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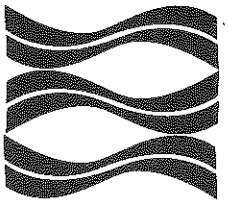

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**M. M. O'Farrell and J. M. Fives**

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## Roinn na Mara
## (Department of the Marine)

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# The feeding relationships of the shanny, *Lipophyrys pholis* (L.) and Montagu's blenny, *Coryphoblennius galerita* (L.) (Teleostei:Blenniidae)

By

M.M. O'FARRELL* and J.M. FIVES,

Zoology Department, University College Galway.

## ABSTRACT

Collections of 279 specimens of Montagu's blenny, *Coryphoblennius galerita* (L.), and 276 shanny, *Lipophrys pholis* (L.), were made over a ten month period on a 2km stretch of the western shore of Mweenish Island on the west coast of Ireland. Further collections of 99 *L. pholis* and 8 *C. galerita* were made in March and April at two mainland sites. Sampling was confined to rockpools in the upper midshore region. The result of this bias was that while all age groups of *C. galerita* were collected, most of the *L. pholis* taken were less than two years old. Both species are omnivorous and exhibit definite seasonal feeding patterns. In general, *C. galerita* mutilate prey species, whereas only juvenile *L. pholis* are found to do this. Both species exploit a wide range of intertidal organisms. The ecological differentiation necessary for co-existence is evident, polychaetes are important only in the diet of juvenile *C. galerita* and bivalves and gastropods are important to *L. pholis*. There are only two food categories of importance to adult *C. galerita* and this may reflect the ecological stress on *C. galerita* of the habitat and the presence of *L. pholis*.

## INTRODUCTION

*Lipophrys pholis* (L.) and *Coryphoblennius galerita* (L.) are Mediterranean-boreal species of the family Blenniidae and inhabit the intertidal zone. *L. pholis* also occurs sublittorally. Results of studies on food and feeding behaviour of *L. pholis* and *C. galerita* have been published by Soljan (1932), Hartley (1949), Qasim (1957), Gibson (1972), Dunne (1977) and Fives (1980). The present study presents information on the ecological differentiation apparent in two species of fish having similar food requirements.

## MATERIALS AND METHODS

Throughout the sampling period (July 1977 to April 1978), specimens of both species were collected on the exposed rocky western shore of Mweenish Island. During March and April, samples were also collected at Inverin, Co. Galway, and Carnsore Point, Co. Wexford (Fig 1). Collections were made, at approximately monthly intervals, at low-water spring and neap tides. Fish were captured from rock pools in the upper midshore region, using a handnet during daylight and these were immediately preserved in 70% alcohol. This limitation of sampling methods and areas resulted in a sampling bias whereby larger specimens of *L. pholis* were excluded.

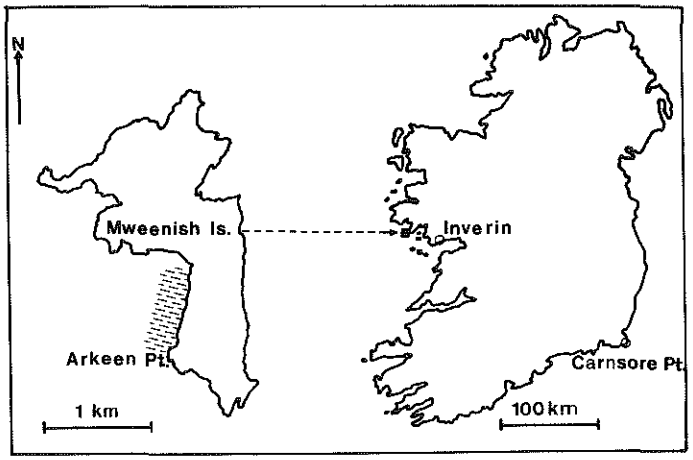


**Fig.1 Ireland, collecting sites at Mweenish, Inverin and Carnsore Point.**

In the laboratory, specimens were placed in fresh 70% alcohol, where they remained for a minimum of three weeks before examination. They were examined externally for meristic abnormalities. Each fish was measured to the nearest mm total length, then surface dried using absorbent paper and weighed to the nearest 0.1g. Gut and gonads were removed, surface dried and weighed. Each fish was decapitated and both sagittal otoliths were removed, washed in absolute alcohol and transferred to creosote for clearing. The maximum width of each

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sagittal otolith was measured. In the case of fish more than one year old at death, the otolith width at the time of completion of the first hyaline zone was measured using a Kenvision microprojector.

*Gut content analysis.*

The method of gut content analysis used in this investigation was a modification of Hynes's (1950) points (volumetric) method. The gut contents were sorted and grouped into food categories. The percentage volume of each food category was visually estimated. Depending on the amount of food present, each gut was allotted from 6 (empty gut) to 30 (distended gut) points. The number of points awarded to a food category was expressed as a percentage of the number of points allotted to the gut. All points awarded to the food categories sum to the total number of points allotted to the gut.

Regression equations describing the relative importance of certain food categories in the seasonal diets of both species were calculated as follows: each fish was considered individually; the number of points awarded to a particular food category in the gut was expressed as a percentage of the number of points that had been allotted to the gut; this percentage value was then plotted against the log10 total length of the fish; scatter diagrams were constructed for food categories, according to season, for both species; these were used for visual interpretation of results, prior to a more critical evaluation.

*Food analysis.*

Percentage (points) compositon - the number of points awarded to a food category is expressed as a percentage of the number of points allotted to a unit of analysis. The unit of analysis is the number of fish of each cm length group collected in a particular season. The seasons are as defined by Qasim (1957). Regressions were calculated of percentage composition of each food category on length of each fish for each season.

## RESULTS

*Distribution*

*L. pholis* was abundant at the three sampling sites, *C. galerita* was abundant at Mweenish, scarce at Inverin and only one specimen was captured at Carnsore Point.

