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EFFECTS OF PEA CRABS PINNOTHERES OSTREUM ON OYSTERS CRASSOSTREA VIRGINICA

Dexter Haven

Virginia Fisheries Laboratory, Gloucester Point, Virginia[1]

Abstract

Oysters with and without pea crabs were compared for growth and fatness. Measurements included volume, wet and dry meat weight, and shell cavity volume. Oysters with crabs contained less meat per unit of shell cavity volume than those without crabs but per cent water content was similar. Incidence of pea crabs in the lower James, York and Rappahannock rivers from 1953-1958 varied from 6 to 22 per cent.

Introduction

In April 1955, a program was started at the Virginia Fisheries Laboratory to measure variations in "fatness" or "condition" of oysters. Important aspects of these studies are effects of Dermocystidium and pea crabs, influence of age, and seasonal cycle of oyster condition. As a measure of condition, dried weight of meats is compared to volume of shell cavity as described by Caswell Grave (1912) under the term "index of condition."

It was found during the studies that oysters with pea crabs had lower condition indices than those without crabs, as suggested by Overcash (1946). Since Sandoz and Hopkins (1947) report infestations as high as 80 per cent in Virginia, crabs may cause important annual losses to the oyster industry.

Previous work along the Atlantic Coast on pea crabs has been primarily concerned with their biology, and their effects on oysters are not well understood. Stauber (1945) reported that Delaware Bay oysters containing crabs frequently showed erosion of gills and enlarged mantle cavities. He also observed that oysters with crabs did not keep as well during air storage as crab-free oysters. Christensen and McDermott (1958) commented on the presence of gill lesions in oysters containing crabs. These authors were unable to detect any influence of crabs on growth rate of spat, but speculated that presence of crabs in oysters over long periods may influence growth.

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Procedure

Immature stages of pea crabs were classified by criteria outlined by Christensen and McDermott (1958) who recognize an invasive stage, a pre-hard stage and Stages I through to the mature Stage V female. The present paper is concerned only with oysters containing the last five stages, which range in carapace width from 1.3 to 15.1 mm.

All oysters utilized in the study were grown on a commercial bed close to Gloucester Point, Virginia. Market-sized oysters which had been in the area for several years were dredged from the bottom. Tray oysters of known age and history were grown on the same ground but elevated about one foot off the bottom. Oysters were treated individually to permit statistical analysis by X^2 (Snedecor 1956: 227-230 Table 9.9.1), and the 0.05 level was regarded as significant. Measurements included total oyster volume, shell cavity volume, wet and dry meat weights. From these data ratios were calculated: per cent dry weight (dry meat weight/wet meat weight), per cent shell cavity volume (shell cavity volume/total oyster volume), and condition index (dry meat weight in gm/shell cavity volume in cc X 100).

Oysters from the natural bottom were tested on four separate occasions at expected times of maximum and minimum fatness: June 1956, at the spring peak of fatness previous to spawning; August 1956, when oysters had spawned; December 1956, after fall fattening; and May 1957 near the spring peak of condition. In each test 40 to 50 oysters with Stage III to V crabs were compared with an equal number of oysters lacking crabs. Both groups may have included crabs of Stage II or earlier for at the time these small forms were thought to be unimportant. Frequently they are hidden by folds of oyster tissue and may have escaped detection.

Since incidence of crabs from the sampling area was always less than 50 per cent, a system for obtaining equal numbers of oysters with and without crabs was necessary. Approximately 300 oysters were cleaned of fouling organisms and numbered consecutively, and individual volumes were determined by water displacement. Oysters were opened in sequence; those containing pea crabs were matched by succeeding oysters without crabs. After one minute of draining, individual oyster meats were weighed wet and dried to a constant weight at 87°C. Shell cavity volume was determined as the difference in displacement between whole oyster and shell valves.

Results

Comparisons of parasitized and crab-free oysters on natural bottoms are given in Tables 1 to 4. During the seasons of maximum fatness (late spring and late fall and winter) parasitized oysters consistently had less meat by weight than controls. Condition indices were 1.3 to 2.4 units lower, a difference which in shucked

Table 1. Comparison between market oysters with and without pea crabs, York River, Va., June 26, 1956.

	With pea crabs	Without pea crabs	X^2	d.f.	X^2,P0.05
No. of oysters	41	40			
Mean volume, cc.	39.9	46.1	9.00*	3	7.81
Mean dry weight, gr.	1.2	1.7	9.18*	1	3.84
Per cent dry weight	17.1	17.2	4.74	4	9.49
Per cent shell cavity	40.2	41.8	4.55	4	9.49
Condition index	7.5	9.3	9.87*	4	9.49

Table 2. Comparison between market oysters with and without pea crabs, York River, Va., August 20, 1956.

