

FURTHER INVESTIGATIONS OF THE FLORA AND FAUNA OF THE LUNDY LENTIC FRESHWATERS

By

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ABSTRACT

The composition of the flora and macroinvertebrate fauna of the four Lundy permanent bodies of standing water, Pondsburry, Quarry Pool, Rocket Pole Pond and the larger pond at Quarterwall, has remained remarkably stable since 1979 when the first comprehensive survey was undertaken. However all three previous surveys had taken place during the summer months (July and August). This autumn investigation has again demonstrated this stability, but it has also shown seasonal differences in the flora and fauna. The ponds again show striking differences between each other, particularly in the macroinvertebrate populations, which can be related to their position on the island and the degree of exposure, vegetation cover, the amount of decaying matter and nutrients present and the occurrence of algal blooms. Three small bodies of water, two in the northernmost quarry and one to the west of the Pondsburry raised dam, were studied for the first time. All three were covered with aquatic plants and hence provided a good habitat for insects and crustaceans.

Keywords: *Lundy, ponds, aquatic plants, macroinvertebrates.*

INTRODUCTION

The freshwater habitats, lotic (streams) and lentic (standing waters), of Lundy were fully documented by Langham in 1968, but until 1979 there had been no comprehensive investigation of their flora and fauna. However some work on selected plant and animal groups had occurred *e.g.* Hemiptera (Morgan, 1947); diatoms (Fraser Bastow, 1949); Crustacea & Rotifera (Galliford, 1953); *Asellus meridianus*, (Williams, 1962). Some freshwater organisms have been listed in terrestrial surveys of specific

animal groups *e.g.* Coleoptera (Brendell, 1975); Diptera (Lane, 1977); Hemiptera (Alexander, 1991).

In August 1979, a comparative investigation of the flora and fauna of the main Lundy standing waters (Pondsbury, Rocket Pole Pond, Quarry Pool and the two ponds at Quarterwall) was carried out (George & Stone, 1979, 1980) and was followed-up seven years later by a further August survey (George & Sheridan, 1986). In July and August 1993, two further detailed studies were undertaken – one on the lotic habitats (Long, 1993) and the other on the largest body of standing water on the island, Pondsbury (Clabburn, 1993a). All of these data which relate to summer conditions were reviewed by George (1997) who highlighted the need for comparative seasonal information.

In the autumn of 2003 (mid-October), the opportunity arose for the authors to undertake further investigation of the standing waters, and the results are given in this paper and in the accompanying paper (George *et al.*, 2003) on the plankton. The summer and early autumn of 2003 had been very warm with little rain; most of the streams and the smaller pond at Quarterwall were dry and the larger ponds had reduced water levels when the survey occurred. The ponds studied were Pondsbury, the Rocket Pole Pond, Quarry Pool and the large pond at Quarterwall. In addition, three small temporary ponds, two in the northernmost quarry (North Quarry 1 and North Quarry 2) and one adjacent to the raised west bank of Pondsbury (named David's Pool) were investigated for the first time.

The main aim of the investigation was to examine the composition of the flora and fauna of the ponds to determine any changes since the previous surveys (Pondsbury, 10 years ago and the other ponds, 17 years ago) and also to document any seasonal differences.

PERMANENT PONDS: METHODS

The four permanent bodies of freshwater studied were Pondsbury, Quarry Pool, the large pond at Quarterwall (Quarterwall 1) and the Rocket Pole Pond.

Physical and chemical measurements

The following factors were measured: air and water temperatures, pH (Whatman pH papers), oxygen content of surface and bottom water (oxygen meter). Mapping of the ponds was undertaken and depth profiles of the ponds were also plotted.

Flora

The species of plants within and at the-edges of the ponds were listed and note was taken of habit (*e.g.* floating, submerged, emergent). The keys of Haslam *et al.* (1975), Bursche (1971) and Clapham *et al.* (1968) were used to identify the plants. The distribution and location of the main plant species were then plotted on to outline maps of each of the ponds.

