The Crayfish *Astacus pallipes* of an Irish lake

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ABSTRACT

The population of a 30 hectare limestone lake was studied. The crayfish were most active from July to September. Females carrying eggs were present from November to June. Parameters describing the measurements of the stock available for trapping were determined.

INTRODUCTION

A single species of freshwater crayfish, *Astacus pallipes* Lereboullet, has been recorded from Irish waters. It is known to be widely distributed but no detailed information on the distribution is available. As the crayfish is a valuable commercial species for which a great demand exists in Sweden and elsewhere it was decided in 1967 that the Irish stocks should be investigated. The first problem was to make a study of the stock of a single lake which was known to carry a large population. This study is the subject of this paper. Work on the stocks of other lakes is in progress.

The lake chosen was White Lake, a land-locked water on the border of Counties Meath and Westmeath. It has a surface area of approximately 30 hectares and reaches a depth of at least 15 m and probably considerably more. The bed of the lake slopes steeply in most places and the area of shallow water (less than 5 m) is restricted to a fringe of 10 m or so in width around the margin. The water is exceptionally clear and rich in lime. Two samples were analysed in 1967 with the following results:

Date	pH	Alkalinity (as ppm Calcium Carbonate)
29 May	7.95	206
24 August	8.15	145

Brown Trout, Rainbow Trout, Perch and Pike are present but there are no eels.

MATERIAL AND METHODS

The first samples of crayfish examined were kindly provided by the Inland Fisheries Trust. They were captured in perch traps made from chicken wire mesh on a stiff wire frame. It was felt that the construction of these traps would allow the escape of small specimens and these catches were not used in the subsequent analysis. The perch traps were replaced at an early stage by plastic eel traps which proved very satisfactory. These traps had a rigid rectangular mesh of 7 x 20 mm and overall dimensions of 130 cm in length with an oval opening 43 cm by 37 cm. Trials were made with collapsible crayfish traps but these required constant attention (lifting and setting every few hours during the night) which was not practicable over long periods.

Two summer seasons were spent at White Lake, the first without a break from 5 July to 8 September 1967. The second comprised 1 to 23 July, 11 to 20 August and 2 to 6 September 1968. The intervening periods in 1968 were spent at other lakes in the district. In 1967 and the first five weeks of 1968 the field work was done by Mr. Kevin Clabby, the second five weeks of 1968 by Miss Barbara Buckley. Both assistants were zoology students holding bursaries from Fisheries Division. Their work consisted of setting and lifting the traps daily and examining the catch. The individual crayfish were measured and marked and most were returned to the water. In 1967 they were weighed in random groups of ten at a time. Various baits were tried in the course of these periods.

From September 1967 to July 1968 and from February to September 1969 samples of crayfish were taken approximately twice a month. The intention was to do this at fortnightly intervals but weather conditions and other considerations made such regular work impossible. In this part of the study three unbaited traps were used. Crayfish enter the traps whether bait is used or not and it was considered that over a period of one or two weeks the decay of unconsumed bait might inhibit entry.

Various measurements of the crayfish were made. During the first season the full length of the carapace, from the tip of the rostrum to the centre of the hind margin, and the breadth of the carapace at its widest point were measured with calipers and the full length of the body was measured with a ruler set in a board with a barrier at the end. The rostrum of the crayfish was pressed against the barrier and the abdomen was pressed

down on the board so that the maximum length without actually stretching the body could be determined. For some of the time the 'short' carapace length from the hind portion of the eye socket to the centre of the hind end of the carapace was measured. All three measurements of length and the weight of a sample of 173 male crayfish were made so that the most suitable length measurement could be chosen.

RESULTS

The measurements of length (mm) and weight (grams) were compared by determining the regression coefficient:

$$R = \frac{\Sigma(x-\bar{x})(y-\bar{y})}{\sqrt{\Sigma(x-\bar{x})^2 \Sigma(y-\bar{y})^2}}$$

The following values of R were calculated from the 173 male crayfish caught on 9th November 1967 which ranged in length from 55 to 105 mm.