	With pea crabs	Without pea crabs	X^2	d.f.	X^2,P0.05
No. of oysters	39	39			
Mean volume, cc.	47.4	50.2	4.63	3	7.81
Mean dry weight, gr.	1.2	1.3	3.45	2	5.99
Per cent dry weight	15.4	13.6	12.09*	2	5.99
Per cent shell cavity	38.5	40.8	1.44	4	9.49
Condition index	6.5	6.2	0.76	5	11.07

Table 3. Comparison between market oysters with and without pea crabs, York River, Va., December 12, 1956.

	With pea crabs	Without pea crabs	X^2	d.f.	X^2,P0.05
No. oysters	49	49			
Mean volume, cc.	45.2	50.7	0.93	4	9.49
Mean dry weight, gr.	1.1	1.6	12.09*	2	5.99
Per cent dry weight	14.7	15.0	2.74	3	7.81
Per cent shell cavity	39.4	40.5	7.37	5	11.07
Condition index	6.6	7.9	10.87*	4	9.49

Table 4. Comparison between market oysters with and without pea crabs, York River, Va., May 13, 1957.

	With pea crabs	Without pea crabs	X^2	d.f.	X^2,P0.05
No. of oysters	50	50			
Mean volume, cc.	51.6	50.7	1.46	5	11.07
Mean dry weight, gr.	1.6	2.0	10.16*	3	7.81
Per cent dry weight	15.9	16.6	2.08	6	12.59
Per cent shell cavity	40.6	38.9	4.95	3	7.81
Condition index	7.8	10.2	19.18*	4	9.49

oysters would approximate one-half to one pint of meats per bushel of shellstock (unpublished data). Although condition indices were lower in parasitized oysters, it will be noted that per cent dry weight of parasitized oysters and controls was almost uniform during seasons of maximum fatness. Mean oyster volume (a measure of oyster size), was usually less in crab-infested oysters, but differences were not consistent and were statistically significant only in June 1956. Per cent shell cavity volumes of parasitized oysters showed no significant difference from controls.

In August 1956 after spawning had reduced food reserves to a seasonal low (period of minimum fatness) there was no difference in condition index of infested and crab-free oysters (Table 2).

Tray-cultured oysters were examined in December 1957 for effects of pea crabs (Stages I to V) on condition (Table 5). These were two and three-year-old James River oysters placed in trays in March 1957. Oysters parasitized with Stage IV or V crabs (Stage III absent from collection), as well as those containing small Stage I and II crabs had lower condition indices than control groups (Table 5). This suggests that immature crabs which were previously considered too small to be of importance may influence condition index to the same extent as larger crabs. It should be pointed out that Stage IV crabs and under had been in the oysters only since about August 1957, while Stage V crabs may have been present one or more years (Christensen and McDermott 1958). Calculations of per cent shell cavity volume and per cent dry meat weight showed no significant difference between parasitized tray oysters and their respective controls. Studies on volume were conflicting, for tray oysters containing crabs of Stage IV and V were statistically smaller than controls, while those with younger crabs were similar in size to the controls.

Discussion

Although parasitized oysters were nearly always lower in dry meat weight when compared to control groups, there was seldom a corresponding reduction in size as measured by oyster volume. Therefore, oyster size cannot account for all differences in dry meat weights between parasitized and crab-free oysters.

Data on condition index offer several possible explanations for the absence of a more direct relation between weight of dry meat and oyster volume. Condition index measures the relation between shell cavity and dry meat weight, consequently it is not influenced by oyster size. If meats of oysters containing crabs have a higher water content than controls, they would lose more water in drying resulting in a lower dry weight, and consequently a lower index. This explanation is unsatisfactory, however, for meats of test and control groups had similar per cent dry weights.

Table 5. Comparison between tray-cultured oysters with and without pea crabs, December 31, 1957.

	With pea crabs	Without pea crabs	X^2	d.f.	X^2,P0.05
A. Oysters with Stage I and II crabs					
No. of oysters	13	129			
Mean volume, cc.	38.9	46.7	2.08	1	3.84
Mean dry weight, gr.	1.1	1.6	13.15*	1	3.84
Per cent dry weight	12.2	13.0	0.46	1	3.84
Per cent shell cavity	44.3	42.4	0.13	1	3.84
Condition index	5.9	7.9	11.81*	1	3.84
B. Oysters with Stage IV and V crabs					
No. of oysters	24	129			
Mean volume, cc.	37.2	46.7	18.79*	2	5.99
Mean dry weight, gr.	1.0	1.6	28.17*	2	5.99
Per cent dry weight	12.4	13.0	2.08	3	7.81
Per cent shell cavity	43.0	42.4	2.07	2	5.99
Condition index	6.5	7.9	14.93*	2	5.99

Ratios of shell cavity volume to total oyster volume show no significant difference between parasitized oysters and control groups. Hence, there is no evidence that lower condition index of parasitized oysters is caused by enlarged shell cavities from pea crab activity.