*Length and age*

Otolith studies showed that while all age groups (0 to 6 years) of *C. galerita* were collected, most *L. pholis* captured were less than two years old. The length frequency distributions (fig. 2), otolith readings and gonad examinations (Dunne 1977 and Fives 1980) revealed that the length at which maturity occurred varied seasonally. Both species populations were divided into juveniles, adolescents and adults on the basis of the following cm length groups:

| | | |
|---|---|---|
| *C. galerita* | juvenile | ≤3cm (summer, autumn, winter),<br>≤ 3.5cm (spring) |
| | adolescent | 3.1 to 4.4cm (summer, autumn, winter),<br>3.6 to 4.4cm (spring). |
| | adult | ≥ 4.5cm (summer, autumn, winter, spring). |
| *L. pholis* | juvenile | ≤ 4cm (summer,<br>≤ 5.5cm (autumn,winter),<br>< 6.0 (spring). |
| | adolescent | 4.1 to < 7cm (summer),<br>5.6 to < 8cm (autumn, winter),<br>6.0 to < 8cm (spring). |
| | adult | ≥7cm (summer),<br>≥ 8 cm (autumn, winter, spring). |

Fig 2 shows the length frequency distribution of both species in each season.

On Mweenish, 77% (213) of the total number of *L. pholis* (276) and 53% (148) of the total number of *C. galerita* recorded (279) were juveniles. Juvenile *L. pholis* appear on the shore in July, measuring approximately 10mm in total length (Dunne, pers. comm.). Juvenile *C. galerita* appear about six weeks later and measure approximately 15mm in total length.

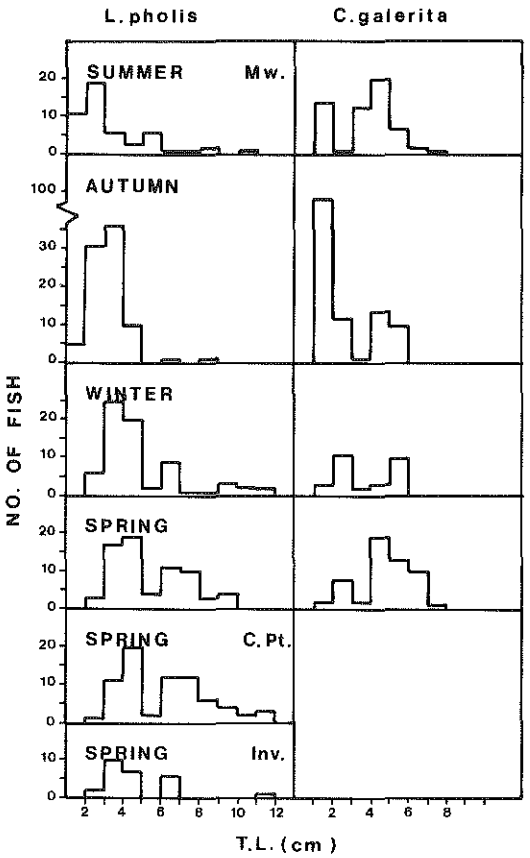


**Fig. 2. Length frequency distribution of *L. pholis* and *C. galerita* at Mweenish and of L. pholis at Carnsore Point and Inverin in spring.**

*The seasonal diets*

Both species were omnivorous and exhibited definite seasonal feeding patterns. Copepods, algae , ostracods, polychaetes, cirripedes, gastropods, bivalves and mites were of primary importance in the diets of either or both species. The food categories which were only of secondary importance in the diets, namely tanaidaceans, isopods, amphipods, insects, and echinoderms, were eaten fairly consistently throughout the year. Sand, gravel, and unidentifiable material rarely accounted for more than 10% by volume of any one gut examined. The guts of one *L. pholis* and three *C. galerita* were found to be empty. Table 1 describes the composition of the diets (expressed as % occurrence) of the juveniles, adolescents and adults of both species at Mweenish.

Table 1 indicates that for juvenile *L. pholis* gastropods and cirripedes occurred most frequently; for adolescents gastropods and algae were frequently eaten as were bivalves and cirripedes and for adults algae and bivalves were the most frequently recorded food items. *C. galerita* showed a different preference, with copepods and ostracods occurring most frequently in the juveniles but with cirripedes and mites also being frequent; in the adolescents algae and, to a lesser extent, cirripedes and copepods were frequent; in the adults algae and cirripedes were the most frequent food items. It is obvious from Table 1 that only about six food items are important to each species. The most frequently recorded food items were selected and treated seasonally in Tables 2 and 3, which also include the regression data describing the seasonal relative importance of the primary food categories in the diets of both species. Quadratic equations, describing the importance of gastropods in the diet of *L. pholis*, are presented in Table 6.

*Seasonal diets of the Mweenish samples*

Semi-logarithmic regression equations of the form $y = a + b \log_{10} x$, where y = % composition and x = total length (cm), were best fits in the description of the relative importance of copepods, ostracods, cirripedes, bivalves, polychaetes and algae in the seasonal diets of both species. Quadratic equations of the form $y = a + bx + cx^2$, where y = % composition and x = total length (mm), were best fits in the description of the importance of gastropods in the seasonal diet of *L. pholis*.

A model of the summer diets of *L. pholis* and *C. galerita* is presented in Figs 3 and 4 respectively.

