Growth and Reproduction of *Asellus hilgendorffii* (Crustacea, Isopoda) Under Laboratory Conditions

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Abstract

The growth and reproduction of *Asellus hilgendorffii* was studied at 5°, 15° and 25°C in the laboratory. The females began to produce their first brood at about 4 mm in length after five weeks at 25°C and after about ten weeks at 15°C. The animals reared at 5°C died before maturation. The mean number of broods per female was 2.6 and 4.3 times at 15° and 25°C, respectively. The mean incubation period was 18.3 and 9.4 days, and the mean parturition interval was 29.9 and 15.4 days at respective temperatures. The mean brood size was 27.4 and 34.7 an 15° and 25°C, respectively. *A. hilgendorffii* grew faster and bred more often in their lifetime, compared with other species of the genus *Asellus*.

1. Introduction

The freshwater isopod, *Asellus hilgendorffii*, is an important source of food for fishes (SHIRAIISHI *et al.*, 1975), and has a role as the decomposer of the fallen leaves (SEKINE and TSUCHIYA, 1972). *Asellus* distributes widely in rivers, lakes, ponds and ditches, and has been known as an indicator of the pollution of organic effluents (HYNES, 1960). The ecology or life history has been studied for several species of Asellidae: *Asellus aquaticus* (ANDERSSON, 1969; ØKLAND, 1978; ADCOCK, 1979), *A. intermedius* (ELLIS, 1961), *A. meridianus* (MOON, 1957; STEEL, 1961; CHAMBERS, 1977), and *A. tomalensis* (ELLIS, 1971). However, the life history of *A. hilgendorffii*, which is the only surface-water Asellidae known from Japan (MATSUMOTO, 1973), is virtually unknown. The objective of the present study was to investigate the growth and reproduction of *A. hilgendorffii* under laboratory conditions.

2. Materials and methods

A. hilgendorffii used in the present study was collected from the River Tama, in July 1978, and has been bred in the laboratory.

The experiments were carried out at 5°, 15° and 25°C, with alternating light and dark periods of 12 hr. The light intensity was about 3,000 lux. The animals were

fed on fallen chestnut leaves. The leaves were soaked in groundwater for one week prior to use. Rearing water and the food were changed weekly.

For the growth study, eight juvenile *Asellus* just departed from the pouch were placed in individual plastic containers, 15 cm in diameter and 9 cm in height, containing 800 ml of groundwater. Twenty replicates were provided for each temperature, of which one or two containers was sacrificed for measuring the body length and body weight at weekly intervals. Body length was measured under a binocular microscope from the base of the antennules to the end of the abdomen.

To determine brood size, incubation period and parturition interval, a pair of *Asellus* were kept in individual 200 ml glass beakers containing 100 ml of groundwater. Twenty replicates were provided for each temperature. All beakers were examined every day for deposition of eggs into the pouch and release of young therefrom.

3. Results

The growth of *A. hilgendorffii* reared at 5°, 15° and 25°C are shown in Fig. 1. When young left the pouch, the body length was 1.03 mm, and the mean body weight was 0.024 mg. The sex of animals could be distinguished at 2.5 mm in body length when reared at 15°C, and at 3.5 mm

when reared at 25°C. Only eight percent of 88 animals reared at 5°C survived after five months, when they had attained about 1.5 mm in length and 0.2 mg in weight. The growth of the animals was significantly different among 5°, 15° and 25°C as indicated in Fig. 1. There was a significant difference in the growth rate between males and females after sex differentiation.

The relationship between body length and body weight may be expressed as $\log Y = 3.184 \log X - 1.598$ for females, $\log Y = 2.750 \log X - 1.373$ for males and $\log Y = 2.945 \log X - 1.506$ for young, where Y is wet body weight in mg and X is body length in mm (Fig. 2). Females are somewhat heavier than males of comparable lengths. Water temperature for rearing did not affect the regression. The data at both 15° and 25°C were plotted together in Fig. 2.

