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Comparative Studies on the Biology of Dryinid Wasps in Japan

(2) Relationship between Temperature and the Developmental Velocity of *Haplogonatopus atratus* ESAKI et HASHIMOTO (Hymenoptera : Dryinidae)

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日本産カマバチ類の生態に関する比較研究
(2) クロハラカマバチの発育速度と温度の関係

北　村　憲　二

Introduction

Rearing techniques of dryinid wasps have been studied by several workers in Japan (Esaki and Samejima,[1] Esaki and Mochizuki,[2] Santa[3] and Nishioka).[5] However, the ecological aspects of these wasps are still little known. The predacious and parasitic efficiency of *Haplogonatopus atratus* ESAKI et HASHIMOTO was previously reported by Kitamura.[6] This paper reports the results of laboratory experiments on the effect of various temperatures on the developmental period of dryinid wasp.

Materials and Methods

To obtain *H. atratus*, parasitized rice planthoppers (*Laodelphax striatellus* FALLÉN) were collected from a paddy field in Matsue during September and October, 1980. The females of *H. atratus* used in the experiments were those reared together with males in the laboratory stocks. A single female wasp was released into a glass tube (2×12 cm) where the 3rd instar of host nymphs were provided for oviposition. After the oviposition, the host nymphs were immediately removed, and then each reared separately in another glass tube with rice seedlings. This tube (2×12 cm) had both ends open ; the lower end was plugged with moist cotton which wrapped the roots of rice seedlings, and its upper side was covered with Nylon gauze.[4]

The experiments were conducted at 4 constant temperatures, 15°C, 20°C, 25°C and 30°C, under 16 hours lighting. Five *H. atratus* females were allowed to deposit eggs on sixty 3rd instar host nymphs at each temperature. The pupation of parasite was recognized by the appearance of eye spots, and the duration measured when the adult parasite emerged from a cocoon.

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Results and Discussion

Effects of temperature on the development of *H. atratus*

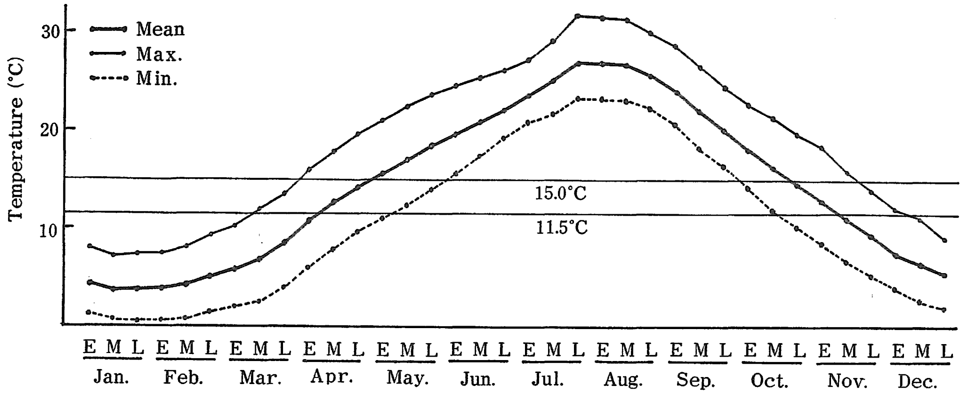
The developmental period of *H. atratus* at various temperatures are shown in Table 1.

Table 1. The developmental period of *Haplogonatopus atratus* at various temperature

Stage of parasite	Temp. (C)	No. of individuals observed	Developmental period (days)		
			Min.	Max.	Mean±S. E.
From egg to the forming of larval sac	15	24	32	47	36.3±3.68
	20	25	12	25	15.4±3.40
	25	32	7	15	8.1±1.66
	30	37	5	13	7.8±2.77
From the forming of larval sac to the hatching of parasite larva	15	16	16	43	25.7±7.56
	20	19	6	12	8.2±1.98
	25	32	3	10	4.5±1.32
	30	20	2	6	3.9±1.00
From the hatching of parasite larva to the pupation in cocoon	15	7	7	10	8.4±1.15
	20	19	3	5	3.6±0.66
	25	32	2	3	2.1±0.31
	30	16	1	3	2.2±0.63
Pupa	15	3	43	45	46.7±4.74
	20	18	14	20	16.1±1.48
	25	26	8	10	9.1±0.53
	30	8	5	8	6.3±0.84
From egg to adult emergence	15				117.1
	20				43.3
	25				23.8
	30				20.2

