# GROWTH RATE, LIFE SPAN AND MOLTING CYCLE OF THE CRAYFISH *ORCONECTES SANBORNI*[1]

F. LEE ST. JOHN, The Department of Zoology, The Ohio State University, Newark, Ohio 43055

*Abstract.* *Orconectes sanborni* young were found to hatch in the spring and to undergo several closely spaced molts. These juveniles could be sexed by mid-summer. A molt occurring in the autumn of the first year was the beginning of a pattern of two molts per year, one in the spring and one in the summer or autumn, although the precise timing of these molts was variable. Both sexes usually reached sexual maturity by the autumn of the second year. At this time the males became form I (breeding) and the oocytes in the females began to increase in size. The maximum life span was found to be thirty-seven months.

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Crayfish have been used extensively in investigations of the physiology and hormonal control of molting. Passano (1960) cited more than twenty such references in his review. Crayfish life histories have not, however, received equal attention. Van Cleave (1931) suggested that one reason for the static condition in the interpretation of individual life histories was the unwarranted assumption by many that closely related forms have identical histories. The purpose of my study was to investigate the molting cycle, growth rate, and life span of *Orconectes sanborni* (Faxon, 1884) (Decapoda: Astacidae).

## METHODS AND MATERIALS

*O. sanborni* were collected by the author in a stream known as Africa Run. Africa Run is an eastern tributary of Alum Creek, in Delaware County, Ohio. Most of the stream has recently been destroyed by the creation of a reservoir on Alum Creek. The substrate of Africa Run was Devonian shale with additional pebbles, cobbles, and occasional boulders of glacial till origin (Bownocker, 1947). The stream drains wooded lots and agricultural fields. During the collection period the stream was never dry, although the water level fluctuated considerably.

Collections were made from 2 stations just south of County Rd 106 approximately every two to three weeks from March, 1968 through May, 1969. Collecting trips were made in the mornings and were usually alternated between the two stations. Specimens were captured by hand, with a metal strainer, or a 4′ x 6′ minnow seine with ¼ inch mesh. Specimens were placed in buckets containing stream water and taken to the laboratory where they were sexed and measured. In the males, the numbers of form I (breeding) and form II (non-breeding) individuals were counted. Each crayfish was assigned an identification number and then placed in a fixing agent. The specimens were later transferred to 70% ethyl alcohol; or 70% alcohol, 2% glycerine and 28% water. Measurements of gonad weight and oocyte diameter were then done on the females.

Since hatching of the eggs is not likely to be observed in nature, an indirect method of determining this important event was used. The time of hatching was assumed to precede the recovery of the smallest juveniles in the collections and to follow the recovery of ovigerous females. A few specimens which were collected from Africa Run in the spring of 1969, were retained in the laboratory and observed for breeding, oviposition and brooding. These animals were kept in five gallon aquaria containing stream water and an air line.

## RESULTS AND DISCUSSION

Inasmuch as crayfish increase in body length as a result of their periodic molts, age may be judged from body length. Therefore, a frequency distribution of body lengths would indicate various age groups within any one collection. Such a frequency distribution was prepared for each collection. The carapace lengths of the crayfish in any one collection were grouped in 1 mm increments. Each group was then plotted as a single point on normal probability graph paper. If the joining of these points produced a single straight line, the collection was considered a normally distributed popu-

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lation of the same approximate size and of the same approximate age. If a single straight line was not produced, it indicated that more than one age group was present in the collection (Li, 1964). This method was used to separate age groups within a collection and was especially useful when a frequency distribution left some doubt as to the group in which a specimen of a particular size belonged. For example, a summer collection containing three distinct age groups (as shown in figure 1), one group being the newly hatched young of the year, suggested that the largest specimens were third year animals, while the intermediate group contained specimens which had probably hatched the previous spring.

Females bearing young on their pleopods were taken in late April and early May. The free-swimming juveniles recovered from Africa Run in the collections of April 30 through June 6 are assumed to be newly hatched. These specimens had a mean carapace length of 8.1±1.6 mm (Juveniles, table 1).