Short carapace/length	...	...	0.73
Short carapace/weight	...	...	0.74
Full carapace/length	...	...	0.71
Full carapace/weight	...	...	0.90

In all cases correlation is much more significant than the 0.1% level, showing that the relationship is linear for the length range examined. The best length/weight relationship is given by measuring the full carapace. The lower values for R in the cases where full length is measured are to be expected because of the difficulty of measuring the full length accurately—it depends on how firmly the abdomen was pressed down during measurement. The still lower values for short carapace related to weight cannot be explained so easily. In practice it is very much easier to use a calipers and measure the rigid carapace of a live crayfish than to observe the full length of the body and future work will be based on carapace measurements.

Regression lines to show the relationships between carapace and full length and between carapace and weight were calculated using the formula:

$$y = \frac{\Sigma y}{N} + \left(\frac{\Sigma(x-\bar{x})(y-\bar{y})}{\Sigma(x-\bar{x})^2}\right)\left(x - \frac{\Sigma x}{N}\right)$$ where N=the number in the sample.

The ratio of carapace length in mm to weight in grams is expressed by the equation $y=1.7x-46.5$ and carapace to full body length in mm by $y = 1.2\,x + 39$. These lines are shown in Fig 1.

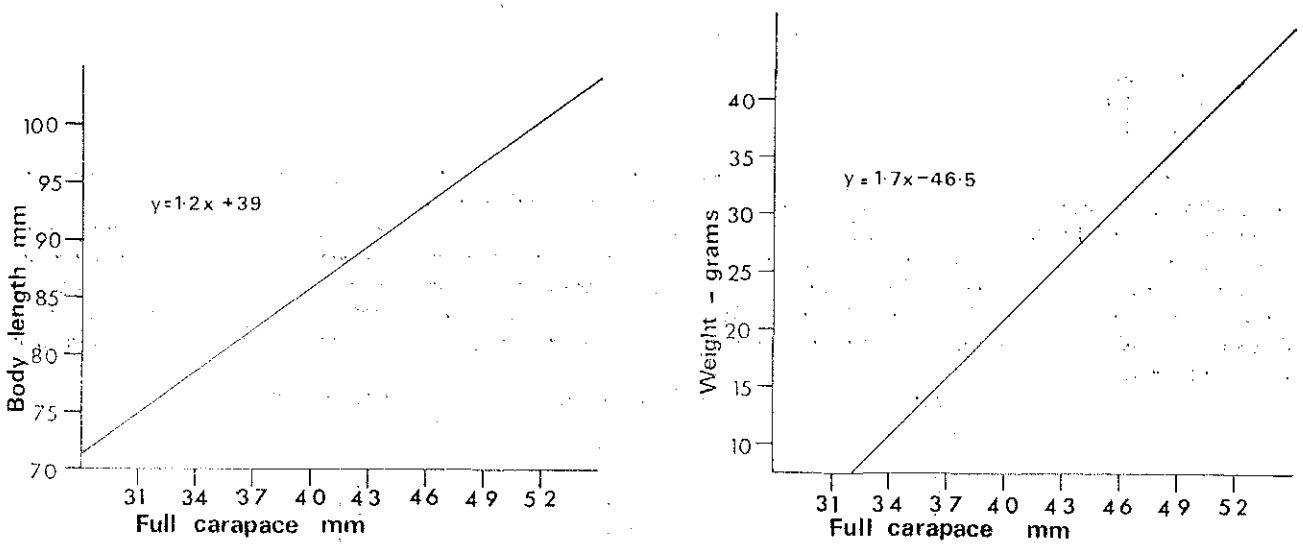

Fig. 1. Regression lines

Observations on the breadth of the carapace in relation to length of the crayfish showed that the smallest males captured (full length 55 mm) had a carapace breadth of 15.5 mm. This figure shows that the smallest crayfish captured were very much larger than the smallest that could escape through the 7 mm mesh of the trap thus indicating a marked difference in the habits of large and small individuals. From July to September crayfish of the year could be found under stones reached by wading at the margin of the lake. Occasionally larger individuals, presumably of over a year old, can be found in the same places. Otherwise the young stages were not seen in the course of the work.