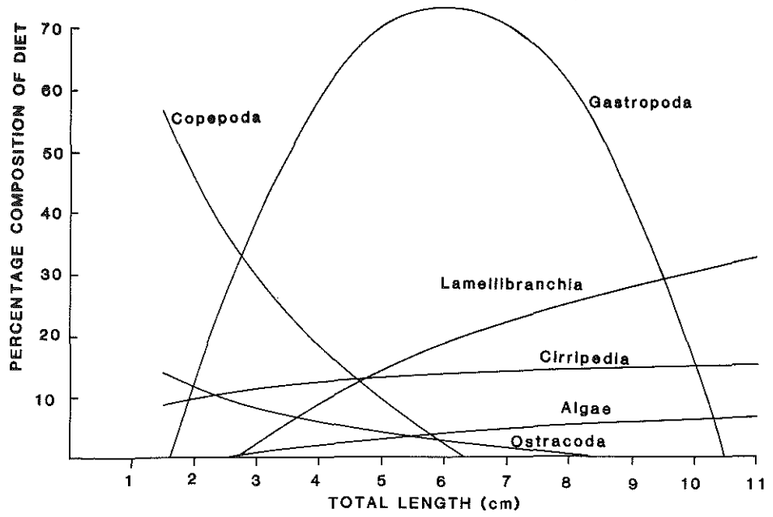


**Fig. 3. Least squares regressions of composition of summer diet on length of *L. pholis* at Mweenish.**

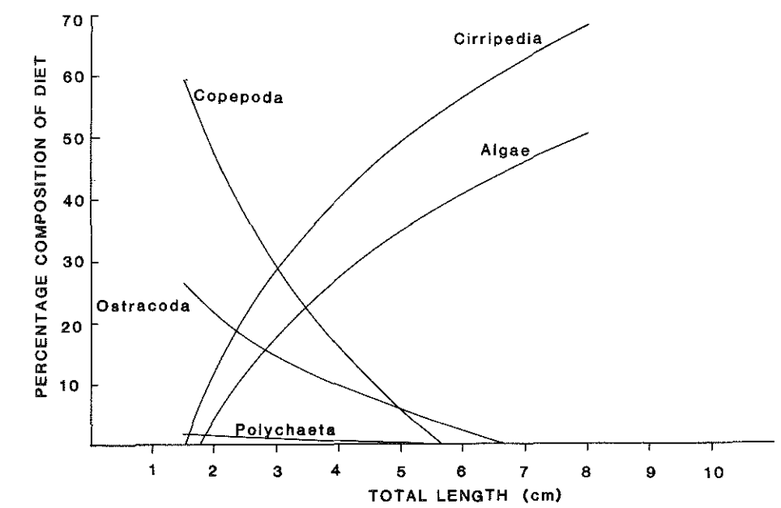


**Fig. 4. Least squares regressions of composition of summer diet on length of *C. galerita* at Mweenish.**





**Summer** (July, August) - *L. pholis* (Table 2). Copepods and to a much lesser extent ostracods and gastropods were the main food categories in the diet of tiny juveniles of 2cm and less. Gastropods (mainly *Littorina neritoides* (L.) and *L. neglecta* (Bean) were important in the diet of larger juveniles of 2.1cm to 4cm. Gastropods were the more frequently recorded food in adolescent fish but became less important in older fish, while bivalves (mainly *Mytilus* spp.) were of increasing importance. Algal material was seldom recorded.

- *C. galerita* (Table 3). Copepods and, to a lesser extent, ostracods were the main food categories in the diet of juveniles of 2cm or less. Cirripedes and, to a lesser extent, algae were more important in the diet of larger juveniles of 2.1 to 3cm. Barnacle cirri were more important than algae in the diets of adolescents and some of the larger fish, but algae were the most important item recorded in the 7 and 8cm fish.

**Autumn** (September, October, November) - *L. pholis*. Copepods, gastropods, ostracods and to a lesser extent cirripedes (barnacle cirri) were important items in the diet of tiny juveniles of 2cm and less. Gastropods were the most important food category in the diet of larger juveniles 2.1 to 5.5cm. Only two fish larger than 5.5cm were examined.

- *C. galerita*. Copepods and to lessening extents ostracods and cirripedes (barnacle cirri), were important in the diet of tiny juveniles, 2cm and less, while copepods and ostracods, and to lesser extents, cirripedes and algae were important in the diet of larger juveniles 2.1 to 3cm. Algae were more important than cirripedes in the diets of adolescent and older fish.

**Winter** (December, January, February) - *L. pholis*. Smaller juveniles 3cm and less consumed mainly gastropods and cirripedes (barnacle cirri), the larger juveniles 3.1 to 5.5cm also included algae in their diet. There was a trend of increasing amounts of algae and to a lesser extent bivalves, being consumed by progressively older fish, but gastropods were less frequently fed upon.

- *C. galerita*. Polychaetes were the most important food category in the diet of juveniles. Barnacle cirri, algae, copepods, and ostracods were also important in the juvenile diet while algae were of primary importance in the diet of adolescent and adult fish.

**Spring** (March, April) - *L. pholis*. Barnacle cirri, gastropods and to a lesser extent algae were important in the diet of small juveniles of 5cm and less, while gastropods, algae, and to lesser extents cirripedes (barnacle cirri, barnacle cypris larvae, newly settled spat, and whole adult barnacles) and bivalves were important in the diet of larger juveniles 5.1 to 6cm. Gastropods were of decreasing importance while algae were of increasing importance in the diets of adolescent to older fish.

- *C. galerita*. Algae and polychaetes were important in the diet of small juveniles, 2cm and less, while cirripedes (cypris larvae, newly settled spat and barnacle cirri), polychaetes, and to a lesser extent, algae were important in the diet of larger juveniles 2.1. to 3.5cm. Algae were of increasing importance in the diets of adolescent and older fish.

*Spring diet of the Inverin sample*

- *L. pholis*. Table 4 indicates that gastropods and cirripedes were the most frequently recorded food in juveniles, whilst bivalves were even more frequently recorded than those two items in adolescents. Only one adult was recorded and it contained these three items plus algae.

Table 5 gives an indication of the contribution of these food items to the total volume of food consumed. Cirripedes and gastropods were important in the diet of juvenile fish; these items plus bivalves contributed to the adolescent's food and cirripedes, bivalves and algae were the main dietary constitutents of the adult.

