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Notes on the Tasmanian Marine Crayfish, *Jasus lalandii* (Milne Edwards)

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The common marine crayfish, *Jasus lalandii* (Milne Edwards), which is taken in large numbers off the coast of Tasmania, occurs also in the waters round New Zealand, South Africa, Juan Fernandez and Tristan da Cunha.

Although the crayfish is of considerable importance to the sea fisheries of this State, reliable data concerning its habits and mode of life under local conditions are not available. In South Africa, however, various phases of the life of the crayfish have been studied and valuable information gained.

With the object of obtaining data concerning the biology of the crayfish in Tasmanian waters, an investigation was carried out in the Biology Department of the University of Tasmania during the five years 1937-1942. Owing to the difficulties of collecting crayfish at a number of separate localities round the coast, it was decided to confine the investigation mainly to crayfish from one locality, namely, Wedge Bay, on Tasman Peninsula.

The crayfish were caught in 'crayfish pots' similar to those used by local fishermen. Fishing was carried out at approximately fortnightly intervals. Six 'pots' were employed at the one time. On each occasion they were baited and put down for a period of three hours. The total catch was then forwarded to the University, together with a record of the temperature of the water, the depth, and the distance from the shore at which the fishing was carried out.

During the five-year period 1058 specimens of *Jasus lalandii* and two specimens of *Jasus verreauxi* (Milne Edwards) were caught and examined. The following notes refer to *Jasus lalandii*.

NUMBERS OF CRAYFISH CAUGHT

Of the 1058 crayfish caught one was a pseudohermaphrodite and has been described in a previous paper (Hickman, 1945). The remaining 1057 consisted of 485 males and 572 females. Of the 572 females, 310 were 'in berry' and 262 not 'in berry.' Although the numbers taken each month are small, they may be of some interest and are therefore recorded in Tables I, II, and III.

TABLE I

Jasus lalandii

NUMBER OF MALES TAKEN EACH MONTH DURING THE FIVE-YEAR PERIOD

Month	1937	1938	1939	1940	1941	1942	Total
January	—	9	2	3	14	10	38
February	—	17	9	12	3	15	56
March	2	16	7	6	21	2	54
April	7	3	1	4	1	—	16
May	26	13	3	4	12	—	58
June	17	20	6	18	15	—	76
July	14	6	12	9	7	—	48
August	4	1	4	16	12	—	37
September	9	0	2	6	1	—	18
October	4	1	1	4	8	—	18
November	6	2	1	10	8	—	27
December	16	7	14	1	1	—	39
Totals	105	95	62	93	103	27	485

TABLE II

Jasus lalandii

NUMBER OF FEMALES 'IN BERRY' TAKEN EACH MONTH DURING THE FIVE-YEAR PERIOD

Month	1937	1938	1939	1940	1941	1942	Total
January	—	0	0	0	0	0	0
February	—	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	1	0	0	0	0	—	1
May	13	13	10	3	16	—	55
June	26	33	9	20	14	—	102
July	25	13	9	12	7	—	66
August	4	1	10	21	7	—	43
September	11	0	10	17	1	—	39
October	0	0	1	1	1	—	3
November	0	0	0	0	0	—	0
December	0	0	0	1	0	—	1
Totals	80	60	49	75	46	0	310

TABLE III

Jasus lalandii

NUMBER OF FEMALES NOT 'IN BERRY' TAKEN EACH MONTH DURING THE FIVE-YEAR PERIOD

Month	1937	1938	1939	1940	1941	1942	Total
January	—	18	6	15	10	3	52
February	—	7	14	16	3	7	47
March	0	9	3	4	9	0	25
April	2	0	0	1	0	—	3
May	0	1	0	0	1	—	2
June	1	2	0	1	1	—	5
July	0	2	2	0	0	—	4
August	0	0	2	2	1	—	5
September	0	0	1	2	1	—	4
October	1	0	5	0	0	—	6
November	6	1	5	4	7	—	23
December	38	16	28	2	2	—	86
Totals	48	56	66	47	35	10	262