The type of bait used depended entirely on what material was convenient at the time. The catch per trap for each kind of bait is shown in Table 1. All of the observations relate to traps set and fished over single nights. The results of fishing baited traps over longer periods were ignored since they would confuse the effects of fresh and stale baits. The word 'stale' refers to bait more than one day old.

Table 1. Bait experiments.

Bait	Number of observations	Catch per trap
Dead Crayfish	2	2.0
Herring *Clupea harengus*	9	2.4
Pike *Esox lucius* (stale)	14	2.8
No bait	148	3.9
Perch *Perca fluviatilis*	25	7.8
Pike	34	9.8
Mackerel *Scomber scomber* (stale) ...	3	10.6
Red Meat (beef or mutton)	7	14.7
Sardine (canned in oil)	15	15.6
Liver (beef)	14	25.0

It seems possible from these figures that some of the articles used for bait (dead crayfish, herring and stale pike) actually repelled the crayfish. The others gave better catches than unbaited traps and beef liver proved the most attractive.

The daily catch in each trap varied considerably. Catch figures for four unbaited and one trap baited with sardines on seven days from 5 to 17 July 1968 are given in Table 2.

Table 2. Daily variations in catch.

Unbaited traps		Baited traps	
Number per trap	Number of occasions	Number per trap	Number of occasions
0	4	3	1
1—2	9	14	3
3—4	9	16	2
5—6	5	36	1
7—8	1		
Total 80	28	113	7
Mean 2.9		16.1	
Mode 9		36	

The largest catch for a night's fishing was made on the last day of the 1968 summer season, 6 September 1968, when 300 were caught in 7 traps (41 per trap) using fresh beef liver as bait.

To reduce the effects of daily variations to a minimum, sampling over long periods was done by setting three unbaited nets for roughly two weeks at a time and calculating the catch per trap per day. These traps were set in water of less than 3 m deep. The figures are taken as a measure of the activity of the crayfish throughout the year and are shown in Fig. 2 and Table 3. From 24 February to 28 May 1969, one trap was set at a depth of approximately 15 m to find out whether there was any noticeable activity in deep water. The catches are compared below :

Date	Shallow Water	Deep Water
24.2.69	0.2	1.1
11.3	0.02	0.5
25.3	0.1	0.4
8.4	0.7	1.1
14.5	1.2	0.1
28.5	1.1	0.1

On subsequent dates the deep catch was substantially smaller than that in the shallow traps. There is therefore slightly more activity by crayfish in deep water than in shallow in early spring but the deep water is largely abandoned by the month of May.

Table 3. Catch and sex distribution in periodical samples.

Date	Number of days	Catch per trap	Number of males	Percentage of males	Percentage of females berried	Temperature °C.
1967						
27 Sep.	5	4.7	1.5	33	0	
11 Oct.	14	4.6	2.2	48	0	
8 Nov.	13	3.3	3.3	100	—	
22 Nov.	14	2.9	1.9	65	71	
6 Dec.	14	1.7	0.9	54	71	
20 Dec.	14	5.6	2.8	50	63	
1968						
5 Jan.	16	3.8	2.1	55	32	
17 Jan.	12	3.4	1.9	55	33	
19 Feb.	33	0.9	0.4	44	51	
7 Mar.	16	0.4	0.3	75	29	
29 Mar.	22	0.8	0.4	50	29	
24 Apr.	31	1.2	0.6	50	23	
17 May	23	0.9	0.5	57	22	
10 Jun.	24	0.9	0.6	66	22	
1969						
24 Feb.	20	0.2	0.1	50	33	3
11 Mar.	15	0.02	0.02	100	—	4
25 Mar.	14	0.1	0.1	100	—	4
8 Apr.	14	0.7	0.3	45	61	9
22 Apr.	14	1.4	0.7	50	40	7
14 May	22	1.2	0.6	50	60	13
28 May	14	1.1	0.6	56	33	14
11 Jun.	14	1.8	0.9	50	33	21
27 Jun.	16	3.0	2.2	73	3	—
11 Jul.	14	3.2	1.7	53	0	15
25 Jul.	14	2.7	1.4	51	0	20
8 Aug.	14	2.0	0.7	35	0	17
22 Aug.	14	2.3	1.5	65	0	—
5 Sep.	14	3.0	1.4	46	0	16
18 Sep.	13	2.9	1.3	44	0	15