- *C. galerita*. Only 7 fish were collected. Cirripedes (mainly barnacle cypris larvae) were consumed in large numbers and algae were important to the one 7cm adult fish collected, as shown in the percentage (points) composition of the food items:

| | Juveniles | Adults |
|---|---|---|
| Algae | 25 | 55 |
| Polychaeta | 19 | |
| Gastropoda | 3 | |
| Acari | 3 | |
| Cirripedia | 50 | 35 |
| Amphipoda | | 10 |

*Spring diet of the Carnsore Pt. sample*

- *L. pholis.* Cirripedes were seldom eaten. Gastropods were the most important category in the diet of juveniles and adolescents. Algae and gastropods and to a lesser extent bivalves were important in the adult diet (Tables 4 and 5).

- *C. galerita.* An adult male, with a total length of 6.1cm was the only specimen collected. The percentage composition of the gut content was

Algae 58
Cirripedia (barnacle cirri) 33
Isopoda 8

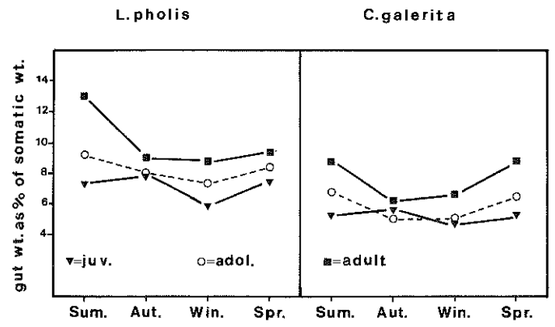


**Fig. 5. The seasonal variation in feeding intensity of juvenile, adolescent and adult L. pholis and C. galerita at Mweenish.**

*Diet and Fish Size.*

Detailed analysis of the consumption of barnacle cirri by juvenile *C. galerita* showed no significant change in cirripede consumption between length groups. However, a definite increase in their importance in September was noticable (Table 7). In October and November, they continued to occur in a high proportion of guts, but their relative abundance decreased. Fig. 5 indicates the feeding intensity of *L. pholis* and *C. galerita* at Mweenish. Juveniles, just returned to the shore from the plankton, seem to have a high feeding intensity during summer and autumn, this drops slightly during the winter, as the fish are much less active and rises again in spring. The adolescents and adults seem to feed less intensively in autumn and winter, than at other times of the year. The feeding intensity values for *L. pholis* at Carnsore Point and Inverin are similar to those recorded at Mweenish. Table 8 indicates the mean number of gastropods and bivalves in the guts of *L. pholis* according to points awarded. *Littorina neritoides* and *Littorina neglecta* are gastropods of approximately the same size, and in general the largest numbers were eaten by juvenile and adolescent *L. pholis*. On the other hand, *Mytilus* spp., with individuals differing greatly in size, were eaten in the greatest numbers by adolescent and adult fish. In general, increasing numbers of gastropods were needed to receive more points in fish of the same size, and also greater numbers of gastropods were needed in adolescent and adults to receive the same number of points as in the juveniles. While increasing numbers of *Mytilus* sp. were needed to receive more points in fish of the same size, increasing numbers were not always needed to receive the same number of points in adult fish, indicating that larger fish were selecting larger individual bivalves.

*Diet and Fish Species.*

Gastropods and bivalves are important only in the diet of *L. pholis*, whereas sedentary polychaetes are important only in the diet of juvenile *C. galerita*. The fact that both species exploit food items differently cannot be accounted for by fish size differences alone. For example, adult *C. galerita* were never found to have eaten whole adult barnacles, whereas *L. pholis* of the same size were frequently found to have done so. Also, echinoid podia were of fairly common occurrence in the guts of adult *C. galerita* but only once was a similar sized *L. pholis* specimen found to have eaten this food item. The food items utilized by each size group of both species were therefore examined. In assessing this utilization, only those food categories which accounted for 5% or more by volume of the food consumed by the fish of that cm length group were included in the analysis (Table 9). The food utilization range does not differ markedly between juvenile, adolescent and adult *L. pholis*, (although small juveniles, of 2 and 3cm length in autumn, did utilize 6 food categories) but does differ between juvenile and adult *C. galerita*; the juveniles having a much broader range than the adults.





*Diet and sampling locality*

The exploitation of named prey categories by the juvenile populations of *L. pholis* on Mweenish and at Carnsore Point during the spring months of March and April was investigated. The fish used in the analysis were members of the 4cm and 5cm length groups from Mweenish (n=35) and Carnsore Point (n=31). No barnacle cypris larvae or recently settled barnacles were recorded in fish captured at Carnsore, however these food items did account for 28.5% by volume of all cirripedes eaten in spring by *L. pholis* collected at Mweenish.

Specimens collected at Inverin on 28th April had consumed large numbers of barnacle cypris larvae and newly settled cyprids (accounting for 71.4% by volume of all cirripedes eaten in spring by the 4 and 5cm length groups). As barnacle cypris larvae and newly settled cyprids were not available to *L. pholis* at Carnsore Point at the time of sampling, 8th and 9th April, only the importance of whole adult barnacles and barnacle cirri in the diets of fish from Mweenish and Carnsore Point was compared. Table 10 shows the percentage frequency with which gastropods, cirripedes (excluding cypris larvae and newly settled cyprids), amphipods, isopods, polychaetes, and algae accounted for a definite percentage composition of the contents of a single gut. For example, amphipods in the Mweenish sample accounted for less than 10% of the contents of a single gut on 9 out of 35 occasions. From Table 10 it is evident that these percentage frequencies are not normally distributed. The Mann-Whitney U-test (Siegel, 1956) with correction for ties, and a significance level of 1% was used to determine whether there was a significant difference in the exploitation of the populations of these food categories by juvenile *L. pholis* on Mweenish and at Carnsore Pt. Before ranking scores (% composition of a prey category in a single gut) it was decided to give occurrences (which were not included in the quantitative analysis), a score of 1. It was found that juvenile *L. pholis* at Carnsore Point consumed significantly greater quantities of amphipods ($Z = 2.599$, $p < 0.0l$), isopods ($Z = 3.003$, $p < 0.01$), polychaetes ($Z = 4.000$, $p < 0.001$) and significantly smaller quantities of cirripedes ($Z = 3.279$, $p < 0.01$) and algae ($Z = 2.306$, $p < 0.05$) than the juveniles on Mweenish. No significant differences in the quantities of gastropods consumed at the two localities was found ($Z = 0.745$).