The number of young per brood at 15° and 25°C is shown in Fig. 3. Brood size,

Fig. 1. Growth of *Asellus hilgendorffii* reared at 5°, 15° and 25°C in the laboratory. Vertical bar indicates 95% confidence limit of the mean.

Fig. 2. Relationship between body length and body weight for *Asellus hilgendorffii*. ○: Female, ●: Male

Fig. 3. Number of young per brood for *Asellus hilgendorffii* reared at 15° and 25°C in the laboratory. Vertical and horizontal bars indicate 95% confidence limits of the mean. Numbers in parentheses are animal numbers used.

incubation period and parturition interval at the respective temperatures are shown in Table 1. The females began to produce the first brood at about 4 mm in length after five weeks at 25°C and after about ten weeks at 15°C. The animals reared at

Table 1. Selected life history characteristics of *Asellus hilgendorffii* reared at 15° and 25°C in the laboratory.

Temperature	15°C		25°C		t
	Mean ± S. D.	Range	Mean ± S. D.	Range	
Life span (days)	>260 (20)	148–(365) ^a	100.6 ± 26.2 (20)	27–135	—
Number of broods	2.6 ± 0.8 (20)	1– 4	4.3 ± 1.2 (19)	2– 6	5.682**
Brood size	27.4 ± 16.6 (51)	3– 79	34.7 ± 16.6 (82)	1– 83	2.483*
Total number of young produced per female	69.8 ± 35.4 (20)	6– 156	156.6 ± 45.0 (19)	80–231	6.721**
Age at first production (days)	76.1 ± 6.4 (18)	60– 92	38.5 ± 2.7 (17)	35– 43	66.567**
Incubation period (days)	18.3 ± 3.2 (23)	11– 24	9.4 ± 1.4 (69)	7– 14	18.764**
Parturition interval (days)	29.9 ± 2.5 (26)	27– 33	15.4 ± 1.7 (63)	13– 19	32.373**

Values in parentheses are animal numbers used.

a) Observation was lasted one year, when six of the twenty females survived.

* $p < 0.05$ ** $p < 0.001$

5°C died before maturation.

The mean number of broods per female was 2.6 and 4.3 times, and the maximum number was 4 and 6 times at 15° and 25°C, respectively. There was a significant difference ($t=5.682$, $p<0.001$) in the number of broods between 15° and 25°C. The number of young per brood increased gradually until the third brood but decreased after that at both 15° and 25°C. The brood size differed significantly among the first three broods at 15°C (between 1st and 2nd brood, $t=4.444$, $p<0.001$; between 2nd and 3rd, $t=2.772$, $p<0.01$; between 1st and 3rd, $t=6.215$, $p<0.001$), but did not differ at 25°C. The mean brood size was 27.4 and 34.7 at 15° and 25°C, respectively, which were significantly different ($t=2.483$, $p<0.05$). The size of the first brood at 15°C was significantly smaller than at 25°C ($t=5.582$, $p<0.001$). The mean total number of young produced per female in lifetime was significantly different at 69.8 and 156.6 ($t=6.721$, $p<0.001$); the maximum number was 156 and 231 at 15° and 25°C, respectively. The mean incubation period from deposition of eggs in the pouch to departure of fully developed young was 18.3 and 9.4 days, and the mean parturition interval was 29.9 and 15.4 days at 15° and 25°C, respectively. These differences according to temperature

were statistically significant (incubation period, $t=18.764$, $p<0.001$; parturition interval, $t=32.373$, $p<0.001$).

Survival curves of females reared at 15° and 25°C are shown in Fig. 4. The mean longevity for females reared at 25°C was 101 days, against 260 days or more at 15°C.

