SHORT COMMUNICATION

COLONISATION OF ARTIFICIALLY CLEARED *LAMINARIA DIGITATA* (HUDS.) LAMOUR. BY THE BLUE-RAYED LIMPET *HELCION PELLUCIDUM* (L.) (MOLLUSCA, GASTROPODA)

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INTRODUCTION

The blue-rayed limpet *Helcion pellucidum* is a herbivorous mollusc commonly found on intertidal and sublittoral laminarian algae, though it is also known from other algae (Vahl 1971; Fretter and Graham 1976; McGrath 1992). McGrath (1992) has suggested that this gastropod species settles on crustose coralline algae and recruits later to foliose macroalgae, including *Laminaria digitata*. This hypothesis implies that this limpet moves between algal species. Migratory behaviour has been reported for this species by a number of authors (Graham and Fretter 1947; Vahl 1972; Warburton 1976). Graham and Fretter (1947) have described the migrations of small individuals from the laminae to the holdfasts of *Laminaria digitata*. They also state that there is a downward migration of limpets on the laminae of *L. digitata* to the most basal part near the stipe in late autumn. They note a similar migration on *L. hyperborea*. However, they provide no data to substantiate their statements. Vahl (1972) and Warburton (1976) also describe similar migrations of *H. pellucidum* on *L. hyperborea*. However, none of these observations on migration is based on data from marked individuals. Rather they are the result of observations of changes in the relative abundances of limpets or changes in the relative abundances of small and large individuals on different parts of the lamina. A mechanism for the proposed migration is unknown, though Vahl (1983) has described the formation of a mucous sail in *Helcion* in the laboratory and suggested that this might allow dislodged individuals to recolonise algae in the field. Post-metamorphic drifting in the water column also occurs in other gastropod species and this is accomplished in many by the production of long mucous threads (Martel and Chia 1991; Martel and Diefenbach 1993).

The observations on colonisation of *H. pellucidum* on *L. digitata* described in this paper are serendipitous and were obtained following an unexpected result of a project designed to test for the possible effects of grazing by *H. pellucidum* on epiphyte cover on *L. digitata* laminae.

METHODS

On 16 September 1993 all visible *H. pellucidum* were removed from the stipes and laminae of four *Laminaria digitata* plants on the lower intertidal of an exposed rocky shore at Ballynahown in Galway Bay on the west coast of Ireland (Irish Grid Reference L990200). The four plants were individually marked using coloured plastic wire threaded through the holdfast, each plant being given a distinct colour. The limpets removed were returned to the laboratory and shell length was measured to the nearest 0.01mm by calipers. They were not returned to the field. The colour-coded algae were examined on thirteen occasions until February 1994 and any limpets found on them were either counted and left in place, to assess the rate of colonisation, or all removed for measurement and not returned (see Table 1 for details). Whenever limpets were removed from the marked plants to be measured after September a number of *L. digitata* plants (known henceforth as reference plants) were removed from the same shore zone at some distance from the marked plants and returned to the laboratory. Selection of reference plants was often haphazard (Krebs 1989) owing to weather conditions, but on four occasions (see Table 2) plants were selected randomly using pairs of coordinates to give distance along and distance from a weighted line across the kelp zone. All *H. pellucidum* were removed from the stipes and laminae of these reference plants and measured for comparison with those on the marked plants. In addition, during the period October to December a series of sixteen *L. digitata* holdfasts (four per month) were removed from the same shore zone, brought back to the laboratory and examined for the presence of *H. pellucidum*.

RESULTS

The numbers initially removed from the marked algae in September and those either counted in place or removed on later sampling trips are shown in Table 1. The results show that *H. pellucidum* rapidly colonised cleared kelps (see, for example, the numbers counted within one day of removal on 17 September 93 and within three days of removal on 15 and 30 January 1994). While these individuals were not measured in the field, it was clear that they were of similar size to those on other nearby plants. The numbers colonising the marked *L. digitata* generally fell steadily over the study period but appreciable numbers continued to attach to cleared plants until February.

A comparison of the mean sizes of initially removed *H. pellucidum*, those appearing later on the marked plants and those on reference plants is shown in Table 2. The population size structures of *H. pellucidum* from marked and reference plants are shown for all months combined in Fig. 2. While there is a suggestion that the specimens from the former are somewhat smaller than those

Table 1—Number of *Helcion pellucidum* removed from and colonising four individual kelps, *Laminaria digitata*, at Ballynahown, Co Galway, from September 1993 to February 1994.