PROPORTION OF MALES TO FEMALES

From the numbers given in Tables I, II, and III, it will be seen that there is no constancy in the proportion of males to females in the monthly catches. In April the catches consist largely of males. This is no doubt due to the fact that the females are preparing to lay their eggs and therefore do not enter the 'pots.' In December the catches often contain twice as many females as males. In referring to *Jasus lalandii* on the coast of South Africa, Von Bonde and Marchand (1935, p. 23) make a similar observation. They state 'Male and female crawfish do not occur in any regular or constant proportions on the fishing grounds, but may vary from time to time, and place to place, and even in the same restricted area, from a pure male population to a pure female population'.

In the report of the Sea Fisheries Board of Tasmania for the years 1933-39, page 26, it is stated that 'female crayfish only enter the "pots" to any marked extent when carrying "berry"'. This statement implies that female crayfish, when not 'in berry' do not enter the 'pots' to any marked extent. A reference to Table III will show that during December, January, and February, female crayfish, which are not 'in berry,' enter the 'pots' in considerable numbers, though not to the same extent as do the 'berried' females during May, June, and July.

SIZE AND WEIGHT

The length of the carapace of each specimen was measured from the tip of the rostrum to the middle of the posterior margin of the carapace. Each specimen was also weighed. The largest male crayfish caught at Wedge Bay had a carapace-length of 15·9 cms. and weighed 1878 grammes. The smallest male had a carapace-length of 6·3 cms. and weighed 128 grammes. Table IV gives the sizes and weights of some of the males taken.

TABLE IV

Jasus lalandii

SIZE AND WEIGHT OF MALES

Carapace-length in cms.	Minimum weight in grammes	Maximum weight in grammes	Average weight in grammes	Number of specimens examined
6·3	—	—	128	1
7·0	166	177	171	2
7·5	229	232	230	2
7·8	220	260	247	4
8·0	—	—	280	1
8·2	255	293	282	4
8·4	294	342	309	4
8·6	320	330	324	3
8·8	335	370	350	6
9·0	335	422	373	10
9·2	374	461	412	9
9·4	415	461	437	11
9·6	407	510	468	12
9·8	468	560	489	12
10·0	465	574	510	16
10·2	503	597	548	9
10·4	524	645	575	22
10·6	588	701	645	20
10·8	600	705	659	6
11·0	670	780	722	4
11·2	673	794	715	9
11·4	645	843	778	17
11·6	744	916	816	12
11·8	792	945	841	10
12·0	865	999	913	8
12·5	992	1114	1064	3
13·0	1077	1195	1119	3
13·5	1148	1240	1194	2
14·0	1422	1474	1448	2
14·8	1478	1509	1493	2
15·5	—	—	1807	1
15·9	—	—	1878	1

The largest female caught measured 12·4 cms. in carapace-length and weighed 1099 grammes. The smallest female had a carapace-length of 6·3 cms. and weighed 129 grammes. Table V gives the sizes and weights of some of the females taken.

TABLE V

Jasus lalandii

SIZE AND WEIGHT OF FEMALES

Carapace-length in cms.	Minimum weight in grammes.	Maximum weight in grammes.	Average weight in grammes.	Number of specimens examined
6·3	—	—	129	1
7·1	191	206	198	2
7·5	214	247	231	5
7·8	241	314	274	10
8·0	274	339	298	8
8·2	290	327	310	8
8·4	280	406	351	14
8·6	326	413	367	13
8·8	336	410	374	8
9·0	315	504	411	19
9·2	375	514	445	15
9·4	400	553	494	22
9·6	432	596	524	19
9·8	432	583	511	16
10·0	465	659	560	25
10·2	517	747	595	10
10·4	503	672	609	17
10·6	567	744	673	10
10·8	600	737	703	6
11·0	640	785	726	11
11·2	652	780	726	5
11·4	701	865	770	5
11·6	—	—	787	1
11·9	843	952	897	5
12·1	840	985	915	3
12·4	—	—	1099	1

SEXUAL MATURITY

Of the 572 females examined during the present investigation, the smallest one, which, by the presence of empty egg-capsules on the pleopods, gave evidence of having carried eggs, measured 7·2 cms. in carapace-length. The smallest specimen actually 'in berry' had a carapace-length of 7·4 cms. The eggs of this specimen contained embryos at the late nauplius stage of development and therefore had been fertilized.