The developmental period from egg to the forming of larval sac was 36.3 days at 15°C, and 7.8 days at 30°C. The duration from the forming of larval sac till the hatching of parasite larvae lasted 25.7 and 3.9 days at 15°C and 30°C, respectively. The duration from larval stage to the pupation in cocoon was 8.4 and 2.1 days at 15°C and 25°C, respectively. The duration from pupa to adult parasite emergence was 46.7 days at 15°C and 6.3 days at 30°C, respectively. The total developmental period of parasite from egg to adult emergence was 117.1, 43.3, 23.8 and 20.2 days at 15°C, 20°C, 25°C and 30°C, respectively. These results show that the developmental period was shortened with the rise of temperature. A remarkable difference in the developmental period was observed at 15°C and 20°C, but not so different between 25°C and 30°C. From this fact, it may be assumed that at 30°C, the threshold temperature for the development of *H. atratus* was approaching the upper limit.

At 15°C, apart from the prolonged development of the immature stages and inactivity of emerging adults, a large number of parasite larvae failed to hatch from the larval sacs. This suggests that the condition at this temperature is least favorable for the development of this parasite. The mean temperature in Matsue is over 15°C in early May and is under this level in late October. Judging from this enviromental condition, in nature the parasite will be active from early May to late October in Matsue. However, the maximum temperature in daytime in early April and mid-November usually exceeds 15°C, therefore, the parasite may still be active during these periods.



Temperature in Matsue throughout the year. Each line represents the average of mean, maximum and minimum temperature in early, middle and the late of each month during 30 years (1951–1980)

There was a wide variation in the developmental velocity of the parasite within the range of temperatures tested, particularly at early stage of the development, during the period from oviposition to the larval hatch. Although the parasite eggs were laid on host nymphs at 3rd instar larvae, the host insects also developed to become 5th instar larvae or adults by the time the parasite larvae hatched from the larval sac. The parasite larvae hatched from their sacs on host adults required more time for development than those from the 5th instar larvae of hosts. This maybe associated with the nutritive qualities of host as a food for parasite during the developmental period.

Relative developmental velocity, developmental zero and thermal constant

The regression equation and the regression line which was obtained by using the value of developmental velocity from four levels of temperature are shown in Table 2 and Fig. 1.

Table 2. Relative developmental velocity, developmental zero and thermal constant of *Haplogonatopus atratus*

Stage of parasite	Relative developmental velocity	Developmental zero	Thermal constant
From egg to the hatching of parasite larva	Y=0.0054 X−0.0634	11.7	186.2
From the hatching of parasite larva to the pupation	Y=0.0241 X−0.2104	8.7	41.6
Pupa	Y=0.0092 X−0.1190	12.9	109.4
From egg to adult emergence	Y=0.0028 X−0.0322	11.5	357.2

The reciprocal value of developmental period from 15°C to 30°C considerably conforms to this regression line. Therefore, when the theoretical developmental zero was calculated from this regression equation in the period from the egg to the adult emergence, it was 11.5°C and the thermal constant was 357.2 degree-days. If the generation of parasite was calculated using the developmental zero, the thermal constant, and the mean temperature in Matsue,