		Marked kelp number			
Date	*Procedure*	*1*	*2*	*3*	*4*
16 Sept. 93	First removal	62	49	143	338
17 Sept. 93	Counted only	2	4	7	36
17 Oct. 93	Counted and removed	37	30	99	161
31 Oct. 93	Counted and removed	9	52	58	94
13 Nov. 93	Counted and removed	26	39	68	58
4 Dec. 93	Counted and removed	*	56	71	67
15 Dec. 93	Counted and removed	31	34	55	63
1 Jan. 94	Counted and removed	22	16	33	67
12 Jan. 94	Counted and removed	25	13	32	38
15 Jan. 94	Counted only	10	11	14	24
27 Jan. 94	Counted and removed	*	*	22	52
30 Jan. 94	Counted and removed	15	7	4	20
10 Feb. 94	Counted and removed	16	9	23	39

* Sampling impossible owing to sea conditions.

Table 2—Mean sizes (mm shell length) ±95% confidence intervals of *Helcion pellucidum* removed from marked and reference kelps, *Laminaria digitata*, at Ballynahown, Co. Galway, with results of Mann-Whitney U-tests and whether samples from reference plants were collected haphazardly or randomly.

Date	*Marked*	*Reference*	*Mann-Whitney U-test*	*Sampling*
16 Sept. 93	4.05 ± 0.16 (105)	Not sampled		
17 Oct. 93	4.70 ± 0.13 (323)	5.31 ± 0.23 (93)	$P < 0.05$	Haphazard
31 Oct. 93	5.61 ± 0.18 (203)	5.51 ± 0.13 (307)	$P > 0.05$	Haphazard
13 Nov. 93	6.08 ± 0.18 (189)	6.36 ± 0.15 (316)	$P < 0.05$	Haphazard
4 Dec. 93	6.93 ± 0.13 (246)	6.66 ± 0.12 (235)	$P < 0.05$	Haphazard
15 Dec. 93	6.72 ± 0.14 (240)	6.88 ± 0.19 (116)	$P > 0.05$	Haphazard
1 Jan. 94	6.93 ± 0.21 (138)	7.18 ± 0.23 (137)	$P < 0.05$	Random
12 Jan. 94	7.02 ± 0.24 (108)	7.17 ± 0.20 (79)	$P > 0.05$	Random
27 Jan. 94	7.15 ± 0.26 (74)	7.20 ± 0.26 (51)	$P > 0.05$	Haphazard
30 Jan. 94	7.15 ± 0.40 (46)	7.22 ± 0.13 (305)	$P > 0.05$	Random
10 Feb. 94	7.13 ± 0.26 (87)	7.69 ± 0.21 (98)	$P < 0.05$	Random

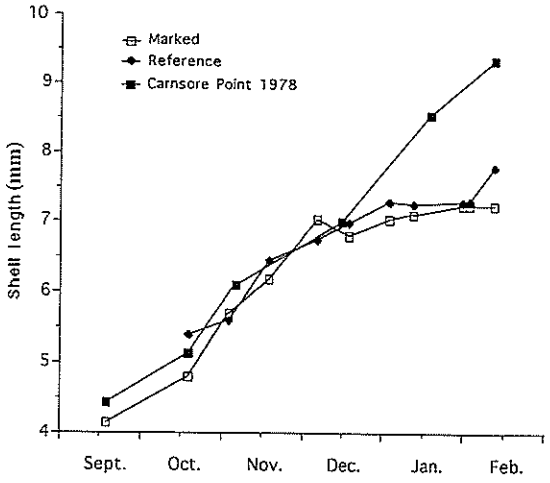

Fig. 1—Growth rates of *Helcion pellucidum* based on the increase in mean size from samples removed from marked and reference *Laminaria digitata* at Ballynahown, Co. Galway 1993–1994 and on the data of McGrath (1992) from Carnsore Point 1978. Note that the data for Carnsore Point from January and February are not from the same cohort of limpets as those from September to December.

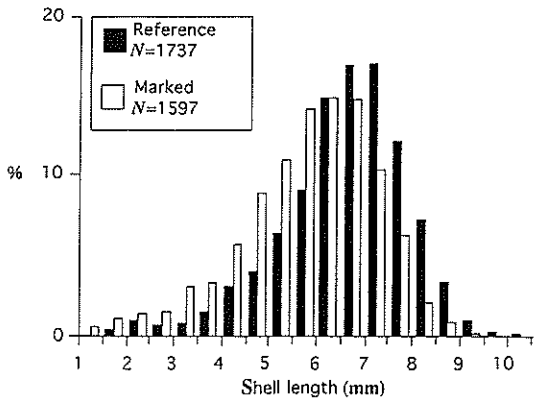

Fig. 2—The length frequency distributions of *Helcion pellucidum* from marked and reference *Laminaria digitata* plants at Ballynahown for all months combined, with number measured (*N*).

on the reference plants, on half of the sampling occasions there is no statistically significant difference between the populations on the marked and reference kelps (Mann-Whitney U-test, $P > 0.05$). On the remaining occasions, the differences are significant (Mann-Whitney U-test, $P < 0.05$), but there is no consistency as to which population had the larger mean size, and differences in mean sizes were always less than 0.60mm.