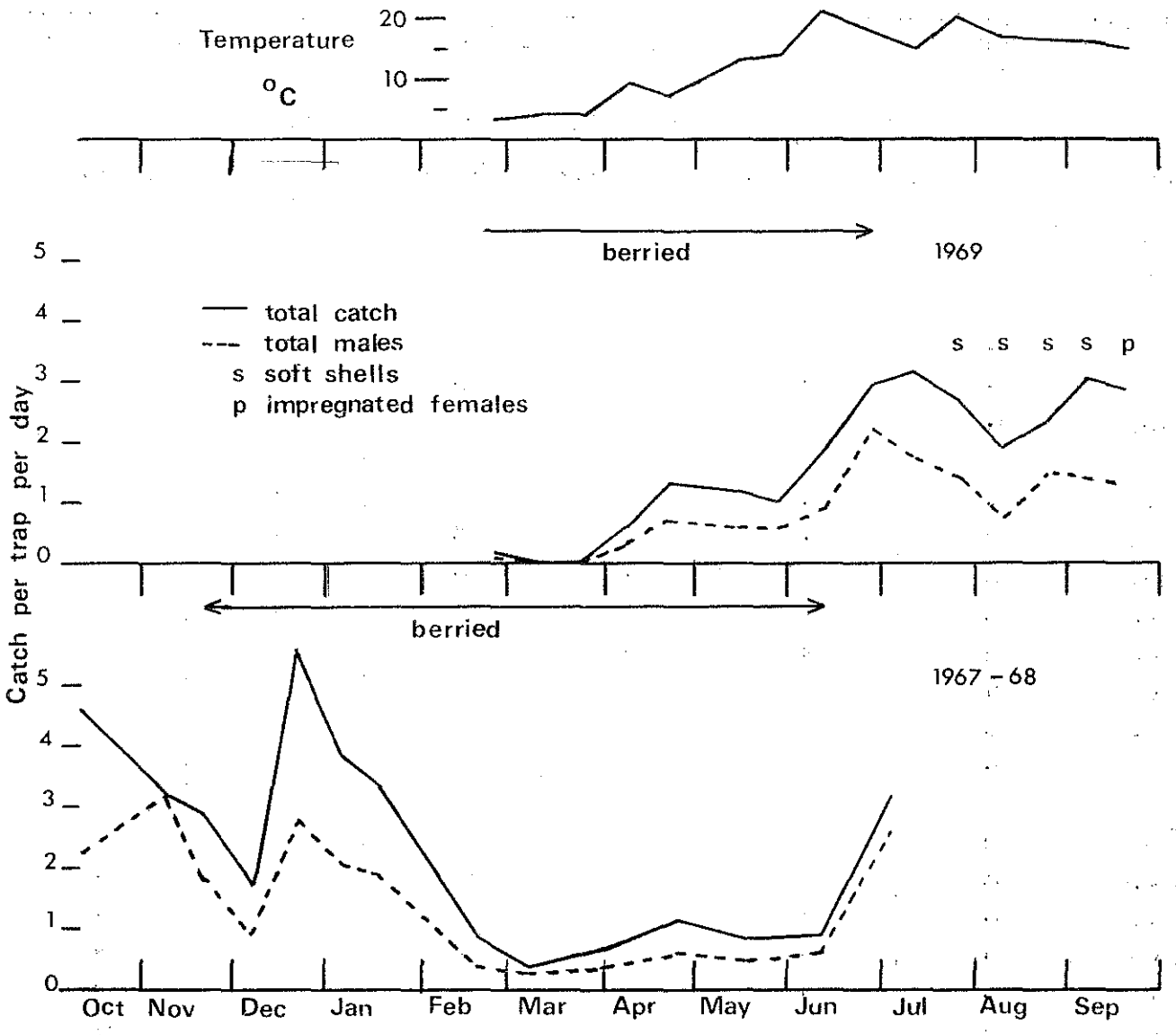

Fig. 2. Catch in unbaited traps.

