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Long-Term Monitoring of Crayfish Populations in the Credit River at the Upper Canada College Outdoor School

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Abstract.— Aspects of the life history of a population *Cambarus robustus* were studied as a part of on-going long-term monitoring (starting September 2008) at the Upper Canada College outdoor school in the Credit River at Norval, Southern Ontario. Data on seasonal reproduction, population structure and density were obtained from regular sampling during late April/early May and September. A particular emphasis was placed on tracking the spring proportions of Form I and II males as well as females with and without glair glands in the population. The results are compared to previous studies of this species in Canada. Analysis of the data to date supports the findings of existing life history studies, but also indicates differences in the size of maturity, as well as the maximum size. These differences may be related to warmer and more predictable local climate and habitat. Long term monitoring of populations of the crayfish species found at Norval may be useful in documenting responses to climate change, water quality fluctuation, as well as effects of invasive species. [*Keywords*.— *Cambarus robustus*; growth; life history; long term monitoring; Ontario].

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INTRODUCTION

As a part of ongoing environmental education at Upper Canada College (UCC) in Toronto Canada, a long-term crayfish monitoring study has been set up in the Credit River near Norval, Ontario, where the outdoor campus of the school is located. The study began in 2008 and is conducted on a yearly basis by various classes of students from the college. It is hoped that over the years, the data obtained from the study will yield information on yearly variation in population densities, life history/reproductive cycles, growth variation, as well as any potential impacts of pollution, climate change or non-native species introductions.

There are three species native to the Credit River at Norval: *Cambarus robustus* Girard, the robust crayfish, *Orconectes propinquus* (Girard), the northern clearwater crayfish, and *Orconectes virilis* (Hagen), the virile crayfish. The former two appear quite common while the latter is found more rarely. *Cambarus robustus*, one of nine crayfish species distributed across Ontario, was the main focus of this portion of the study. In Ontario, *C. robustus* has been observed to reproduce in the summer, with mature females showing glair gland development from May to August and females in berry (with eggs) found from June to July (Hamr and Berrill 1985). There has been some dispute about whether the species exhibits a specific breeding season or not (Crocker and Barr 1968; Hamr and Berrill 1985). By the end of their second summer, immature *C. robustus* appear to reach a size of 17 – 26 mm carapace length (CPL; length from tip of the rostrum to the back of the thorax) and mature at 2 years of age at around 40 mm CPL (Hamr and Berrill 1985). The average lifespan of the species has been recorded as 3 years, with the maximum age being approximately 4 years. The maximum recorded size is 57 mm CPL (Hamr and Berrill 1985).

Interesting among the males of this species is that throughout the year there are Form 1 (reproducing) and Form 2 (non-reproducing) males found in a non-synchronous moulting pattern. Crayfish usually moult into Form 1 shortly before they mate, and back into Form 2 shortly after. The presence of both mating forms appears common to crayfish of this genus (Crocker 1957; Guiasu 2002; Loughman 2010). This is separate from other crayfish species, which tend to show cyclical changes between forms in the whole population, not staggered (*Orconectes propinquus* (Girard), for example, is another crayfish present in the Credit River which shows very cyclical moulting patterns).

METHODS

A long-term monitoring study has been set up in a 500 m section of the Credit River at the UCC outdoor school campus. The location of the sampling area was the Credit River just upstream of the village of Norval, Ontario. Samples were taken each year in both the fall (early September) and spring (late April to early May). Student groups remained centred within 500 m near an area known as “Cole’s Creek,” (GPS coordinates: 43.656063, -79.87739, WGS-84). The sampling method was modified for students from a protocol designed for the Ontario Ministry of Natural Resources (Hamr 2007). Students were divided into five