A subjective estimate of relative abundance of each of the species was made on a scale of 1 to 5 as follows:

Score	Relative abundance	
1	<i>Rare</i>	<i>Less than 1% of total number of plants present</i>
2	<i>Occasional</i>	<i>1-5% of total number of plants present</i>
3	<i>Frequent</i>	<i>6-10% of total number of plants present</i>
4	<i>Common</i>	<i>11-50% of total number of plants present</i>
5	<i>Abundant</i>	<i>More than 50% of total number of plants present</i>

At Pondsburry it was not possible, as in 1979, to carry out a transect due to the difficult physical nature of the pond. Instead plants were surveyed at 66 sites at approximately 5 metre intervals around the perimeter and recorded as present or absent and abundance noted. Relative abundance was recorded for each species by taking an average for relative abundance at all 66 sites.

A subjective estimate of percentage cover was also made for each species at Quarry Pool, Rocket Pole Pond and the pond at Quarterwall (Quarterwall 1) using a scale of 1 to 5 as follows:

Score	Percentage cover
1	<i>Less than 1%</i>
2	<i>1-5%</i>
3	<i>6-10%</i>
4	<i>11-50%</i>
5	<i>51-100%</i>

Macroinvertebrates

Invertebrates were collected from plant beds and open water using a standard FBA net (aperture 0.96mm) by sweeping for a five minute period at each pond. Preliminary sampling revealed that very few organisms were present in the sediments with no organisms being found that were not represented in the general sweep samples. Consequently, no quantitative sampling was undertaken in the sediments.

PERMANENT PONDS: RESULTS

Physical and chemical characteristics

The physical and chemical characteristics of the four ponds are given in Table 1. Depth recordings in each of the ponds are shown in Figures 1 to 4.

As shown in the previous surveys, the ponds are acidic with Pondsbury being slightly more acidic than the others. Pondsbury lies in a *Sphagnum* bog and this explains the constant value of pH 4.8-5.0 recorded over the years. (*Sphagnum* has the ability to bind cations and release hydrogen ions in their place, thus maintaining a constant acidity).

Water temperatures were similar in both shallow and deep areas thus showing little evidence of temperature stratification. During the entire week of sampling, a strong easterly wind blew across the island, which kept the fairly shallow ponds well-mixed. Consequently the surface waters of all ponds were well-oxygenated (often super-saturated), with high levels of oxygen in the deeper waters.

Table 1. Physical and chemical characteristics of the four permanent Lundy ponds.

	PONDSBURY	ROCKET POLE POND	QUARRY POOL	QUARTER WALL POND 1
Max. depth m	0.6	1.65	1.5	0.4
Air temp. °C	11	12	12	14.5
Water temp.				
Surface °C	12.5	13.5	14	14
Bottom °C	12	13	13	13.5
pH	5	5.5	5.5	5.5
O ₂ Surface mg/l	10.4	12.3	12.3	12.6
Bottom mg/l	8.6	9.6	8.2	10.2
OS Grid	SS 13463	SS 13481	SS 13756	SS 13630
Reference	45508	43681	45037	44965

Flora

Figures 1 to 4 show the distribution and location of the main plant species which are plotted on outline maps of each of the ponds. Table 2 shows the percentage frequency and relative abundance of the main plant species found at Pondsburry and Table 3 shows the relative abundance and percentage cover of the main plant species found at the other permanent ponds.

As in previous surveys (George & Stone 1979, 1980) Pondsburry shows the greatest diversity of macrophytes with eleven species being recorded. The Rocket Pole and Quarterwall ponds have the smallest diversity with only four species being recorded at each. Five species were present at Quarry Pool. Although the species composition is very similar to previous surveys, relative abundance is lower than before in all ponds except in the Rocket Pole Pond.

Table 2. Relative abundance scores and percentage frequency for the flora of Pondsburry.