*Numbers of food organisms consumed.*

Both species studied in this investigation are omnivorous; where whole food items occurred in the guts, they were counted; when only parts of animals occurred, definitive body parts were counted, e.g. both species ate barnacle cirri, which often included the penis of the male reproductive system. Peni counts therefore represent the minimum number of barnacles that had been attacked. Table 11 lists the maximum numbers of named food species/categories that occurred in a single gut.

## DISCUSSION

All age groups of *C. galerita* were collected during this investigation but most of the *L. pholis* captured were less than two years old because of the sampling bias. The collected specimens were divided into juveniles, adolescents and adults using information on biology published by Dunne (1977) and Fives (1980). These sampled populations of *L. pholis* and *C. galerita* appear to co-exist in the short term because of the variety of food types available in the intertidal zone. The food categories utilized by both species are similar but they seem to exploit the food items differently. Gastropods and bivalves are important only in the diet of *L. pholis*, whereas sedentary polychaetes are important only in the diet of juvenile *C. galerita*; adult *C. galerita* were never found to have eaten whole adult barnacles, whereas *L. pholis* of the same size were frequently found to have done so; echinoid podia were often recorded from the guts of *C. galerita*, but only once was a similar size *L. pholis* specimen found to have eaten this food item. *C. galerita* may be described as a mutilator because of its effect on barnacles and other prey items.
The seasonal food resource utilization of the juveniles, adolescents and adults of both species was investigated. With the exception of small juveniles in autumn, the diet does not differ markedly between juvenile, adolescent and adult *L. pholis*, but does differ between adult and juvenile *C. galerita*, the juveniles, in general, having a broader range than the adults. It is suggested, therefore, that intraspecific dietary competition occurs between juveniles of *C. galerita*, while interspecific dietary competiton is occurring between adult *C. galerita* and juvenile, adolescent and possibly adult *L. pholis*.

The results of an investigation of the exploitation of named prey categories by the juvenile populations of *L. pholis* at two sampling sites in spring, showed a significant difference in the quantities of certain items consumed at the two sites. This could suggest that the juvenile *L. pholis* will exploit the most abundant of the preferred food items available.

## ACKNOWLEDGEMENTS

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**TABLE 1. Percentage occurrence of all food items consumed by *L. pholis* and *C. galerita* at Mweenish during the sampling period.**

| | *L. pholis* | | | *C. galerita* | | |
|---|---|---|---|---|---|---|
| Food Items | Juveniles (212) | Adolescents (43) | Adults (20) | Juveniles (148) | Adolescents (48) | Adults (80) |
| ALGAE | 38.2 | 74.4 | 95.0 | 44.6 | 52.1 | 100.0 |
| MOLLUSCA | | | | | | |
| Bivalvia | 33.5 | 69.8 | 75.0 | 0 | 0 | 0 |
| Gastropoda | 87.3 | 81.4 | 50.0 | 2.7 | 8.3 | 13.8 |
| ANNELIDA | | | | | | |
| Polychaeta | 10.4 | 11.6 | 5.0 | 39.9 | 2.1 | 10.0 |
| ARTHROPODA | | | | | | |
| Ostracoda | 51.4 | 20.9 | 0 | 80.4 | 27.1 | 27.5 |
| Copepoda | 40.1 | 14.0 | 0 | 91.9 | 37.5 | 53.8 |
| Cirripedia | 67.0 | 62.8 | 50.0 | 57.4 | 47.9 | 86.3 |
| Amphipoda | 27.8 | 32.6 | 25.0 | 20.3 | 0 | 15.0 |
| Isopoda | 15.6 | 11.6 | 5.0 | 8.8 | 2.1 | 8.8 |
| Decapoda | 1.4 | 4.7 | 5.0 | 0 | 0 | 0 |
| Tanaidacea | 17.5 | 7.0 | 0 | 18.2 | 0 | 2.5 |
| Acari | 17.0 | 0 | 0 | 54.1 | 4.2 | 21.3 |
| Insecta | 18.0 | 7.0 | 0 | 27.0 | 6.3 | 8.6 |
| ECHINODERMATA | | | | | | |
| Ophiuroidea | 0 | 2.3 | 10.0 | 0 | 0 | 0 |
| Echinoidea | 0 | 0 | 0 | 0 | 4.2 | 26.3 |