In South Africa, Von Bonde (1936, p. 8) reports having observed females 'in berry' when they measured only 4·5 cms. (1·75 inches) in carapace-length. T. Challenger (1943, p. 51) states that in Tasmanian waters females of only 1·5 inches have been found carrying eggs, 'which proved, however, to be unfertilized'.

The male crayfish does not appear to reach sexual maturity as early as the female. A small specimen collected from drifted kelp on the beach at Kingston had a carapace-length of 2·2 cms. It showed no signs of external genital apertures. A second specimen collected at the same locality had a carapace-length of 3·9 cms. (1·5 inches) and, although the genital apertures were present on the coxopodites of the fifth pereiopods, they were closed by a membrane and appeared to be non-functional.

The smallest male taken at Wedge Bay had a carapace-length of 6·3 cms.. It was caught on 23rd July, 1938. Dissection of the specimen showed that the testes were but slightly developed and, although the external genital apertures were quite distinct, the vasa deferentia leading to them were not yet formed. A similar condition of the reproductive system was also observed in a male having a carapace-length of 6·8 cms.

During March, April, and May it was not unusual to catch males in which the vasa deferentia were so distended with viscous seminal fluid that spermatophores were partially extruded through the genital apertures. This condition was observed in males having a carapace-length of 9·4 cms. Such males were obviously sexually mature. It seems probable, however, that males attain sexual maturity on reaching a carapace-length of about 8·0 cms.

Shelling or Ecdysis

The casting of the exoskeleton or shell of the crayfish not only allows for the growth of the animal, but also renews the chitinous parts of the various superficial sensory organs, thus helping to restore any sensitivity that may have been lost through wear and tear, or through the action of encrusting marine organisms. Young crayfish may cast their shell several times in the year. Von Bonde and Marchand (1935, p. 15) have shown that even a mature female having a carapace-length of 9·0 cms. may undergo ecdysis twice in the one year.

In endeavouring to determine the time of year at which crayfish in Wedge Bay cast their shells, a record of the condition of the exoskeleton of each specimen was kept. As ecdysis approaches the flesh of the crayfish becomes pink, and the developing new shell takes on a dark colour and separates easily from the overlying old shell. Male crayfish showing these features were usually caught during September and October. While undergoing ecdysis crayfish do not feed. There is thus a marked decrease in the number of males taken during the shelling period. Reference to Table I will show that this falling off in numbers occurs during September and October. A marked decrease in the number of males also takes place during April. This, however, is due to the fact that the males are busy mating with the females at that period.

Immediately after ecdysis the new exoskeleton is very soft. It gradually hardens, however, and when it has become firm enough for the crayfish to move about, the animals, made hungry by their fast during ecdysis, readily enter the ' pots '. As a consequence there is an increase in the number of males taken during November and December. Moreover, most of the males caught during these months have clean shells, which are free from barnacles, serpulids, algae and other marine growths. The above evidence makes it clear that male crayfish at Wedge Bay usually cast their shells during September and October. It must not be inferred, however, that all male crayfish in the locality undergo ecdysis at the one time. A few specimens with new and somewhat soft shells were caught during January, February, March, May, and June. These are listed in Table VI.