One remaining possibility is that infested oysters have less dry meat per unit of shell cavity than controls. Only in June 1956 and December 1957 (Table 5B) could reduced quantity of meat be attributed to smaller size of parasitized oysters.

Factors that bring about the observed differences in quantity of meat are not clear. A possible explanation is that the mass or weight of the pea crab displaces a sufficient quantity of oyster meat to bring about the difference in condition index. Fifteen ovigerous female crabs which represent the maximum possible weight of crabs had a mean dry weight of 0.14 grams, while 12 dried Stage I and II crabs weighed about 0.01 grams each. Recalculated condition indices based on addition of dried-crab weights to weights of meat from parasitized oysters are still far below the indices of control groups.

Future work should include a study of possible pathological changes in structure or metabolism of parasitized oysters, in addition to gill lesions, which may account for their lowered meat content. A most important aspect would be the effects of crabs on the survival of their host.

Incidence Of Pea Crabs

Incidence of large crabs, mostly Stage IV or V, from 1953 to 1958 at stations in Hampton Roads near Darling's Watchhouse, York River near Gloucester Point, and Rappahannock River at Hoghouse Rock near Urbanna, was obtained from monthly samples of oysters for Dermocystidium tests. Market-size oysters were chosen for these tests to insure full acclimation to the area, hence incidences of pea crabs should be representative. In Table 6 the mean annual incidence based on 12 samples of 25 oysters each is given. Only rarely were more than 20 per cent of oysters infested and annual variations were not large. The Hampton Roads and York River stations are located in areas where salinity probably rarely becomes unfavorable for pea crabs, but incidence at Hoghouse Rock may be reduced by spring freshets. In Delaware Bay, Flower and McDermott (1952) found pea crabs most abundant in high-salinity waters.

From April 1956 through June 1958, monthly samples of 100 oysters were examined from the planted bed near Gloucester Point. Oysters were carefully opened and searched under a dissecting microscope for crabs of all stages.

Table 6. Incidence of pea crabs in percentages in York, James and Rappahannock rivers, 1953-1958.

Year	James	York	Rappahannock
1953	12.0	20.0	8.0
1954	6.4	12.8	9.2
1955	10.4	19.2	15.2
1956	21.6	16.1	15.6
1957	18.8	21.2	11.2
1958	16.0	11.8	6.8

Stage V crabs increased in number during August and reached a peak of 35 per cent in September (Figure 1). During fall and winter 1957-58 there was a steady decline in mature crabs, presumably through mortality.

Immature stages showed a seasonal mode in July 1957 which preceded that of the mature Stage V females in September 1957. A similar relation was observed in Delaware Bay by Christensen and McDermott (1958). The increase in number of immature forms during winter is difficult to understand. Explanations based on growth of previously undetected stages or individuals are not satisfactory since Christensen and McDermott (1958) suggest that in Delaware Bay growth and development stop around November 1. Also, the increase cannot be attributed to invasion from outside sources since a major portion of the increase was in soft Stage II crabs which are believed to be incapable of infecting oysters (Christensen and McDermott 1958).

Conclusions

1. The lesser quantity of dry meat of parasitized oysters as compared with the controls is not caused by relatively smaller shell cavity volumes. Also, it is not associated with meats of high water content.

2. Parasitized oysters apparently have less meat per unit of shell cavity volume. In only two instances was smaller size of parasitized oysters a factor.