Since each newly hatched juvenile kept alive in aquaria was observed to molt several times during the spring, it

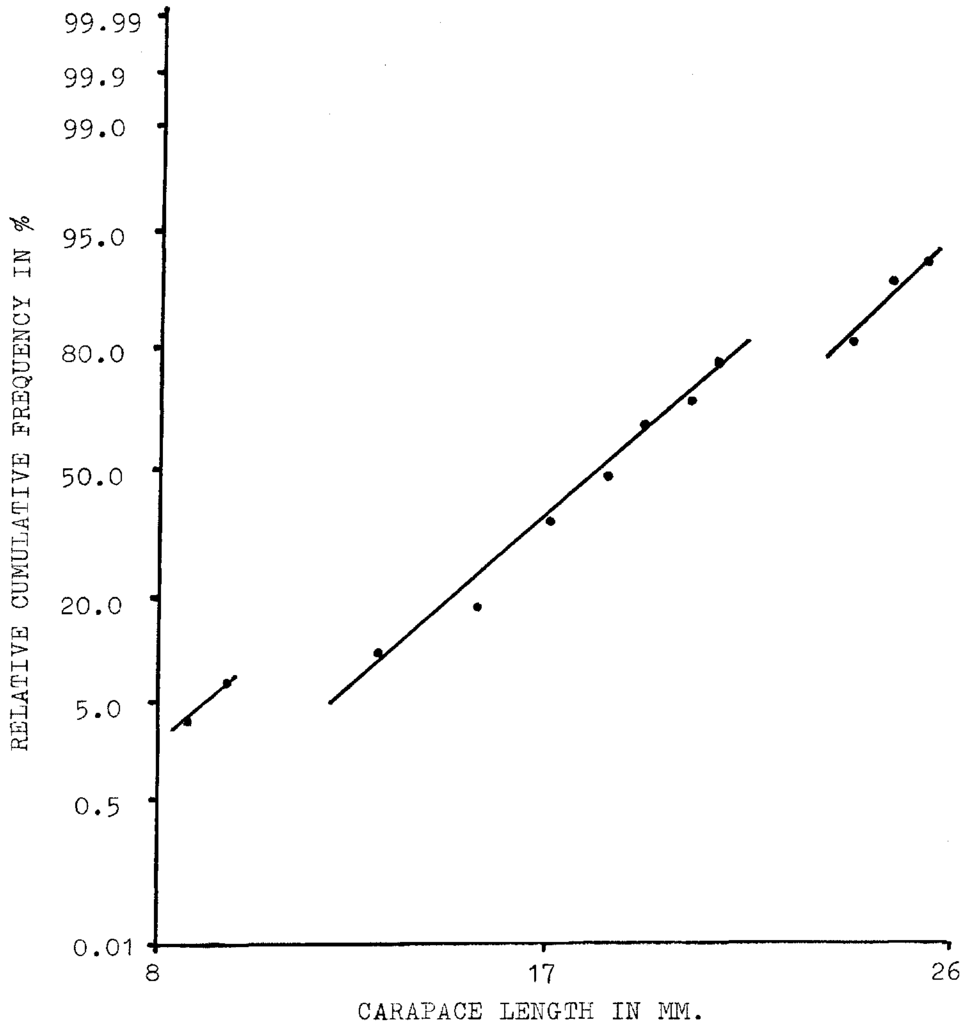


FIGURE 1. Africa Run collection of July 18, 1968, plotted on normal probability scale, showing the collection to be composed of three distinct size groups.

was assumed that juveniles in the field did likewise. A twice a year molting pattern beginning at the first autumn of their life was apparently established.