TABLE VI

Jasus lalandii

NUMBER AND SIZE OF SOFT-SHELLED MALES TAKEN IN MONTHS OTHER THAN SEPTEMBER AND OCTOBER

Date when Caught	Carapace-length in cms.	Weight in grammes.	Number of Specimens
27th June, 1938	9·4	461	1
27th February, 1940	9·7	415	1
14th March, 1940	10·0	504	1
14th March, 1940	9·4	301	1
14th March, 1940	8·3	255	1
14th March, 1940	8·1	252	1
6th January, 1941	12·1	850	1
6th January, 1941	9·5	442	1
12th May, 1941	10·0	488	1
10th June, 1941	8·9	365	1
10th June, 1941	8·8	370	1
23rd June, 1941	10·0	505	1

The soft-shelled males mentioned in Table VI form a very small proportion of the total number of males caught. However, as they were taken at times other than the usual shelling period, they serve to contradict the statement sometimes made that all the males in a given locality moult at the same time (Challenger, 1943, p. 53).

Female crayfish at Wedge Bay generally undergo ecdysis during April, and as a consequence very few of them enter the 'pots' during that month (see Tables II and III). Egg-laying is always preceded by ecdysis. Von Bonde and Marchand (1935, p. 15) have shown that the time which elapses between moulting and spawning may vary from 8 to 48 days. In a later publication Von Bonde (1936, p. 9) says 'Egg-laying usually follows ecdysis by about two or three days'.

Females carrying recently laid eggs were caught during April, May, and June. It is therefore probable that the moulting period is spread over these months. The majority of the females, however, appear to cast their shells in April.

While it is true that egg-laying is always preceded by ecdysis, it does not follow that ecdysis is always succeeded by egg-laying. A few soft-shelled females, which were not 'in berry,' were caught during May and June. Some females moult twice within the year. When this occurs spawning takes place after the second moult (Von Bonde and Marchand 1935, p. 15), and not after the first.

THE TIME OF SPAWNING AND HATCHING

No females carrying external eggs were caught during January, February, and March. The earliest date in any one year at which a female 'in berry' was taken was 26th April and the latest date 7th December (see Table II). A total of 310 females 'in berry' was caught during the five-year period. The eggs of each one were examined in order to determine the stage of development of the embryo. The chorion of the egg is quite transparent and, if the egg is fixed in Bouin's fluid, the embryo may be readily seen with the aid of a binocular dissecting microscope. In this way the main stages of development may be recognised. An analysis of these stages, as seen in the eggs of the 'berried' females caught during the different months, makes it possible to determine with reasonable accuracy the time and duration of spawning and also the rate of development and time of hatching of the embryo. Table VII shows the monthly totals of females 'in berry' and the stages of development of their eggs.

TABLE VII

Jasus lalandii

MONTHLY TOTALS OF 'BERRIED' FEMALES ANALYSED ACCORDING TO THE STAGES OF DEVELOPMENT OF THEIR EGGS

Stage of Development of Eggs	Number of Females Carrying Eggs at the Stage of Development Indicated in the First Column											
	Jan.	Feb.	Mch.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Morula	—	—	—	1	7	—	—	—	—	—	—	—
Blastopore formed	—	—	—	—	15	6	—	—	—	—	—	—
Germinal disc	—	—	—	—	12	11	2	—	—	—	—	—
Early nauplius	—	—	—	—	15	26	4	2	1	—	—	—
Maxillipeds formed	—	—	—	—	3	39	28	7	2	—	—	—
Median eye pigmented	—	—	—	—	3	16	23	15	2	—	—	—
Paired eyes pigmented ..	—	—	—	—	—	4	6	14	13	2	—	—
Ready to hatch	—	—	—	—	—	—	3	5	21	1	—	1
Monthly totals	—	—	—	1	55	102	66	43	39	3	0	1

The 'berried' female mentioned previously as being caught on 26th April carried eggs at the morula stage. Von Bonde (1936, p. 13) has shown that under artificial conditions this stage of development is reached after three days. It is therefore probable that the eggs were laid about 23rd April. From Table VII it is seen that three females taken in July carried eggs which were ready to hatch. Pigment spots were clearly visible on the pereiopods and the larvae were in the prenaupliosoma condition. The eggs had probably been laid in the preceding April. On this assumption the length of time from egg-laying to hatching is from three to four months. These observations are in agreement with those of Von Bonde and Marchand (1935, p. 14), who state that in aquarium experiments 'it was found that the female carried her eggs for about three to four months'.