The mean size of *H. pellucidum* on both marked and reference plants increased in size over the study period, though this increase slowed after December (Fig. 1). The increase in size at Ballynahown is similar to that seen at Carnsore Point in 1978 over the same period (McGrath 1992) until December but is thereafter slower, with the Ballynahown population showing little or no growth. However, it must be noted that the data from Carnsore do not derive from a single cohort, those from January and February 1978 being from a previous year class.

A total of sixteen *H. pellucidum* were found in the sixteen holdfasts examined, with a mean size of $3.29 \pm 95\%$ C.I. 1.79mm (range 1.26–7.70mm). Single specimens were occasionally seen on the surface of the holdfast of the marked plants.

DISCUSSION

One possible explanation for the data presented here is that *H. pellucidum* found on the marked plants after removal had been overlooked on the previous sampling occasion in the field, being essentially invisible to the eye, and had subsequently grown to the observed size by the following sampling occasion. This is unlikely. In December, for example, a growth rate of about 10mm per month would have been required, given that limpets of 3mm or greater are unlikely to have been overlooked. This is greater than the estimated growth over one year for this species in Irish and British waters (Graham and Fretter 1947; McGrath 1992). Although Vahl (1971) found faster growth rates in his Norwegian study area (about 2mm per month), his estimated maximum mean growth rate of 0.12mm per day only gives a rate of 3.60mm per month. This still remains substantially less than the necessary growth rate calculated and is far too low to explain the appearance through growth of those specimens that appeared on the cleared kelps within three days of removal on 15 January. While these were not measured it was clear that they were of a similar size to those of the general kelp population in January, approximately 7mm mean shell length.

Further, if growth of an invisible cohort between sampling occasions is to explain the appearance of *H. pellucidum* on cleared kelps on subsequent sampling trips, then there must be a sizeable population of such individuals remaining following clearance in the field. There is no evidence from the size structure of limpets on the reference kelps for such a population. Specimens <3mm in shell length made up from 0–4.4% (mean 1.7%) of the limpet population on these kelps. The *H. pellucidum* from the reference kelps were removed in the laboratory making the overlooking of small specimens with blue coloration unlikely. The blue coloration appears at a shell length of 1.1mm and *H. pellucidum* recruits to *L. digitata* at a shell length of $1.82 \pm$ S.D. 0.61mm

(McGrath 1992). There was also a very low incidence of limpets <3mm on *L. digitata* at Carnsore Point, ranging from 0% to 1.3% (mean 0.5%) of the population (author's observations).

It appears, therefore, that *H. pellucidum* individuals rapidly colonise the cleared laminae of *L. digitata* plants and that the colonisers have a similar size structure to that of the general population on *L. digitata*. The source of the colonising individuals is not known. One possibility is that there are large numbers of *H. pellucidum* in the holdfasts of the cleared plants. Whilst these could not be examined during the study, examination of sixteen *L. digitata* holdfasts from the same zone found only very small numbers of individuals. However, the holdfast could form part of the route for colonisation.

It appears that the colonising *H. pellucidum* derive from some other source and that movement between algae (either intra- or inter-specific or both) is involved. *Helcion pellucidum* have been observed on *L. digitata*, *L. hyperborea* (Gunn.) Foslie, *Himanthalia elongata* (L.) S.F. Gray, *Mastocarpus stellatus* (Stackh.) Guiry, crustose coralline algae and *Fucus serratus* L. in the study area (author's observations). Those on *Mastocarpus stellatus* and crustose algae are probably too small to be the source of colonisers, given the reported growth rates of *H. pellucidum* (see McGrath 1992).

The mechanism of the proposed movement is also not known. Given that the plants are intertidal, movement may follow direct contact of algal laminae. Preliminary experiments carried out by the author in aquaria in the laboratory have shown that *H. pellucidum* can attach to cleared pieces of *L. digitata* laminae suspended in close contact with pieces with attached limpets. Movement could also be via the rock substrate. Individuals are occasionally seen on open rock. Vahl (1983) observed that detached *H. pellucidum* in the laboratory produced a mucous sail. He suggests that this might allow dislodged specimens to reattach to *Laminaria*.

The data from this study provide evidence for rapid colonisation of cleared *L. digitata* by *H. pellucidum*, and this has implications for previous reports (Graham and Fretter 1947) that these limpets undergo seasonal migrations on the laminae of this kelp species.

Confirmation that individuals of *H. pellucidum* move between algae at all sizes and in appreciable numbers must await successful discovery of a method to mark limpets and follow individuals. Attempts to do this using limpets marked with paints and varnish in the field have so far been unsuccessful.

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