The graph shows that activity was at its lowest in March, rose slowly until June and sharply from June to July, remaining high until October. It fell from October to December and then, in December 1967, rose very sharply and remained high through January, falling again in February. Unfortunately it was not possible to investigate this remarkable winter activity subsequently. Mating took place in September, females with encrustations of sperm were first noted in 1969 on 18 September. The earliest 'berried' females, that is females carrying eggs, were seen on 22 November 1967 and the latest on 10 June 1968 and 11 June 1969. A female with a single young attached was caught on 27 June 1969. Specimens with soft shells were found from 25 July to 5 September 1969. In 1969 the surface temperature was recorded and is included in Fig. 2.

The increase in activity from March to April coincides with temperatures rising from 4° to 9°C and that in June with a rise from 14° in May to the maximum observed of 21° in June. This change in activity is not necessarily controlled by the temperature.

The number of males in the catch is shown by the dotted line in Fig 2; the figures are given in Table 3. No females were captured on 8 November and on 22 November 1967 they made up only one third of the catch. From

then, except in February, until August 1968 the females were always outnumbered by males. On 8 April, 8 August and in September 1969 females outnumbered males. In June of both seasons males were noticeably more numerous than females. Otherwise the differences in numbers of the sexes were not significant. Possibly the scarcity of females in November and June may be explained by the breeding cycle. These are the months just following the laying of eggs and abandoning of the young. Column 6 of Table 3 shows the percentage of females which were berried. This is at its highest in November and December. The lower numbers of berried females found subsequently may suggest that they are less active than the others. The smallest breeding females found were in the 28 to 30 mm carapace length group.

It was noticed in 1968 that very few large crayfish were caught during the winter but incomplete data made it impossible to find out precisely when they appeared again. The observations were checked from February to September 1969 when the lengths of individuals in all samples were measured. The length distributions for 1969 are shown in Fig. 3. The numbers of large (carapace length over 46 mm) specimens were very small until the beginning of June. The high proportion, 25%, in March represented only a single individual in a catch of four. On 11 June 10% and 27 June 1969 13% of the catch were large. The numbers remained of this order until September when 13% were large on 5th and none greater than 46 mm were found on 18th out of a sample of 35. A carapace length of 46 mm is the equivalent of a full body length of 93 mm. The disappearance of large crayfish in September may be connected with the moulting period which, judged on the appearance in the catches of specimens with soft shells, extends from late July to September. It is possible that fully grown individuals fail to moult properly and either die in the attempt or get eaten by predators. The lake has a stock of Perch *Perca fluviatilis*, a species which is known to prey on crayfish.