After September there is a rapid falling off in the number of 'berried' females caught. During the five-year period only three females 'in berry' were taken in October, none in November, and one in December. From Table VII it is evident that, at Wedge Bay, laying takes place mainly during April, May, and June and hatching during July, August, and September.

Number of Eggs carried by Females in 'Berry'

In their work on *Jasus lalandii* in South Africa, Von Bonde and Marchand (1935, p. 11) state that the number of eggs carried by a female 'in berry' varies 'according to the female's size from 3000 to near 200,000'. In a later publication, however, Von Bonde (1936, p. 9) gives the number as varying from '3000 in the smallest to about 20,000 in the largest'. T. Challenger (1943, p. 52) states that an 'average specimen carried 850,000 eggs'. This estimate was based on a determination of the number of eggs carried by a female having a carapace-length of 5 inches (12·7 cms.). It is very doubtful whether a female of this size can be regarded as an average specimen. Apparently the determination was made on the eggs of only the one female. The method used is not fully described and the accuracy of the results obtained must therefore remain in doubt.

In the present investigation the number of eggs carried by a female 'in berry' was determined in the following way. The whole mass of eggs was carefully stripped from the pleopods and weighed. The eggs in two grammes of the mass were then counted. In six different specimens the numbers thus obtained were found to be 8500, 8780, 8350, 8340, 8320, and 8820 respectively, the average number being 8520. The number of eggs in one gramme was therefore about 4260. The number of eggs in the total weight of the egg-mass was then readily calculated. Table VIII gives a summary of the number of eggs carried by females whose carapace-length varied from 7·4 cms. to 12·4 cms.

TABLE VIII

Jasus lalandii

PRODUCTION OF EGGS

Length of Carapace in cms.	Smallest Number of Eggs	Largest Number of Eggs	Average Number of Eggs	Number of Crayfish Examined
7·4	—	—	68,650	1
7·8	65,170	116,080	90,730	7
8·0	110,330	132,060	121,410	3
8·2	109,110	129,930	119,520	2
8·4	107,560	170,610	136,740	10
8·6	115,740	169,120	140,150	8
8·8	69,430	164,860	127,370	5
9·0	93,500	217,430	146,300	9
9·2	136,320	242,820	198,090	6
9·4	143,130	230,040	189,570	15
9·6	186,010	324,180	232,170	12
9·8	193,830	251,340	222,370	4
10·0	143,130	338,240	236,000	12
10·2	172,100	367,640	249,210	18
10·4	180,200	295,640	260,710	11
10·6	247,080	325,460	286,700	6
10·8	215,550	309,270	269,080	4
11·0	227,910	413,220	308,420	8
11·2	248,360	319,500	283,720	2
11·4	276,470	328,020	302,030	2
11·9	323,760	393,620	358,690	2
12·4	—	—	339,590	1

An inspection of Table VIII will show that there is a tendency for the egg production of *Jasus lalandii* to obey the general law of fecundity, which Herrick (1895, p. 52) enunciated for the American lobster, *Homarus americanus*, and which he stated in the following form: ' The numbers of eggs produced by female lobsters at each reproductive period vary in geometrical series, while the lengths of the lobsters producing these eggs vary in an arithmetical series '.

NATURAL FOOD OF THE CRAYFISH

In nearly all the crayfish caught, an examination of the contents of the gut was made. Often the gut was empty or contained only the bait used in the ' pots '. However, in a number of cases the gastric-mill was filled with the remains of molluscs, other crayfish, crabs, echinoids, and sea-weeds. In some instances the molluscs could be identified from shell-fragments, which had not been completely disintegrated. One of the molluscs occurring most frequently in the gut-contents was the small *Cantharidus eximius* Perry, which is often found living on kelp. The common mussel, *Mytilus planulatus* Lamark, and a species of *Ischnochiton* were also sometimes present. Occasionally the gastric-mill contained the remains of other crayfish. In Table IX is given a monthly summary of the various foods found in the gut.

