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THE SEVEN-RAYED SCALLOP *PSEUDAMUSSIUM PESLUTRAE* (LINNAEUS, 1771) (PECTINIDAE) FROM THE ROCKALL CONTINENTAL SLOPE

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Abstract Pseudamussium peslutrae *has a geographical range from southern Iceland and Norway southwards to the western Mediterranean Sea and North Africa. In this study, its biometrics were examined from two collections at mean depths of 353 and 517m from the Rockall continental slope, with only four scallops obtained at depths to 810m. Growth was based on the formation of shell rings, with one specimen having seventeen rings. Associates fouling the shells were classified according to nine taxa.*

Key words *growth, boreal, pectinid, epifauna, predation*

Introduction

Pseudamussium peslutrae (Linnaeus, 1771) has undergone a number of recent nomenclatural changes, having been previously recognized as *Chlamys septemradiata* (Müller, 1776) (Allen, 1953, 1962; Tebble, 1966; Ansell, 1974). More recently, the genus changed to *Pseudamussium septemradiatum* (O.F. Müller, 1776) in Wagner, 1991, and subsequently the species to *Pseudamussium peslutrae* (Linnaeus, 1771) in Dijkstra & Gould, 2002. *Pseudamussium peslutrae* is a cold-water species, occurring within some Scottish fiords known from Upper Kilbrennan Sound, Upper Lough Fyne, the Cumbrae Deep, Arran Deep and Upper Loch Fyne (Allen, 1953) and extends westward to the continental slope. It is usually found within a range of 50–500m (Dijkstra *et al.*, 2009). There are large deposits of its shell within the Mediterranean Sea that accumulated during the Würm glacial period at a time when its northern distribution was probably restricted (Emig & Geistdoerfer, 2004). It remains in the deeper water of the western Mediterranean within the Alboran Sea; but unable to tolerate salinities in the eastern Mediterranean region, which includes the Aegean Sea, where salinities can exceed 36.5psu (Emig & Geistdoerfer, 2004). *Pseudamussium peslutrae* has a range that extends northwards to the southeast and southwest of Iceland (Dijkstra *et al.*, 2009) and was recorded from 90 to 722 fathoms (164–1320m) during the Porcupine expedition of 1869 (Jeffreys, 1882). In a further study, it was dredged from 37 to 2002 fathoms (67–3660m) by Dautzenberg and Fischer in 1912 (in: Massey, 1929–1931). It is associated with fine sediments; but being a byssate species, it requires a firm surface for attachment during its early life history. Here the likely rates of growth of scallops taken from two depths from the Rockall continental slope are examined and show that this species provides a settlement surface for a wide range of taxa including conspecifics that utilize the shell surface for attachment over soft sediments.

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Methods

The RSS *Challenger* cruise, during 29 October to 1 November 1987, involved benthic trawl sampling within an area lying to the west of the Stanton Banks. Samples of *Pseudamussium peslutrae* were collected from a minimum depth of 210m to a maximum depth of 810m on the Rockall continental slope over mobile sediments (Table 1). The station furthest up-slope used a shallow-water trawl with a 65mm mesh for depths of 210–435m with a mean depth of 353m for 64 minutes at 56° 39' N, 09° 00' W. The deeper stations used an otter trawl with a 35mm mesh over depths of 545 to 590m with a mean depth of 517m and deployed for 60 minutes at 56° 23' N, 09° 08' W. The deepest station was at 735m to 810m with a mean depth of 772m for 59 minutes at 56° 20' N, 09° 11' W. All trawls had a 10mm cod end.

Scallops were measured for shell height, from the umbo to the ventral margin, down to the nearest mm. Each shell ring was measured along

Table 1 The Rockall continental slope stations where scallops were obtained.

Cruise	Latitude	Longitude	Depth m	Mean depth m	No. scallops	Biometrics
20/87/22	56° 20 N	9° 11 W	735–810	772	4	rings
20/87/30	56° 23 N	9° 08 W	545–590	517	285	size, rings, weight
20/87/31	56° 39 N	9° 00 W	210–435	353	294	size, rings, weight

Table 2 Numbers of scallops obtained at each depth (No.). The ring shell heights on selected scallops, numbers used in parentheses (ring height). Size distributions by shell ring numbers for two depths and numbers collected on the Rockall continental slope .* No clear ring on these scallops but were of similar size to the larger scallops with a clear first ring.