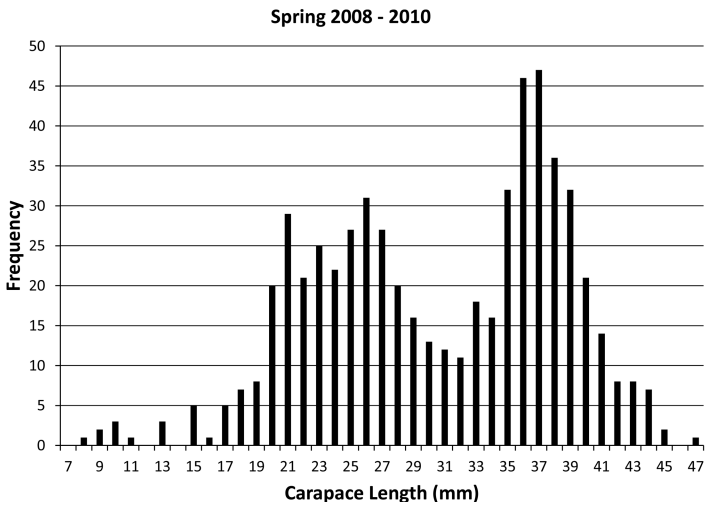


Figure 1. Frequency distribution of all *C. robustus* (male and female combined) in spring samples from the Credit River at Norval from 2008 to 2010.

groups of 4 – 5 students each, all equipped with a dip net. Five meter wide transects across the river were marked out with ropes and each group captured as many crayfish as possible in two hours in their assigned transect. Site coordinates were recorded using a GPS and water chemistry measurements were taken with an Ultrameter portable water chemistry probe for each sampling event.

The data used in this investigation was collected over 3 years from April 2008 to May 2010. Six samples were taken over a week-long period each spring and fall, amounting to sixty transects in total. The statistical and graphical analyses, for the purpose of this study, were mostly restricted to spring samples, as they yield better results in terms of reproductive biology (proportions of breeding vs non-breeding adults).

Crayfish were either caught by hand or scooped with flat bottom dip nets. Rocks were overturned to flush specimens out from their refuges. Once captured, crayfish were brought onto land in a bucket, identified and measured. Males were classified as reproductive (Form 1) or non-reproductive (Form 2) while for females, reproductive status was determined by the presence of white glair/cement glands on the bottom of the uropod. Females were also classified as mature if they were found to carry abdominal eggs or young. Carapace length of each specimen was measured in millimeters and the moulting condition was also recorded. All crayfish were returned to the river near the location of capture. Growth and reproductive data were pooled, tabulated and analyzed using Excel.

RESULTS AND DISCUSSION

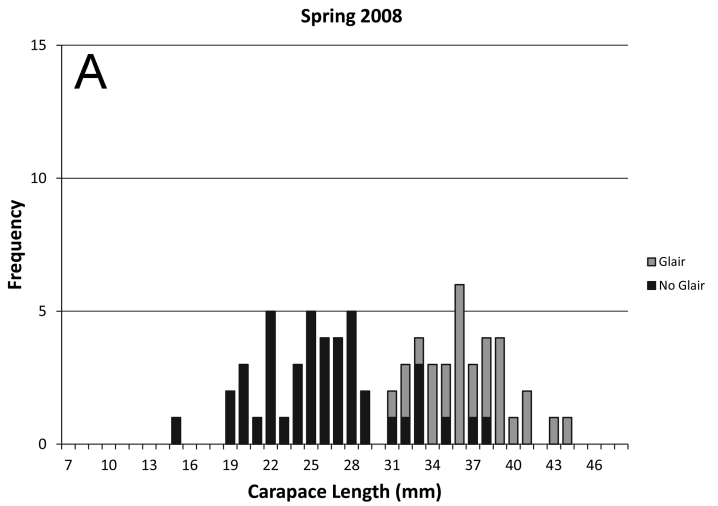
Cambarus robustus is the most abundant species in the Credit River at Norval as it comprised between 85 and 95% of the catches in the spring samples taken from 2008 to 2010 (n = 844). The life cycle largely corresponds to available literature: The species has a three to four year lifespan (Figure 1) with crayfish coming into sexual maturity in the second or third year (Figures 2 & 3; Table 1). Most adults at Norval probably reproduce only once or twice in their lifespan. The sizes of maturity for both males and females are smaller than values found in populations from the Kawarthas region of north-central Ontario (Hamr and Berrill 1985) but larger than those of the Eramosa River in southern Ontario (Table 1). Similarly the maximum size at Norval was lower than that in the Kawarthas but larger than the Eramosa. This implies that size of maturity/growth are site specific and influenced by regional factors such as temperature, flow regime and food availability. Such relationships have been demonstrated by studies of other crayfish species (Nystrom 2002; Reynolds 2002).