TABLE 1

*Mean carapace lengths of groups and growth increments at molts, Africa Run crayfish*

| Seasonal molt (Groups) | Females | | | Males | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | No.* | MCL** | GI** | No. | MCL | GI | No. | MCL | GI |
| (Juveniles) | | | | | | | 9 | 8.1 | |
| 1st spring | | | | | | | | | 1.2 |
| (Group 1) | 5 | 9.4 | | 6 | 9.2 | | 11 | 9.3 | |
| 1st fall | | | 2.3 | | | 2.2 | | | 2.3 |
| (Group 2) | 51 | 11.7 | | 34 | 11.4 | | 85 | 11.6 | |
| 2nd spring | | | 5.3 | | | 5.0 | | | 5.1 |
| (Group 3) | 63 | 17.0 | | 62 | 16.4 | | 125 | 16.7 | |
| 2nd fall | | | 2.1 | | | 2.7 | | | 2.4 |
| (Group 4) | 28 | 19.1 | | 32 | 19.1 | | 60 | 19.1 | |
| 3rd spring | | | | | | 3.6 | | | 3.6 |
| (Group 5) | 0 | — | | 3 | 22.7 | | 3 | 22.7 | |
| 3rd fall | | | | | | 3.2 | | | 3.0 |
| (Group 6) | 5 | 25.2 | | 10 | 25.9 | | 15 | 25.7 | |
| 4th spring | | | | | | 2.3 | | | 2.5 |
| (Group 7) | 0 | — | | 2 | 28.2 | | 2 | 28.2 | |

*Number of specimens in this category.
**Mean carapace lengths (MCL) and growth increments (GI) in millimeters.

Increases in the mean carapace lengths of the various age groups indicated that a molt had occurred. This information on the molting cycle was utilized in the construction of table 1. By the first autumn the average carapace length had increased to $9.3 \pm 1.77$ mm. In general, females were longer than males. Following the first autumn molt the crayfish increased to $11.6 \pm 1.6$ mm. Since no further size increases were found until the following spring it is assumed that no further growth occurred during the winter (Group 2, table 1). Van Deventer (1937) concluded that *Cambarus propinquus* (=*O. propinquus*) did not molt during the winter and referred to their ". . . dark, almost black . . ." exoskeleton in the spring as evidence for absence of molting. *O. sanborni* specimens from Africa Run had a similar dark dirty appearance beginning in late October and continuing through April to mid-May, at which time the spring molt occurred, producing a new, clean exoskeleton.

The remainder of the growth cycle followed a similar pattern. The crayfish molted again in the spring of their second year achieving a mean carapace length of $16.7 \pm 2.3$ mm (Group 3). In the autumn of their second year they increased in carapace length to $19.1 \pm 1.9$ mm (Group 4). At the spring molt of the third year (at about 25 months of age) the crayfish grew to $22.7 \pm 0.8$ mm (Group 5), and the following summer to $25.7 \pm 2.1$ mm (Group 6). The males which survived the third winter molted in the fourth spring to $28.2 \pm 0.5$ mm carapace length (Group 7). No specimens longer than those of this group were collected from Africa Run, so it was assumed that the oldest crayfish died preceeding the autumn molt of the fourth year.

Table 1 shows the growth increments at each molt for males, females and the total for each group. The largest growth increment for both sexes occurred during the spring molt at the beginning of the second year (between Groups 2 and 3). The average increase was 5.1 mm carapace length, with the males increasing 5.0 mm and the females 5.3 mm. The increments in female growth exceeded those of the males through the spring of the second year, but the male growth increments exceeded those of the females at the autumn molt at the end of year two (between Groups 3 and 4).

The occurrence of the spring and autumn molts was variable. For example, the autumn molt of the first year (between Groups 1 and 2) was at the end of August and beginning of September. However, the autumn molt of the second year was spread from mid-July through mid-October. The autumn molt of the third year was completed by mid-August. The first spring molt (between Groups 2 and 3) was spread from early April through early May, while the second spring molt (between Groups 4 and 5) began in early May and was completed by Mid-May. Those males which underwent a third spring molt did so during April and had completed the process by mid-May.

The greatest increases in both weight of ovaries and diameter of oocytes occurred in the autumn of the second year (table 2).

*O. sanborni* collected from Africa Run had a life span of up to 37 months. The young hatched in the spring of the first year and apparently underwent several closely spaced molts. The sex of the juveniles was obvious by midsummer because the annulus ventralis of the female appeared at this time (Andrews, 1906). The first pair of pleopods in males became distinctively longer than those of females of the same carapace length (Creaser, 1933a).