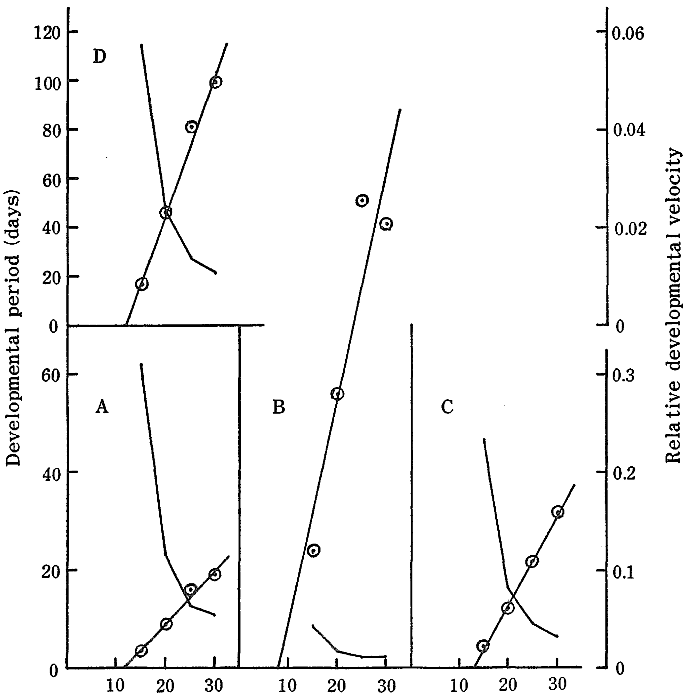


Fig. 1 Developmental period and relative developmental velocity.
A : From egg to the hatching of parasite larva,
B : From the hatching of parasite larva to the pupation, C : Pupa, D : From egg to adult emergence

it was five generations in a year.

The parasite hibernated in the host which was in the larval stage, and the parasite larvae grew to be adults of the first generation during mid-May. The adults of the second generation emerged during late June to early July. Therefore, another three generations of parasite would appear during the period from early July to October. But the polyvoltine insect is susceptible to the influences from the outside, e. g., changes in atmospheric temperature, daily periodicity, nutritive quality of host for the parasite, the time required for host hunting and so on. Furthermore, the oviposition period of this parasite is about one month (Nishioka[5]). With regard to these matters, it can be concluded that *H. atratus* has 4 to 5 generations in a year.

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Summary

The 3rd instar nymphs of *L. striatellus* attacked by *H. atratus* were immedietly reared at 15°C, 20°C, 25°C and 30°C under 16 hours lighting.

The developmental period of *H. atratus* from the egg to the adult emergence was 117.1 days at 15°C, 43.3 days at 20°C, 23.8 days at 25°C and 20.2 days at 30°C. The developmental period had a remarkable difference between 15°C and 20°C, but it showed a little difference between 25°C and 30°C.

There was a large fluctuation in the developmental velocity of parasites when they were in the host. The 3rd instar of host nymphs, attacked by the parasite, can grow up to be a 5th larvae or adults ; and the parasite larvae hatched from the host adult required longer developmental period than those from the 5th instar larvae.

The regression equation of developmental velocity from the egg to the adult emergence was shown by Y = 0.0028X−0.0322, developmental zero was 11.5°C and thermal constant was 357.2 degree-days. If the generations of parasite are caluculated using the developmental zero, the thermal constant, and the mean temperature in Matsue, it has 5 generations in a year.

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摘　　　要

クロハラカマバチをヒメトビウンカを寄主として15°C，20°C，25°Cと30°Cの温度条件下で飼育した.

クロハラカマバチの卵から羽化までの発育日数は15°Cで117.1日，20°Cで43.3日，25°Cで23.8日，30°Cで20.2日であった．発育日数の差は，15°Cと20°Cの間において大きく，25°Cと30°Cの間において小さい.

寄主体内で生活しているカマバチの発育日数には大きな変動がみられた．寄主の3令幼虫に寄生したカマバチは寄主の5令幼虫または成虫期に幼虫態で脱出するが，寄主の成虫期に脱出する個体は発育日数が長くなった.

クロハラカマバチの卵から羽化での比較発育速度の回帰式は Y=0.0028X−0.0322 で，発育零点は11.5°C，有効積算温度は357.2日度であった．これらの発育零点，有効積算温度と松江の平均気温から単純にクロハラカマバチの世代数を計算すると年5世代となった.