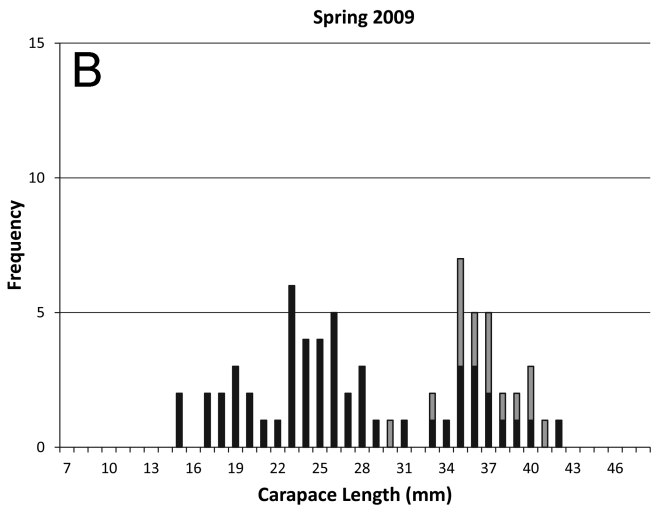
Both Form 1 and 2 males are present from spring to fall as previously documented for this species, as well as for the genus overall (Hamr and Berrill 1985). Similarly, not all mature females appear to be reproductive during a given season, which is again consistent with findings of previous studies (Hamr and Berrill 1985; Corey 1990). Tables 2 and 3 show the relative proportions of reproductive (Form 1 males and females with glair) adults during the fall and spring. The proportions of non-glaired females as well as Form 2 males are higher in fall samples and this is in part due to the fact that many mature breeding females have not yet developed glair glands (in preparation for the following summer breeding) and some males may not have finished moulting (to Form 1). In contrast, in the spring, all mature (large) females which are preparing to breed, had strong glair, while those that do not have been observed to have small ovaries containing undeveloped white eggs. Similarly, large Form 2 males will apparently not be participating in spring/early summer mating. Asynchronous (non-breeding) portions in spring vary from 19 to 48% (Table 2) but may be more variable in females than in males as the females may

Table 1. Analysis of size at maturity for *C. robustus* in the Credit River compared to previous studies in Ontario (Credit River maturity estimate (mean – SD); Male: 32 mm CPL; Female: 33 mm CPL).

	Credit River Mean CPL at Maturity (Form 1/With Glair) (Range, Standard Deviation)				
Sex	Fall 2008	Fall 2009	Spring 2008	Spring 2009	Overall
Male	36.5 mm (29 – 41)	36.9 mm (28 – 41)	33.8 mm (27 – 40)	36.6 mm (32 – 48)	36.1 mm (27 – 48, SD = 3.6)
Female	37.3 mm (31 – 42)	38.0 mm (36 – 40)	36.9 mm (31 – 44)	36.8 mm (30 – 53)	36.9 mm (30 – 53, SD = 3.6)

Past Studies	Hamr and Berrill (1985) - Kawarthas	Corey (1990) - Eramosa
Male	44 mm (35 – 57, SD = 4.2)	30.6 mm (23 – 42, SD = 3.2)
Female	43 mm (34 – 57, SD = 4.5)	29.7 mm (24 – 34, SD = 1.4)