TABLE IX

Jasus lalandii

MONTHLY SUMMARY OF GUT-CONTENTS

(The figures represent the number of stomachs in which the various foods were found)

Food	Jan.	Feb.	Mch.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Cantharidus eximius	—	1	2	—	20	25	8	1	2	2	3	7
Ischnochiton sp.	2	3	4	—	—	2	4	2	—	1	—	3
Mytilus planulatus	5	1	2	—	2	1	1	1	—	—	8	4
Other molluscs	7	19	2	4	2	24	15	10	6	—	4	9
Crabs	—	—	1	—	—	—	1	—	—	—	—	1
Crayfish	—	2	3	—	—	4	1	10	—	4	2	2
Echinoids	—	—	—	—	—	1	—	—	—	—	—	—
Sea-weeds	—	7	—	—	1	1	—	—	—	—	—	—

It will be noticed from Table IX that shells of *Cantharidus eximius* and other molluscs were found in the gut most frequently during May, June, and July. The catches of crayfish during these months contained a high proportion of females which had recently undergone ecdysis. The need for calcareous food for the strengthening and hardening of the new exoskeleton no doubt accounts for the frequent occurrence of shells in the gut.

Number of Marketable Crayfish

The regulations under the Fisheries Act, 1935, make it illegal to take crayfish having a carapace-length of less than 4¼ inches (10·8 cms.). It is also unlawful to take soft-shelled crayfish and females 'in berry'.

The specimens required for the present investigation were caught by the usual methods employed in the fishing industry. It is therefore instructive to note the proportion of the total catch that would have had to be returned to the sea if it had been necessary to comply with the regulations. The following list gives the numbers of crayfish of legal size and of those which, being undersized, soft-shelled, or 'in berry', could not have been lawfully taken:—

Males of legal size and condition	185
Females of legal size and condition	31
Males undersized and/or soft-shelled	300
Females not 'in berry' but undersized and/or soft-shelled	231
Females 'in berry'	310
Total	1057

It will be seen from the above list that, out of a total catch of 1057, only 185 males and 31 females could have been retained. The remaining crayfish, forming almost 80% of the total number caught, would have had to be returned to the sea.

Provided, therefore, that fishermen comply with the present regulations, there does not seem to be any danger of depleting the crayfish at Wedge Bay through over-fishing.

I desire to express my thanks to the Trustees of the John Ralston Bequest, under whose auspices the above research was carried out. I am also indebted to Colonel J. E. C. Lord, Chairman of the former Sea Fisheries Board, and Mr. E. P. Andrew-artha, Secretary to the Board, for help in obtaining the crayfish needed for the investigation. My thanks are also due to Dr. K. H. Barnard of the South African Museum for specimens of *Jasus lalandii* from South Africa. Valuable help in the laboratory was given by my former assistant, Mr. A. M. Olsen, and by Mr. J. W. Wyett. The crayfish were caught by Mr. G. L. Spaulding of Nubeena. The cost of collecting the specimens was defrayed by the Commonwealth Research Grant.

References

Challenger, T., 1943.—The Story of the Crayfish. *Tasmanian Journal of Agriculture*, Vol. XIV, No. 2, pp. 51-55.

Herrick, F. H., 1895.—The American Lobster. *Bull. U.S. Fish. Com.*, 15, pp. 1-252.

Hickman, V. V., 1945.—Some Abnormal Conditions of the Reproductive System of the Saltwater Crayfish. *Pap. Roy. Soc. Tasm.* 1944, pp. 57-59, Pls. VI and VII.

Von Bonde, C., and Marchand, J. M., 1935.—The Natural History and Utilization of the Cape Crawfish, Kreef or Spiny Lobster (*Jasus lalandii*). *Fish Bull. No. 1, Fish and Mar. Biol. Survey, S. Africa.*

Von Bonde, C., 1936.—The Reproduction, Embryology and Metamorphosis of the Cape Crawfish (*Jasus lalandii*). *Investigational Report*, No. 6. *Fish and Mar. Biol. Survey, S. Africa.*