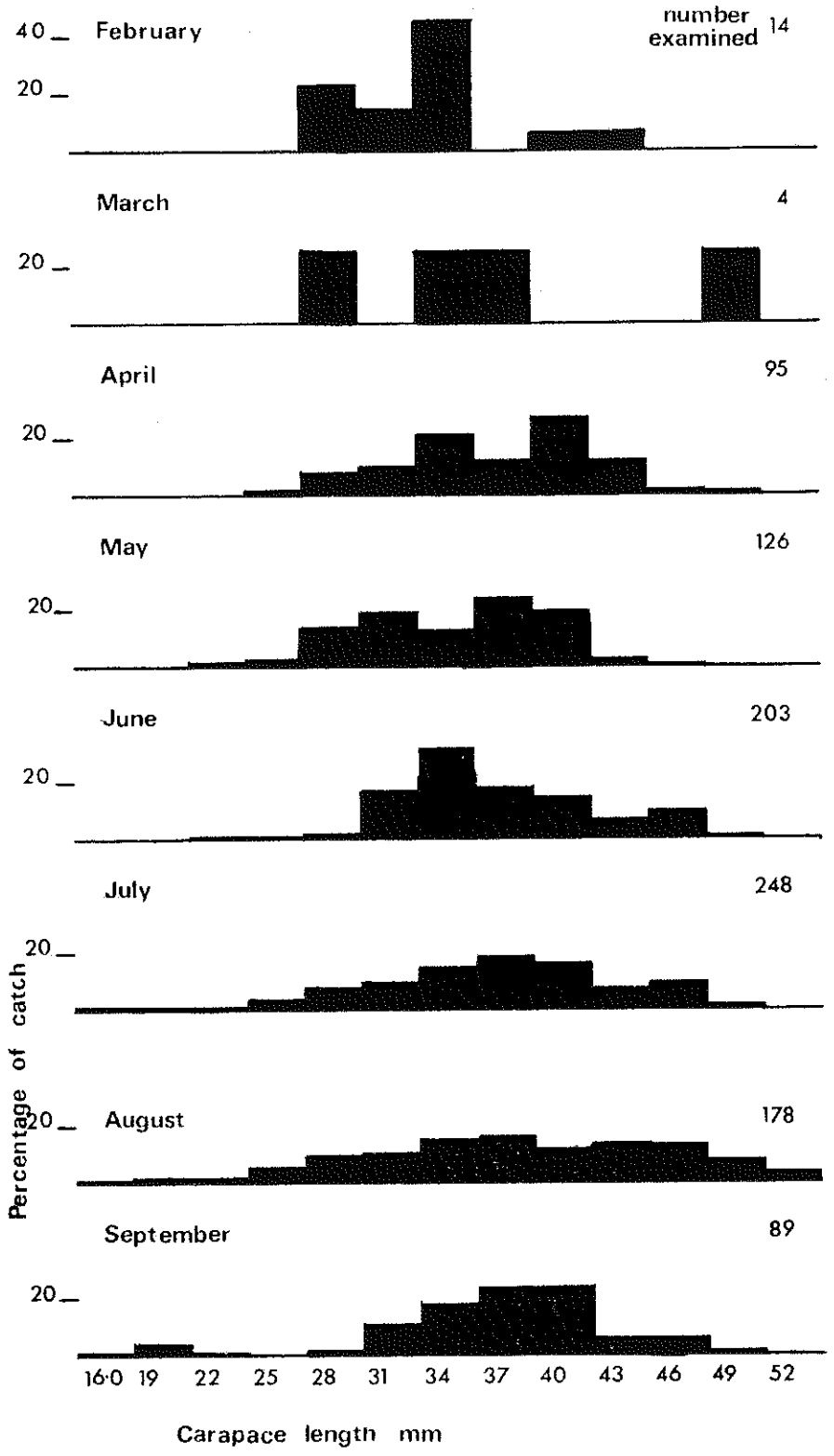

Fig. 3. Length distributions for 1969.

These observations suggested that July would be the most satisfactory month for sampling crayfish with a view to studying the length distribution in a particular water. The catch is at its highest and moulting and breeding activity should have their least influence. The length distribution of males and females of the July 1967 sample is shown in Fig. 4 based on 1 mm differences in carapace lengths. The measurements were made to the nearest 0.1 mm. There are three modes in the female histogram and five in the male. In view of the small numbers in the sample the female mode at 33 mm and the male modes at 34 mm and 49 mm cannot be considered significant. It is suggested that the female modes at 35 mm and 37 mm and the male modes at 39, 42 and possibly 44 mm represent year classes. A female hatched in captivity in June 1969 had a carapace length of 13 mm at the end of December and, judged by the appearance of young crayfish in White Lake in September, this one had developed at a normal rate. Specimens from 16 to 25 mm carapace length were regularly seen amongst the stones at the edge of the lake from July to September and it is considered that these represent a second year class. It is suggested therefore that the female mode of 35 mm and the male mode of 39 mm represent the third year class (two years old from the time of hatching) and females of 37 mm and males of 42 mm represent the next year. The only available corroboration of this suggestion is the case of a female kept in an aquarium from September 1968 to December 1969. She moulted at the beginning of June 1969 and the shed carapace measured 35.7 mm and the new one 37.4 mm. It is interesting also to record that this female mated in the aquarium on 12 November and died approximately three weeks later. This supports the suggestion made above that the crayfish die in the winter after reaching their maximum size.