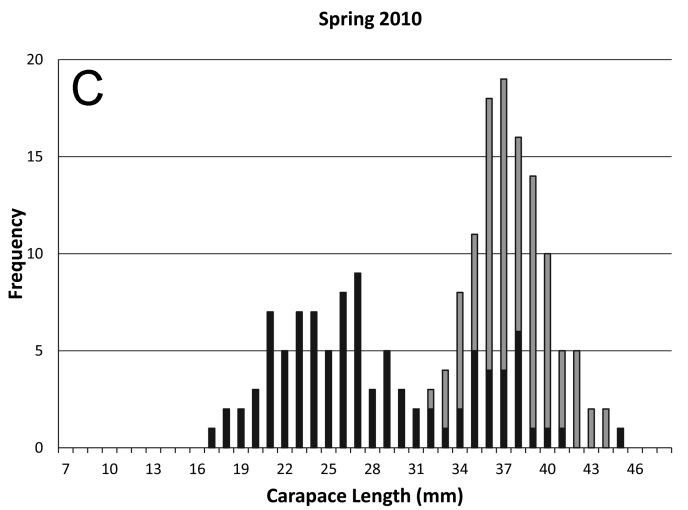
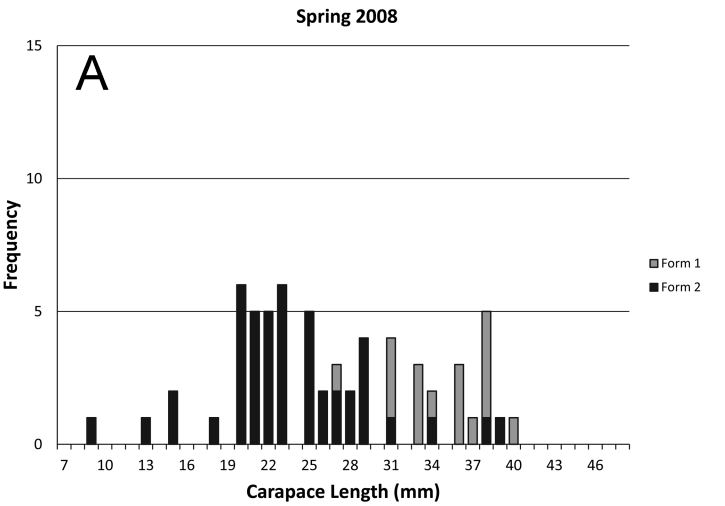
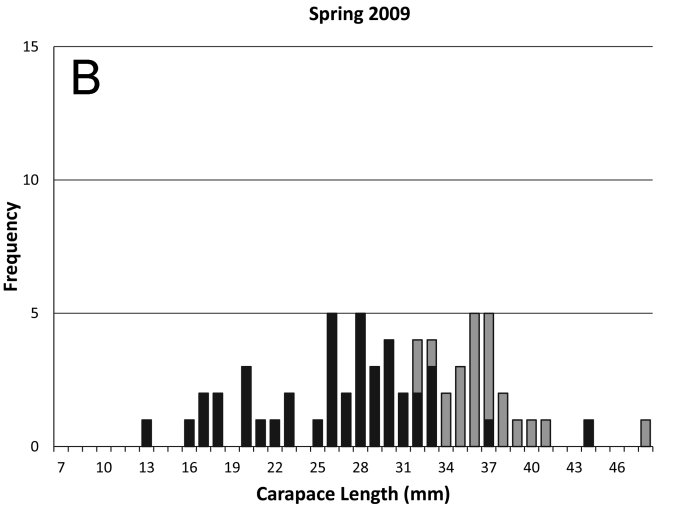


Figure 2. Frequency distribution of female *C. robustus* in spring samples from the Credit River at Norval in A.) 2008, B.) 2009 and C.) 2010.