Ring group	353m No.	Ring height mm	Shell height mm	Mean weight g	517m No.	Ring height mm	Shell height mm	Mean weight g
0	1*	9.3±2.3 (50)	9.4*		2*	8.4±2.7 (48)	8.3*	
I	4	26.7±5.0 (50)	36.2	3.8	1	20.7±3.4 (50)	34.4	3.6
II	60	36.9±4.8 (50)	43.7±2.1	7.7	5	34.1±3.3 (50)	40.3±1.6	5.0
III	64	42.8±3.8 (46)	47.0±2.5	9.6	29	41.4±2.3 (50)	45.8±2.4	7.5
IV	77	45.6±3.5 (43)	48.9±2.9	10.6	17	45.5±1.9 (50)	46.7±1.9	8.0
V	52	47.2±3.2 (35)	49.5±3.0	13.3	11	47.8±2.0 (50)	47.9±2.0	9.2
VI	12	48.5±3.2 (24)	49.8±2.9	13.3	22	49.2±2.0 (50)	49.2±2.6	9.0
VII	8		49.1	12.2	33		49.3±3.2	8.9
VIII	9		51.3	13.2	51		49.7±2.7	10.0
IX	6		52.0	10.1	49		51.2±2.4	11.1
X & X+	1		52.2	10.2	65		52.4±2.9	12.0

this dorso-ventral alignment. A ring was considered to be laid down each year as is known for other scallop species (Mason, 1957; Wiborg, 1963; Hart and Chute, 2009). Where available, fifty individuals with seven to ten rings were selected. Those with little or no recognizable fouling were selected to provide an indication of annular growth for the two depths 353m and 582m. Weights were measured for each ring group on a digital balance to obtain the mean weight for each ring class, to 0.1g. Internal tissues were examined for gonadal development.

Epibiota on the shell surface were classed according to nine separate taxa. These were recorded according to the number of rings on living scallops' shells from 582m.

Separate valves were collected and examined for indications of predation. Two benthic feeding fishes with subterminal mouths were selected for stomach analysis. This consisted of two *Hydrolagus miriabilis* (Collett, 1904) and two *Corphaenoides rupestris* Gunnerus, 1765. In addition, four witch *Glyptocephalus cynoglossus* (Linnaeus, 1758), a pleuronectid fish, were also examined.

RESULTS

Four living scallops with eight or more shell rings were retrieved between 735 and 810m (Table 1). Scallops were not seen in trawl samples from greater depths. Sufficient samples of scallops were obtained from depths 353m (N=294) and 517m (N=285) to examine shell rings for a population study. The growth rings for these two depths followed a similar pattern (Table 2). Those at the greater depth of 517m had more older scallops with ten or more rings (22%) whereas at 353m the majority had two to five rings. Scallops with one to ten rings were present in both samples. The growth pattern of rings from shallow water were not as distinct when compared with the deeper site.

The three smallest scallops, 8.3 to 9.4mm, were byssally attached to the otherwise unfouled shell surface of older scallops at both depths.

Scallops from the 353m attained a weight of 13.3g at five rings. Those at 517m reached 12.0g at ten or more rings (Table 2). Internal tissues and gonads at both stations were flaccid which may indicate recent reproduction.

Table 3 Taxa recorded from fouled scallops sampled from 582m by ring group.

Taxon	Overall prevalence by taxa	II	II	III	IV	V	VI	VII	VIII	VIII+
molluscs	1.0		1				1	2		
brachiopods	2.8							4	1	3
bryozoans	7.0							3	4	13
cirripedes	15.4		2	1		6	4	5	9	17
hexacorallia	1.0							1		2
hydroids	4.5	1			1		1	3	4	3
polychaetes	1.7								4	1
serpulids	52.6	1	10	11	7	11	20	19	34	37
tunicates	9.1					2		9	5	10
Σ fouled	71.5	1	15	10	9	18	22	33	41	55
Σ clean	27.3	4	14	7	2	4	11	18	8	10
Σ scallops	–	5	29	17	11	22	33	51	49	65
Prevalence by ring group		20	51.7	58.9	81.8	81.8	66.6	64.7	83.6	84.6

Left valve surface colour ranged from a pale pink, lemon, light orange-brown to brown, some with a mottled patterning. The right valve was white except in the region close to the umbo with colours similar to the left valve. Shells had five to nine undulating rays, some shells demonstrating some level of asymmetry.

Most shells had some level of fouling (> 60%). Those with more shell rings supported a greater diversity of taxa (Table 3). Serpulids were the most prevalent, at 52%, with up to three on a single shell. Other groups present include brachiopods of which *Novocrania anomala* (O.F. Müller, 1776), *Terebratulina septentrionalis* (Couthouy, 1838) and *Macandrevia cranium* (O.F. Müller, 1776) were collectively present at ~ 2%. Bryozoa, including a *Sertella* sp., were only found on scallops with eight or more rings. A single *Capulus ungaricus* (Linnaeus, 1758) and *Puncturella noachina* (Linnaeus, 1771) were present.

Thirty-five separate valves were collected from both depths, of which four had shell damage. One, 43mm, had features similar to chelae damage, and three had drill holes through the right valve. The selected fishes had no scallop shell within their stomachs.