**TABLE 2. Seasonal diet of *L. pholis* at Mweenish: percentage (points) composition of the major food categories and the values in the regression ($y = a + b \log_{10} x$) of composition on fish length (cm).**

| Food Items | Juvenile | Adolescent | Adult | a | b | r | d.f. | Probability |
|---|---|---|---|---|---|---|---|---|
| Summer | | | | | | | | |
| ALGAE | 0 | 1.9 | 11.5 | -4.92 | 11.3 | 0.599 | 48 | <0.001 |
| MOLLUSCA | | | | | | | | |
| Bivalvia | 0 | 10.0 | 46.2 | -23.56 | 54.0 | 0.645 | 48 | <0.001 |
| Gastropoda | 40.1 | 74.5 | 25.0 | | | | | |
| ARTHROPODA | | | | | | | | |
| Ostracoda | 8.2 | 0 | 0 | 17.4 | -18.99 | -0.548 | 48 | <0.001 |
| Copepoda | 30.6 | 0 | 0 | 72.89 | -91.08 | -0.7 | 48 | <0.001 |
| Cirripedia | 9.9 | 13.5 | 16.3 | 7.59 | 7.77 | 0.133 | 48 | >0.1 |
| Autumn | | | | | | | | |
| ALGAE | 1.7 | 31.3 | 72.2 | -14.17 | 31.29 | 0.364 | 82 | <0.001 |
| MOLLUSCA | | | | | | | | |
| Bivalvia | 1.2 | 6.3 | 0 | -3.99 | 9.29 | 0.365 | 82 | <0.001 |
| Gastropoda | 58.6 | 31.3 | 11.1 | | | | | |
| ARTHROPODA | | | | | | | | |
| Ostracoda | 5.6 | 0 | 0 | 28.46 | -40.47 | -0.615 | 82 | <0.001 |
| Copepoda | 4.9 | 0 | 0 | 28.50 | -41.45 | -0.532 | 82 | <0.001 |
| Cirripedia | 12.6 | 6.3 | 5.6 | 23.43 | -18.75 | -0.164 | 82 | >0.1 |
| Winter | | | | | | | | |
| ALGAE | 9.4 | 41.5 | 57.0 | -60.43 | 113.44 | 0.587 | 69 | <0.001 |
| MOLLUSCA | | | | | | | | |
| Bivalvia | 2.5 | 3.7 | 9.2 | -7.6 | 16.71 | 0.326 | 69 | <0.01>0.001 |
| Gastropoda | 56.3 | 39.9 | 20.4 | | | | | |
| ARTHROPODA | | | | | | | | |
| Ostracoda | 0.9 | 0 | 0 | | | | | |
| Copepoda | 2.0 | 0 | 0 | | | | | |
| Cirripedia | 11.7 | 5.9 | 1.4 | 32.5 | -31.91 | -0.311 | 69 | <0.01>0.001 |
| Spring | | | | | | | | |
| ALGAE | 27.8 | 40.7 | 47.0 | -33.57 | 86.92 | 0.412 | 67 | <0.001 |
| MOLLUSCA | | | | | | | | |
| Bivalvia | 6.2 | 14.6 | 28.7 | -26.97 | 51.18 | 0.435 | 67 | <0.00l |
| Gastropoda | 37.7 | 16.6 | 3.0 | | | | | |
| ARTHROPODA | | | | | | | | |
| Ostracoda | 0 | 0 | 0 | | | | | |
| Copepoda | 0.3 | 0 | 0 | | | | | |
| Cirripedia | 15.3 | 18.1 | 19.7 | 36.76 | -23.97 | -0.139 | 67 | >0.1 |

**TABLE 3. Seasonal diet of *C. galerita* at Mweenish: percentage (points) composition of the major food categories and the values in the regression ($y = a + b \log_{10} x$) of composition on fish length (cm).**

| Food Items | Juvenile | Adolescent | Adult | a | b | r | d.f. | Probability |
|---|---|---|---|---|---|---|---|---|
| Summer | | | | | | | | |
| ALGAE | 2.1 | 22.0 | 31.0 | -18.87 | 70.65 | 0.604 | 56 | <0.001 |
| ANNELIDA | | | | | | | | |
| Polychaeta | 0.7 | 0 | 1.2 | 2.08 | -2.60 | -0.617 | 56 | >0.1 |
| ARTHROPODA | | | | | | | | |
| Ostracoda | 21.9 | 8.0 | 4.0 | 33.86 | -40.85 | -0.738 | 56 | <0.001 |
| Copepoda | 47.9 | 8.7 | 5.1 | 79.19 | -105.34 | -0.877 | 56 | <0.001 |
| Cirripedia | 6.8 | 53.3 | 47.4 | -16.06 | 93.41 | 0.607 | 56 | <0.001 |
| Acari | 4.1 | 1.3 | 1.4 | | | | | |
| Autumn | | | | | | | | |
| ALGAE | 8.2 | 70.0 | 62.4 | -28.02 | 118.45 | 0.829 | 132 | <0.001 |
| ANNELIDA | | | | | | | | |
| Polychaeta | 8.1 | 0 | 0.7 | 8.18 | -7.85 | -0.120 | 132 | >0.1 |
| ARTHROPODA | | | | | | | | |
| Ostracoda | 18.6 | 0 | 1.7 | 30.12 | -38.38 | -0.584 | 132 | <0.001 |
| Copepoda | 32.5 | 0 | 2.8 | 59.73 | -80.23 | -0.665 | 132 | <0.001 |
| Cirripedia | 10.9 | 20.0 | 24.5 | 2.36 | 31.27 | 0.346 | 132 | <0.001 |
| Acari | 9.8 | 0 | 2.8 | | | | | |
| Winter | | | | | | | | |
| ALGAE | 18.3 | 80.0 | 68.5 | -51.03 | 158.67 | 0.731 | 27 | <0.001 |
| ANNELIDA | | | | | | | | |
| Polychaeta | 23.5 | 15.0 | 2.8 | 40.03 | -46.07 | -0.389 | 27 | >0.02<0.05 |
| ARTHROPODA | | | | | | | | |
| Ostracoda | 7.8 | 0 | 1.1 | 17.19 | -21.54 | -0.285 | 27 | >0.1 |
| Copepoda | 13.9 | 0 | 1.1 | 18.93 | -24.32 | -0.548 | 27 | >0.001<0.01 |
| Cirripedia | 15.7 | 0 | 10.1 | 24.71 | -20.36 | -0.145 | 27 | >0.1 |
| Acari | 9.6 | 5.0 | 1.1 | | | | | |
| Spring | | | | | | | | |
| ALGAE | 20.9 | 85.7 | 76.5 | -53.16 | 169.08 | 0.662 | 53 | <0.001 |
| ANNELIDA | | | | | | | | |
| Polychaeta | 23.6 | 0 | 0.1 | 50.01 | -65.06 | -0.566 | 53 | <0.001 |
| ARTHROPODA | | | | | | | | |
| Ostracoda | 0.9 | 0 | 0 | | | | | |
| Copepoda | 6.4 | 0 | 0.5 | 13.0 | -15.96 | -0.474 | 53 | <0.001 |
| Cirripedia | 31.8 | 7.1 | 16.9 | 56.78 | -50.22 | -0.288 | 53 | >0.02<0.5 |
| Acari | 0.9 | 0 | 0.3 | | | | | |