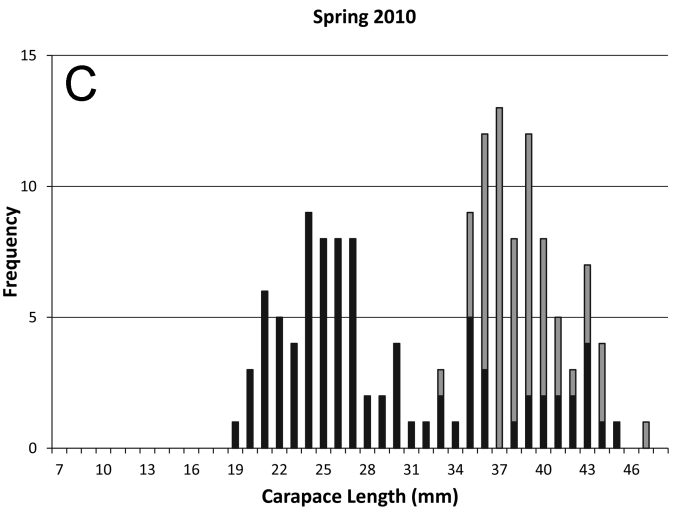


Figure 3. Frequency distribution of male *C. robustus* in spring samples from the Credit River at Norval in A.) 2008, B.) 2009 and C.) 2010.

be more sensitive to environmental conditions such as temperature and flow. It is worth noting that following a particularly cold spring and summer in 2008, the portion of non-breeding adults in Spring 2009 rose markedly. Long term monitoring may shed further light on this possible correlation. Spring samples in Hamr and Berrill's study in the Kawarthas (1985) showed from 20 to 30% asynchrony in both sexes, which is comparable to the present study. Overall, the breeding season of *C. robustus* at Norval is concentrated in the summer months, but reproduction appears possible throughout the year. Copulations were observed regularly in early May but no eggs

Table 2. Proportions of Form I and Form II mature male *C. robustus* compared to average water temperature during Fall and Spring samples in the Credit River (Maturity: CPL = 32 mm).

	Proportion of Seasonal Sample (%)				
Form	Fall 2008	Fall 2009	Spring 2008	Spring 2009	Spring 2010
1	89%	85%	81%	77%	69%
2	11%	15%	19%	23%	31%
Water Temp. (°C)	14.0	14.0	9.95	14.73	16.08

Table 3. Proportions of mature Female *C. robustus* with and without glair or abdominal eggs/young compared to average water temperature in the Credit River (Maturity: CPL = 33 mm).

	Proportion of Seasonal Sample (%)				
Glair Gland/Egg Presence	Fall 2008	Fall 2009	Spring 2008	Spring 2009	Spring 2010
Yes	39%	12%	81%	52%	77%
No	61%	88%	19%	48%	23%
Water Temp. (°C)	14.0	14.0	9.95	14.73	16.08

were observed to be extruded at this time and so it is most likely that females in this population do not extrude eggs until late May or June. Additional samples taken in late July 2010 failed to produce any females with broods and in fact, adult crayfishes proved very difficult to locate in the main river during summer months.

This is in direct contrast to the high abundances in the same areas in both fall and spring samples. Further studies are needed to determine the location and proportion of ovigerous females during the summer.

It is certain, however, that at Norval, some broods are carried over winter and are released in early spring rather than late fall, as shown by the presence of females carrying late stage young broods in late April to early May. This is similar to the findings of Corey (1990), but not to those of Hamr and Berrill (1985), who found no females with young in early spring. This post winter release of some young in the population may be a contributing factor to the asynchrony in breeding, as the spring-released young may grow and mature at a different rate/age than those released in late summer or autumn. Note that females carrying late stage young were also captured in several fall samples.

Long term monitoring of populations of the crayfish species found at Norval may be useful in documenting responses to short term climate variation as well as long term climate change, water quality fluctuation, flow variation, as well as effects of invasive species. The introduced *Orconectes rusticus* (Girard) is found in watersheds both west and east of the Credit River and could invade the Credit River watershed in the near future.

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