The number of eggs or young per brood increased in proportion to the size of the female. Linear relationships were obtained between the number of egg in the pouch and the female body length, as well as between the number of young released from the pouch and the body length of female; *i. e.*, $Y=18.928 X-46.730$ for the number of eggs and $Y=20.349 X-71.174$

Fig. 4. Survivorship curves for females of *Asellus hilgendorffii* reared at 15° and 25°C.

Fig. 5. Relationship between number of eggs or young per brood and body length of females for *Asellus hilgendorffii*.

for the number of young, where Y is fecundity and X is body length of females in mm (Fig. 5). The smallest female bearing eggs measured 3.0 mm, and the smallest to release young was 3.5 mm. When the females were divided into body length groups of 3.5–4.0 mm, 4.5–5.0 mm, 5.5–6.0 mm and 6.5–7.0 mm, the rates of reduction in number from eggs in the pouch to young released were 68.0, 46.9, 19.4 and 15.8%, respectively.

4. Discussion

The principal food of *Asellus* is decaying vegetable matter with its associated flora of fungi, bacteria and other microorganisms (MARCUS *et al.*, 1978). In the laboratory, elm leaves (ELLIS, 1961; HYNES and WILLIAMS, 1965; BROWN, 1976;

FRASER *et al.*, 1978), alder leaves (ELLIS, 1971; PRUS, 1971), poplar leaves (ELLIS, 1961; ZIMAKOWSKA-GNOINSKA, 1977; OSEID, 1978) and oak leaves (WILLOUGHBY and MARCUS, 1979) have been used as a food for *Asellus*. In the present study, *A. hilgendorffii* grew well on chestnut leaves.

ELLIS (1961) reported the growth of *A. intermedius* at four different temperatures in the laboratory. In his study, about 1.2 mm young in the average length at the beginning became 1.4 mm, 1.5 mm, 1.8 mm and 3.6 mm at 7.7°, 12.8°, 18.3° and 23.9°C, respectively, after 30 days. In the present study, the mean length of *A. hilgendorffii* at 28 days was 2.18 mm and 4.69 mm at 15° and 25°C, respectively, suggesting that the growth of *A. hilgendorffii* is more rapid than that of *A. intermedius*. The growth of *A. hilgendorffii* used in the present study was expressed in relation to degree-days above 3°C, as also reported for *A. aquaticus* (ANDERSSON, 1969; ØKLAND, 1978). *A. hilgendorffii* did not grow at 5°C, which is in agreement with the minimum temperature for growth described above. There was no size difference between male and female *A. aquaticus* and *A. meridianus* (STEEL, 1961) until the animals became 3 mm in length, but thereafter males grew more rapidly. The size differentiation in *A. hilgendorffii* due to sex began at 2.5 mm with 15°C and at 3.5 mm for 25°C. *A. aquaticus* (STEEL, 1961; CHAMBERS, 1977; ØKLAND, 1978), *A. meridianus* (STEEL, 1961; CHAMBERS, 1977) and *A. intermedius* (ELLIS, 1961) breed twice in their life, *A. tomalensis* (ELLIS, 1971) breeds only once, whereas, *A. hilgendorffii* bred a maximum of six times during their lifetime (approximately 4 month).

ANDERSSON (1969) reported that the incubation period of *A. aquaticus* was dependent on temperature and directly proportional to the number of degree-days above 4°C. ØKLAND (1978) also reported the estimated incubation period of *A. aquaticus* to be 23–35 days, corresponding to about 300 degree-days above 4°C. The

Table 2. Regression of fecundity on size of *Asellus* species.

