured aphids were weighed.

The weight of parents showed very little fluctuation ranging from 0.9 to 1.0 mg. Longevity was significantly correlated with the fecundity in parents ($r=0.79$, $n=855$) and this was also true of later generations ($r=0.49$, $n=175$). The nymphal period correlated with the fecundity ($r=-0.45$, $n=175$) and adult weight ($r=-0.29$, $n=94$). The longevity and nymphal period are shown in the following results.

The effects of sucrose concentration on aphid growth are shown in Table 1. The longevity of parents with no food and those fed only distilled water was 0.54 day and 0.90 day respectively and the aphids did not produce progeny. A diet of 25% sucrose (MD25) was most suitable for parents but not as good as the plant on which they survived for 18.61 days. The aphids grew well in the first two generations but did not mature in the fourth generation on MD25. On MD20 the aphids completed six generations, but in the second generation the growth was not as good as on MD25. On MD15 the second generation did not reach the adult stage. TAHORI and HAZEN (1970) reported that

¹ Appl. Ent. Zool. **19** (1): 114–117 (1984)

² Contribution from the Fruit Tree Research Station, B-98.