**TABLE 4. Percentage occurrence of all food items consumed by *L. pholis* at Carnsore Point and Inverin in spring.**

| Food Items | Carnsore Point Juveniles (34) | Carnsore Point Adolescents (24) | Carnsore Point Adults (15) | Inverin Juveniles (19) | Inverin Adolescents (6) | Inverin Adults (1) |
|---|---|---|---|---|---|---|
| ALGAE | 32.4 | 70.8 | 80 | 21.1 | 33.3 | 100.0 |
| MOLLUSCA | | | | | | |
| Bivalvia | 14.7 | 66.7 | 80 | 47.7 | 100.0 | 100.0 |
| Gastropoda | 91.2 | 100.0 | 75 | 84.2 | 83.3 | 100.0 |
| ANNELIDA | | | | | | |
| Polychaeta | 41.2 | 16.7 | 40.0 | 26.3 | 0 | 0 |
| ARTHROPODA | | | | | | |
| Cirripedia | 17.6 | 20.8 | 26.7 | 78.9 | 83.3 | 100.0 |
| Amphipoda | 70.6 | 50.0 | 46.7 | 21.1 | 16.7 | 0 |
| Isopoda | 52.9 | 50.0 | 46.7 | 21.1 | 0 | 0 |
| Decapoda | 2.9 | 20.8 | 6.7 | | | |
| Tanaidacea | 8.8 | 12.5 | 13.3 | | | |
| Acari | | | | 15.8 | 0 | 0 |
| Insecta | 23.5 | 4.2 | 0 | 15.8 | 0 | 0 |

**TABLE 5. Diet of *L. Pholis* at Carnsore Point and Inverin in spring: percentage (points) composition of the major food categories and the values in the regressions ($y = a + b \log_{10} x$) of composition on fish length (cm).**

| Food Items | Juvenile | Adolescent | Adult | a | b | r | d.f. | Probability |
|---|---|---|---|---|---|---|---|---|
| CARNSORE PT. | | | | | | | | |
| ALGAE | 11.0 | 23.2 | 32.8 | -1.01 | 23.65 | 0.204 | 71 | <0.1>0.05 |
| MOLLUSCA | | | | | | | | |
| Bivalvia | 1.6 | 13.3 | 16.0 | -25.53 | 43.65 | 0.501 | 71 | <0.001 |
| Gastropoda | 46.2 | 41.3 | 29.8 | | | | | |
| ANNELIDA | | | | | | | | |
| Polychaeta | 7.8 | 2.8 | 2.3 | | | | | |
| ARTHROPODA | | | | | | | | |
| Cirripedia | 2.3 | 1.6 | 3.0 | 3.13 | -1.27 | -0.042 | 71 | >0.1 |
| Amphipoda | 17.8 | 5.0 | 8.7 | | | | | |
| Isopoda | 8.5 | 6.9 | 6.0 | | | | | |
| Decapoda | 0.8 | 3.9 | 0.7 | | | | | |
| Tanaidacea | 0.8 | 1.1 | 0.7 | | | | | |
| Insecta | 3.0 | 0.3 | 0 | | | | | |
| INVERIN | | | | | | | | |
| ALGAE | 7.8 | 7.7 | 29.2 | 3.44 | 10.45 | 0.06 | 24 | >0.1 |
| MOLLUSCA | | | | | | | | |
| Bivalvia | 5.7 | 26.9 | 29.2 | -39.03 | 72.18 | 0.601 | 24 | <0.001 |
| Gastropoda | 37.8 | 30.8 | 8.3 | | | | | |
| ANNELIDA | | | | | | | | |
| Polychaeta | 1.7 | 0 | 0 | | | | | |
| ARTHROPODA | | | | | | | | |
| Cirrepedia | 39.5 | 33.3 | 33.3 | 86.16 | -68.12 | -0.287 | 24 | >0.1 |
| Amphipoda | 1.7 | 1.2 | 0 | | | | | |
| Isopoda | 2.4 | 0 | 0 | | | | | |
| Acari | 2.0 | 0 | 0 | | | | | |
| Insecta | 1.4 | 0 | 0 | | | | | |

**TABLE 6. Quadratic equations of the form $y = a + bx + cx^2$ (where y = % composition in diet; x = total length in mm and a, b and c are degree 0, 1 and 2 respectively) describing the importance of gastropods in the seasonal diet of *L. pholis* at three locations.**

| | Degree | Polynomial in X Regression coefficient | Std. err. | T. value |
|---|---|---|---|---|
| MWEENISH | | | | |
| Summer | 0 | -63.56938 | 14.56128 | -4.37 |
| | 1 | 4.58624 | 0.63239 | 1.25 |
| | 2 | -0.03804 | 0.00563 | -6.76 |
| Autumn | 0 | -85.30190 | 19.48250 | -4.38 |
| | 1 | 6.01063 | 0.85897 | 7.00 |
| | 2 | -0.05619 | 0.00896 | -6.27 |
| Winter | 0 | 58.17363 | 29.52048 | 1.97 |
| | 1 | 0.05651 | 0.96046 | 0.06 |
| | 2 | -0.00388 | 0.00675 | -0.58 |
| Spring | 0 | 21.89244 | 32.56188 | 0.67 |
| | 1 | 0.76934 | 1.09837 | 0.70 |
| | 2 | -0.01083 | 0.00856 | -1.26 |
| CARNSORE PT. | | | | |
| Spring | 0 | 30.78288 | 36.66681 | 0.84 |
| | 1 | 0.64745 | 1.16802 | 0.55 |
| | 2 | -0.00710 | 0.00868 | -0.82 |
| INVERIN | | | | |
| Spring | 0 | -19.44320 | 41.57731 | -0.47 |
| | 1 | 1.71467 | 1.33349 | 1.29 |
| | 2 | -0.01287 | 0.00954 | -1.35 |