Following the first summer's growth only two molts occurred in a year, one in the autumn (or summer) and one in the spring. Van Deventer (1937) states that in *C. propinquus* the adults molt twice during the spring or early summer, changing to form II with the first adult molt and reverting to form I with the second adult molt. *O. sanborni* in Africa Run molted twice during the year, but one molt was in the spring and the second appeared to occur in the autumn, except for the third year specimens (Group 5) which molted between mid-June and mid-July. The exact time of this molt was difficult to determine since specimens of Group 5 and 6 size were not taken in the collection from mid-June to mid-July. Nevertheless, the autumn molts were initiated earlier as the crayfish aged, i.e., Group 1 began in late August, Group 3 began in mid-July, and Group 5 began at some time between mid-June and mid-July. Molts were accompanied by increases in body length and the long

TABLE 2
*Weight of Ovaries and Diameter of Oocytes of Africa Run Females at Autopsy*

| Month and Group No. | Mean Wt (mg) | Mean Dia ($\mu$) |
|---|---|---|
| *Group 1* | | |
| June | 0.2 | 9 |
| July | | |
| August | 0.4 | 132 |
| September | 1.3 | 208 |
| *Group 2* | | |
| October | 0.6 | 182 |
| November | 0.5 | 198 |
| December | 0.9 | 257 |
| January | | |
| February | 1.0 | 286 |
| March | 0.7 | 181 |
| April | 1.0 | 230 |
| May | 1.4 | 248 |
| *Group 3* | | |
| June | 2.9 | 301 |
| July | 4.2 | 399 |
| August | 11.0 | 580 |
| September | 31.6 | 973 |
| October | 112.6 | 1623 |
| *Group 4* | | |
| November | 147.0 | 1950 |
| December | 122.2 | 2262 |
| January | 122.1 | 1962 |
| February | 78.0 | 1778 |
| March | 95.0 | 1846 |
| April | 69.3 | 1269 |
| May | | |
| *Group 5* | | |
| June | | |
| July | 16.8 | 577 |
| August | | |
| *Group 6* | | |
| September | | |
| October | | |
| November | | |
| December | | |
| January | | |
| February | | |
| March | 42.8 | 346 |

autumn and winter period of no molting activity was usually marked by the accumulation of material on the exoskeleton giving it a dark, dirty appearance.

Van Deventer (1937) reported that some *C. propinquus* die as yearlings, some as two year olds, and a very few (primarily females) survive into the spring of the third year. Creaser (1933b) reported that in *Faxonius propinquus* (=*O. propinquus*) ". . . a few apparently pass over a second winter and become two years old." *O. sanborni*, therefore, lives longer than *O. propinquus* with which it was once considered to be conspecific (Fitzpatrick, 1967). Fielder (1972) also noted differences in the life histories of *O. sanborni* and *O. propinquus*.

Van Deventer (1937) reports the occurrence of free swimming young *C. propinquus* at 5 mm carapace length. The smallest free swimming *O. sanborni* in my study was found to be 6.0 mm. The *C. propinquus* (Van Deventer, 1937) were 12–27 mm at the end of their first growing season, while my *O. sanborni* were 7.5–14.6 mm (mean = 11.6 mm) at the end of their first growing season (Group 2).

Those *C. propinquus* which reached sexual maturity during their first autumn (Van Deventer, 1937) were about 20 mm in carapace length. Although the Africa Run *O. sanborni* specimens did not attain sexual maturity until the autumn molt of their second year (Group 4) with the appearance of the first form I males, their carapace length at this time was 19.1 mm. This may be explained by the rapid growth of *C. propinquus* during its first year (Creaser, 1933b) as compared with *O. sanborni* which showed the greatest growth increment at the spring molt of the second year (between Groups 2 and 3).

While it is not surprising that a particular age group of crayfish did not molt simultaneously, the period of time required for Group 3 to reach Group 4 size was twice as long as that for any of the other molts. This may be because this molt was destined to produce sexually mature individuals for the first time. Group 4 contained the first form I males, and table 2 shows that both growth of oocytes and weight of ovaries increased dramatically beginning in the autumn of the second year. Therefore, attainment of certain conditions of sexual development may be a prerequisite for the second autumn molt, but not for the initiation of the other autumn and/or spring molts.

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