DISCUSSION

Sampling and population structure

The seven-rayed scallop *P. peslutrae* occurred on the Rockall continental slope between 210 and 810m, although it may exist at greater depths. Previous collections in 1983 (Anon, 1983) from the same region, as in this study, at 56° 23 N 9° 08 W at depths between 500–560m obtained an estimated > 2000 individuals of *P. peslutrae*. The samples from 1983, together with the presence of individuals with up to seventeen rings, indicates a persistence in this region.

The distribution of the number of ring groups varied between the two depths studied. There were more individuals with fewer rings from 353m than at 517m. This probably reflects the selectivity of the trawls with the smaller 35mm mesh capturing more of the younger scallops (Table 2). However, older scallops would also have been expected with the smaller mesh that was used. This difference might relate to differences in mortality or an uneven distribution of the different year classes that could include variable recruitment. Byssally attached scallops lacking a ring were found attached to older scallops. This young stage during its early development requires a firm surface for settlement. On open areas of soft sediment, attachment to older conspecifics as found in this study may be important. It is likely the numbers of the byssally attached stage may have been greater than recorded in this study as many would have expected to have become detached from the trawling activity. As each scallop develops the byssus is eventually cut and the scallop then typically become dispersed over sediments, aided by swimming. Scallops are capable of swimming even under cooler conditions in deep water where temperatures would range within 8 to 11° C during the late autumn (Gordon 1983). Such temperatures are unlikely

to suppress swimming activity in cold-water scallops. In the case of the Antarctic *Adamussium colbecki* (E.A. Smith, 1902), it is capable of swimming at –1.4 C° (Ansell *et al.,* 1998). Pye (1980) reports that once on sediment, *P. peslutrae* in the Scottish sea lochs swims and is capable of 'flapping' its valves to prevent sedimentation on its upper shell surface so enabling other sessile species to attach.

Rings in other scallop species are generally laid down over winter with the progressively greater number of concentric rings considered to represent different age groups. As this survey took place in the autumn, a ring may not have formed. There was a greater initial size progression of the rings in the shallower sample from 353m that would indicate faster earlier growth. The rings were not as strongly marked in many of the shallow water scallops, nevertheless these rings could be distinguished. The greater numbers of rings in the sample from 517m might reflect a lower level of mortality as many individuals had ten or more rings and only one had seventeen.

Scallops from 353 and 517m ultimately attained 52mm shell height. This is greater than the 47mm for those at a similar latitude in the shallower conditions on the west coast of Scotland (Allen, 1953). The continental slope scallop population has a faster growth and attains a larger size and lives longer. Growth is greater again off the coast of Iceland where it can attain a shell height of 65mm (Dijkstra *et al.,* 2009).

Associates attached to shells

There is a trend for an increase in fouling once six rings have been attained. Allen (1953) noticed an increase in fouling to four rings, as scallops seldom lived longer than this. This pattern probably reflects the surface area available for settlement with growth. Fouling on older scallops was likely to impair their swimming ability, although it is unclear if this activity is an important behavioral feature on the continental slope. Generally, young scallops have greater abilities to swim, and are less likely to become fouled. Currently it is not known when settlement takes place on the continental slope. Thorsen (1946) records settlement during October in the Kattegat. Young *P. peslutrae* clearly attach by means of a byssus during their early life history. Duchêne and Rosenberg (2001) report small individuals attached to tubes of the sabellid *Echone papillosa* (Sars, 1851) using a video at 75m in a Swedish fjord and Allen (1953) is of the view that firm surfaces, other than those of older scallops, are important for the majority of settlement. Depending upon the numbers present at depth, and the association of this scallop with fine sediments, the shell of older scallops may provide an important substrate for the distribution of biota over the fine sediments of the slope floor. Once the byssus is cut, scallops most probably disperse by swimming.

Predation

Little is known of the levels of natural mortality of this scallop, although with individuals attaining seventeen rings, that would indicate a low-level of predation. There are indications that *P. peslutrae* occurs in the diet of deep-water benthic fishes (Kopp *et al.,* 2018) although none were found in this study. Of the thirty-five separate valves recovered in this study, one had marks consistent with chelae damage, and decapods were present at the same depths. The three valves with drill marks might have been due to natacid predation.

The scallop *P. peslutrae* on the continental slope had individuals with ten or more shell rings indicating a low level of predation when compared with the shallow water populations in deep-water Scottish sea lochs. Furthermore, this cold-water scallop has a faster shell growth on the continental slope than in Scottish lochs. On the continental slope the level of fouling increases in accordance with the number of rings produced as the shell surface area increases. This scallop may provide an important settlement surface for sedentary taxa over soft sediments on the continental slope where other firm settlement sites are not available.

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Marine Research Laboratory, Scottish Marine Biological Association, Oban, Scotland. Alan had a distinguished career in marine biology greatly contributing to molluscan biology (Gibson & Barnes, 2000). It was our intention to publish these records before now; but Alan died in October 1999.

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