**Table 7. The monthly consumption of Cirripedia by juvenile *C. galerita* on Mweenish.**

| | August | September | October | November |
|---|---|---|---|---|
| Number of juveniles | 14 | 61 | 29 | 10 |
| Number containing Cirripedia | 1 | 28 | 14 | 5 |
| Cirripedia as % of total food | 3.5% | 16.2% | 6.3% | 6% |
| ranging from: | | 3.2 to 34% | 1.3 to 12.3% | 4.3 to 8.5% |





**Table 8. — The mean number of gastropods and bivalves in the guts of juvenile, adolescent and adult *L. pholis* according to points awarded.**

| | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | Total sample size |
|---|---|---|---|---|---|---|---|---|---|
| | | | Points awarded to Gastropoda | | | | | | |
| Juveniles | 1.3 | 4.1 | 10 | 13.3 | 8.2 | 20.3 | 23 | 26.8 | 76 |
| Adolescents | 2.7 | 10.8 | 30 | 29.9 | 31 | 55 | 84 | | 25 |
| Adults | 1.7 | 6 | 33.5 | | | | | | 12 |
| | | | Points awarded to Bivalvia | | | | | | |
| Juveniles | 1.2 | 2.3 | 6.8 | 26 | | | | | 27 |
| Adolescents | 1.4 | 7.6 | 15.8 | 22 | | | | | 23 |
| Adults | 3 | 5.3 | 6 | 13.5 | | | | | 9 |

**Table 9. — The mean numbers of food categories accounting for > 5% of the food of juveniles, adolescents and adults.**

| | | Juvenile | Adolescent | Adult | Total sample size |
|---|---|---|---|---|---|
| *L. pholis* | | | | | |
| Mweenish | Summer | 4 | 3 | - | 42 |
| | Autumn | 4.3 | - | - | 82 |
| | Winter | 4 | 3 | - | 60 |
| | Spring | 3.5 | 5 | 4 | 55 |
| Carnsore Pt. | Spring | 5 | 5 | 4.5 | 61 |
| Inverin | Spring | 3.5 | 4 | - | 23 |
| *C. galerita* | | | | | |
| Mweenish | Summer | 3 | 4 | 3 | 54 |
| | Autumn | 6.5 | - | 2 | 133 |
| | Winter | 7 | - | 3 | 21 |
| | Spring | 5 | - | 2.5 | 50 |

**Table 10. — The percentage frequency with which named food categories accounted for a definite percentage (points) composition of the contents of a single gut in juvenile (4 and 5 cm length groups) *L. pholis* from Mweenish and Carnsore Point in spring.**

| | | Percentage points composition | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 | 1-10 | 11-20 | 21-30 | 31-40 | 41-50 | >50 |
| Gastropoda | | | | | | | | |
| | Mweenish | 8.6 | 11.4 | 5.7 | 14.3 | 11.4 | 8.6 | 40 |
| | Carnsore Point | 3.2 | 9.7 | 6.5 | 16.1 | 9.7 | 9.7 | 45 |
| Cirripedia | | | | | | | | |
| | Mweenish | 22.9 | 28.6 | 25.7 | 8.6 | 2.9 | 2.9 | 9 |
| | Carnsore Point | 64.5 | 25.8 | 6.5 | 3.2 | | | |
| Amphipoda | | | | | | | | |
| | Mweenish | 48.6 | 25.7 | 11.4 | 8.6 | 2.9 | 2.9 | |
| | Carnsore Point | 29.0 | 9.7 | 29.0 | 9.7 | 6.5 | 3.2 | 13 |
| Isopoda | | | | | | | | |
| | Mweenish | 68.6 | 20.0 | 11.4 | | | | |
| | Carnsore Point | 35.5 | 19.4 | 32.3 | 9.7 | | | 3.2 |
| Polychaeta | | | | | | | | |
| | Mweenish | 88.6 | 5.7 | 5.7 | | | | |
| | Carnsore Point | 41.9 | 22.6 | 22.6 | 3.2 | 6.5 | | 3.2 |
| Algae | | | | | | | | |
| | Mweenish | 40.0 | | 2.9 | 11.4 | 14.3 | 5.7 | 26 |
| | Carnsore Point | 58.1 | 9.7 | 3.2 | 9.7 | 12.9 | 6.5 | |

**Table 11. — Maximum numbers of named food species/categories occurring in a single gut.**

| Fish Species | Food Category | Identification | Number | Sampling Location |
|---|---|---|---|---|
| *L. pholis* | Gastropoda | *Littorina neritoides* + *Littorina neglecta* | 84 | Mweenish |
| | Lamellibranchia | *Mytilus spp.* | 80 | Inverin |
| | Cirripedia | mutilated adults | 24 | Mweenish |
| | | cypris larvae | 146 | Inverin |
| | | whole adult animals | 65 | Inverin |
| *C. galerita* | Cirripedia | cypris larvae | 291 | Inverin |
| | | mutilated adults | 127 | Mweenish |



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