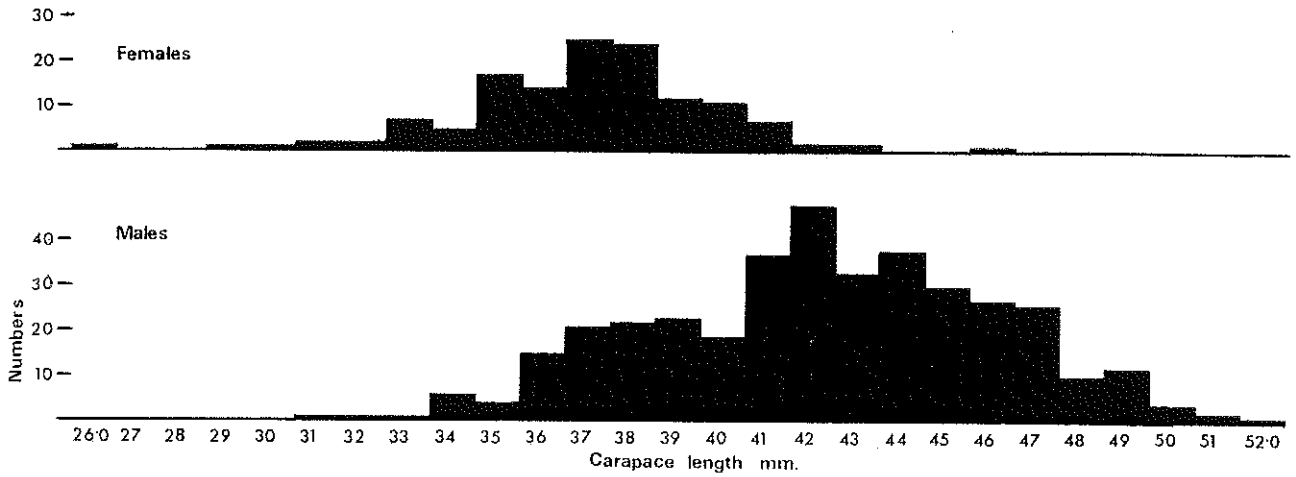

Fig. 4. Length distribution in July 1967 (26.0—26.9 mm etc.)

The length distributions for July 1967 and 1969 for each sex by 3 mm carapace length groups are shown in Table 4. Except in the case of the males in 1969 these large length groups give a unimodal distribution. The average length of individuals in 1969 was considerably less than in 1967. This may be explained by the numbers of small specimens taken in 1969. The modal length (40 to 42 mm for males, 37 to 39 mm for females) was the same in both cases. Standard deviations were greater in the 1969 catch.

Table 4. Length data for crayfish caught in July 1967 and 1968 (length groups 16.0—18.9 mm, etc.)

Length Group	Numbers				Percentage			
	1967		1969		1967		1969	
	Male	Female	Male	Female	Male	Female	Male	Female
16-18	0	0	2	1	0	0	1	1
19-21	0	0	0	1	0	0	0	1
22-24	0	0	0	1	0	1	0	1
25-27	0	1	8	4	0	1	6	4
28-30	0	2	10	11	0	1	7	10
31-33	3	11	8	17	1	6	6	15
34-36	25	36	18	21	7	20	13	18
37-39	66	66	21	28	17	38	16	24
40-42	104	47	22	22	27	27	16	19
43-45	101	11	16	5	26	6	12	4
46-48	63	1	22	3	16	1	16	3
49-51	18	0	7	0	5	0	5	0
52-54	3	0	0	0	1	0	0	0
Total	383	175	134	114				

	1967		1969	
	Male	Female	Male	Female
Mean length	42.8	39.3	38.9	35.8
Modal length	40-42	27-39	40-42	27-39
Standard deviation	4.1	3.6	7.2	5.4

In July and August 1968 779 crayfish were marked by branding with a red hot needle and returned to the water. In September ten of these were recaptured out of a total catch of 474. On the assumption that the released individuals became randomly distributed amongst the remainder of the population a figure of 37,000 can be deduced for the number of crayfish of the sizes caught in the lake.

CONCLUSIONS

The seasonal variation in the size and sex distribution of crayfish shows that in attempting to compare stocks in different waters it is desirable to take samples at a particular period. The month of July is the most satisfactory month for sampling. Measurement of the length of the carapace from the tip of the rostrum to the centre of the hind margin gives an excellent correlation with the weight of specimens of carapace length 16 to 54 mm. Differences in mean weight and standard deviation between samples taken in July 1967 and 1969 show that annual fluctuations in the stock may occur in an unexploited fishery.