Species	Stage of brood	Regression*	Size of female (mm)	Author
<i>A. aquaticus</i>	eggs	$Y=19.80X-65.81$	4-10	STEEL (1961)
<i>A. meridianus</i>	eggs	$Y=16.04X-41.44$	3-7	STEEL (1961)
<i>A. tomalensis</i>	eggs	$Y=9.08X-33.60$	5-8	ELLIS (1971)
<i>A. tomalensis</i>	embryos	$Y=3.91X-1.75$	6-9	ELLIS (1971)
<i>A. intermedius</i>	eggs and embryos	$Y=26.78X-119.21$	4-12	ELLIS (1961)
<i>A. hilgendorffii</i>	eggs	$Y=20.35X-71.17$	3-7	Present study
<i>A. hilgendorffii</i>	young	$Y=18.93X-46.73$	3.5-7	Present study

* In the regression equation, Y =fecundity and X =body length of female.

incubation period of *A. intermedius* was expressed in relation to degree-days above 1°C, and about 288 degree-days were required for the development of the eggs (ELLIS, 1961). The temperature sum of *A. hilgendorffii* used in the present study was about 194 degree-days above 4°C, suggesting that their embryos grow more rapidly than those of *A. aquaticus* and *A. intermedius*. However, the size of females required to produce young did not differ between *A. hilgendorffii* and other species. Females of *A. aquaticus* matured at about 3.5 mm and those of *A. meridianus* at about 3 mm in length (STEEL, 1961), *A. hilgendorffii* females also matured at 3 mm.

The number of eggs in the pouch increased in proportion to the size of the female *A. hilgendorffii*. Similar relationships have been noted for other species also (Table 2). The fecundity of *A. hilgendorffii* is almost the same as that of *A. aquaticus*. The range of the size of females to produce young was different among species.

When the number of eggs was compared with the number of embryos in *A. aquaticus*, *A. meridianus* and *A. intermedius* of comparable female length, a reduction in the numbers from egg to embryo stage was observed (ELLIS, 1961, 1971; STEEL, 1961; ANDERSSON, 1969). In the case of *A. hilgendorffii*, the similar reduction in the brood size was observed when comparably sized females were examined.

STEEL (1961) reported that eggs and embryos were expelled from the pouch during development in *A. aquaticus* and *A. meridianus*. ANDERSSON (1969) attributed the loss of brood to the increasing volume of the embryos during development in relation to the constant volume of the pouch. In the present study, the mortality rate of the brood decreased with the increase of female body length in *A. hilgendorffii* (Fig. 5). Since the number of young released from the pouch can be expressed in proportion to the cube of body length in *A. hilgendorffii*, the size of brood seems to be regulated by a capacity of the pouch.

Females of *A. hilgendorffii* reared at 25°C matured earlier and had higher fecundity, but shorter life span than those reared at 15°C. The range of water temperature at the collection site in the River Tama was from 7.5°C in February to 30°C in August, and pregnant females were found from March (water temperature, 8.3°-10.2°C) to December (11.2°-11.9°C). The overwintering females start the breeding in March, and the new generation is able to mature in May. The alternation of generations would be 4 or 5 times in a year.

A. hilgendorffii distributed widely in Japan and has been found to survive an alpine lake such as Lake Yunoko in which the ice cover period lasted for about four months in winter. Studies on the population dynamics of this species must be undertaken.

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摘 要

ミズムシ (*Asellus hilgendorffii*) の成長, 産仔数, 産仔周期と水温との関係を実験室で調べた。飼育は 5°, 15°, 25°C の人工環境室において行ない, 餌として栗の枯葉を与えた。25°C における成長は雌雄共に 15°C の成長を上まわっていた。5°C での成長はほとんど見られなかった。雌は体長が約 4 mm になると産仔する。25°C では約 5 週目, 15°C では約 11 週目に初産がみられる。25°C では平均 4.3 回, 15°C では平均 2.6 回産仔する。25°C における産仔周期および抱卵期間は約 15 日と約 9 日で, 15°C のほぼ半分の期間であった。産仔数は 15°, 25°C ともに 3 回目の産仔まで増加し, その後減少した。1 回当りの平均産仔数は 25°C では 34.7 個体, 15°C では 27.4 個体で, 最高は 25°C で 83 個体, 15°C では 56 個体であった。また一生涯における平均産仔数は 25°C で 156.6 個体, 15°C で 69.8 個体であった。

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