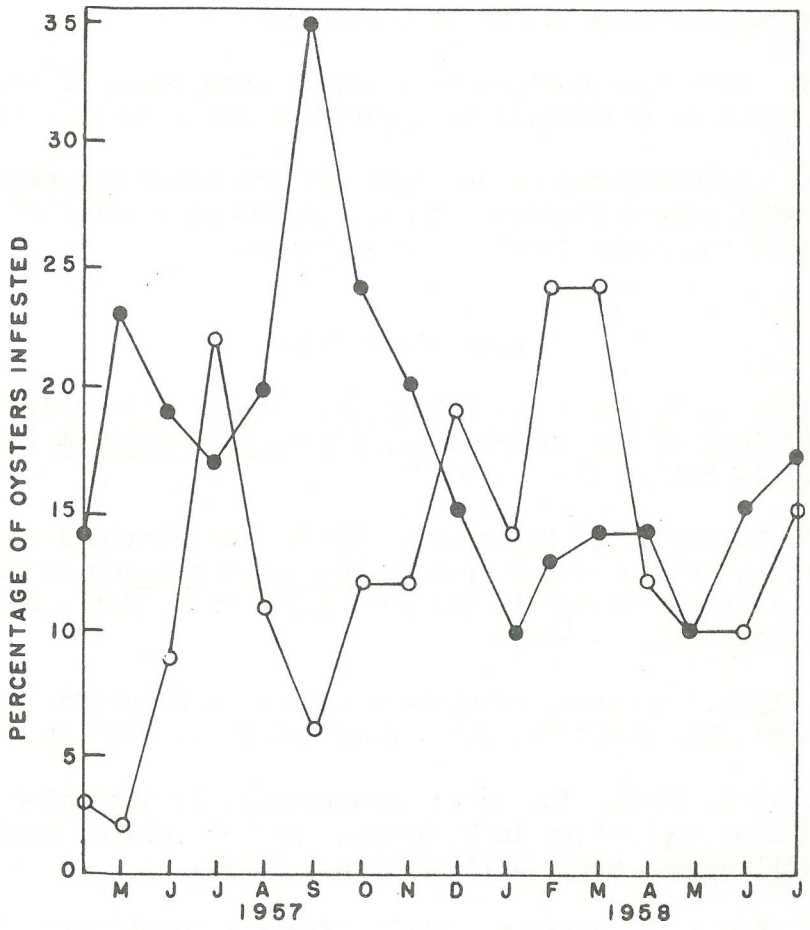

Fig. 1. Incidence of pea crabs in market oysters from a commercial bed close to Gloucester Point, Virginia. Closed circles show Stage V crabs. Open circles show immature forms.

3. Reduced quantity of meat cannot be accounted for on the sole basis of volume of meat displaced by the crab.

4. Monthly samples of oysters from Hampton Roads, and the lower York and Rappahannock Rivers from 1953-1958 gave incidences of pea crabs ranging from 6.4 to 21.6 per cent.

5. Wide fluctuations in seasonal occurrence of mature and immature crabs were observed in lower York River in 1957 and 1958.

6. Infestations of pea crabs of the order demonstrated in Virginia will reduce yields of meat. In future studies of yield, incidence of pea crabs should be considered.

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Christensen, A. M. and J. J. McDermott. 1958. Life-history and biology of the oyster crab, Pinnotheres ostreum (Say). Biol. Bull. 114: 146-179.

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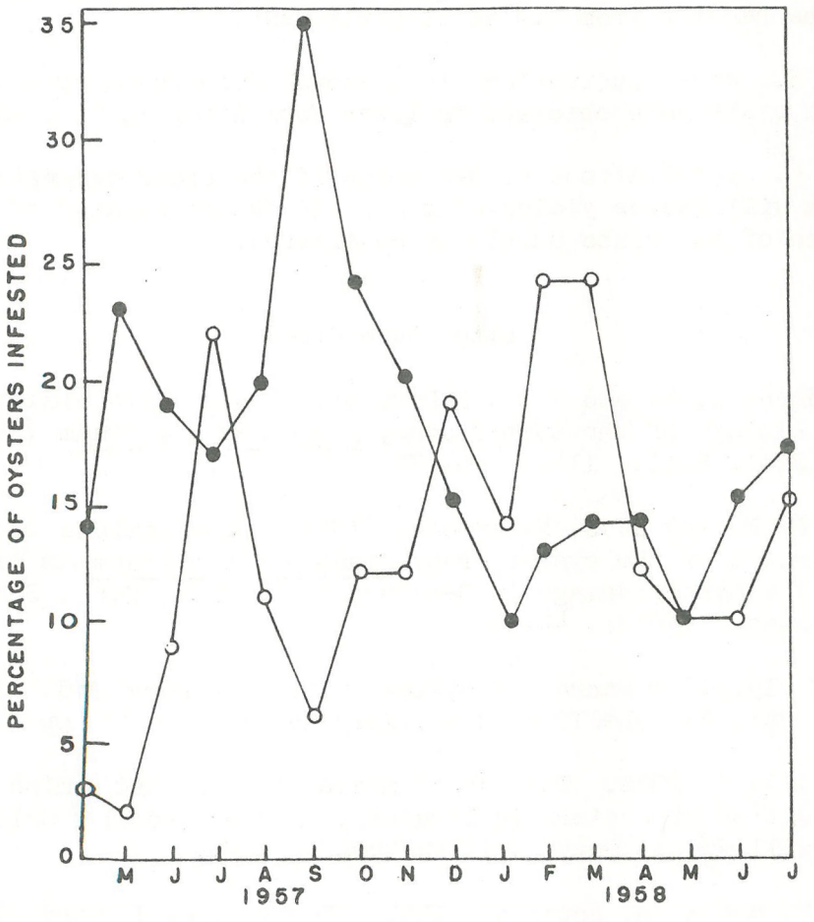

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