SPECIES	NUMBER OF SAMPLING SITES RECORDED AT	% FREQUENCY	RELATIVE ABUNDANCE SCORE
<i>Sphagnum cuspidatum</i> Ehrh. Bog moss	35	53	5
<i>Hypericum elodes</i> L. Marsh St. John's wort	5	8	2
<i>Hydrocotyle vulgaris</i> L. Marsh pennywort	15	23	3
<i>Ranunculus flammula</i> L. Lesser spearwort	1	1.5	1
<i>Callitriche stagnalis</i> Scop. Mud water starwort	21	32	4
<i>Potamogeton polygonifolius</i> (Pourret) Bog pondweed	28	43	4
<i>Juncus effusus</i> L. Soft rush	40	61	5
<i>Juncus articulatus</i> L. Jointed rush	14	21	3
<i>Juncus conglomeratus</i> L. Compact rush	4	6	1
<i>Eleocharis palustris</i> L. Common spike rush	26	40	4
<i>Myosotis scorpioides</i> L. Creeping water forget-me-not	15	23	3

As in the 1979 survey, the moss, *Sphagnum cuspidatum*, was one of the dominant species at Pondsburry appearing at 53% of the sites surveyed (Table 2) and with high relative abundance (5). Even more abundant this time was the rush, *Juncus effusus*, which was recorded at 61% of sites. An emergent, it formed dense stands of vegetation in the open water and around the margins of the water body. These findings agree with those of Clabburn (1993b) who also found these two species to be the most dominant in Pondsburry. Another rush, *Eleocharis palustris*, occurred with less frequency (40%) but again was widespread around the margins; it formed pure stands further out into the open water than *Juncus effusus*. The most common submerged aquatic species were *Potamogeton polygonifolius*, the bog pondweed, (43% frequency) and *Callitriche stagnalis*, the mud water starwort, (32% frequency). Both were found in water a few metres out from the margin in association with *Sphagnum cuspidatum*. Although both of these species were found in the 1979 survey neither was found with the same frequency or relative abundance as before. *Hypericum elodes*, marsh St. John's wort, although present at some sites (8% frequency, relative abundance 2), was not a dominant species as it was in 1979. This time, isolated shoots were found at the south side of Pondsburry but most occurred in the north-east corner. The two species, *Elatine hexandra*, waterwort, and *Lythrum portula*, water purslane, recorded in 1979 were not found on this occasion.

Table 3. Relative abundance and percentage cover scores for the flora of the three permanent Lundy ponds.

SPECIES	QUARRY		QUARTERWALL		ROCKET POLE	
	Rel.Ab Score	% Cover (Score)	Rel. Ab. Score	% Cover (Score)	Rel. Ab. Score	% Cover (Score)
<i>Hydrocotyle vulgaris</i> L. Marsh pennywort			1	1	4	1
<i>Lythrum portula</i> L. Water purslane			1	1		
<i>Rumex acetosella</i> L. Sheep's sorrel	1	1				
<i>Ranunculus flammula</i> L. Lesser spearwort	2	1				
<i>Juncus effusus</i> L. Soft rush	3	2	3	2	5	1
<i>Juncus conglomeratus</i> L. Compact rush					2	1
<i>Eleocharis palustris</i> L. Common spike rush	3	2	4	2	4	1
<i>Myosotis scorpioides</i> L. Creeping water forget-me-not	1	1				

In the other three ponds virtually no plants were growing in the open water. All species recorded were confined to the margins. This agreed with the 1979 investigation in the case of the Rocket Pole and the Quarterwall ponds. The rushes, *Juncus effusus* and *Eleocharis palustris* were the only macrophytes to be found at all three ponds where they were the most dominant of the macrophytes (Table 3). *Hydrocotyle vulgaris*, the marsh pennywort, was present at both the Rocket Pole and Quarterwall ponds. *Potamogeton polygonifolius* and *Fontinalis* sp. were absent this time from the Quarry Pool. Another rush, *Juncus conglomeratus*, was recorded at the Rocket Pole Pond.

Macroinvertebrates

The species and numbers of macroinvertebrates in the sweep samples are given in Table 4.

Pondsbury and Quarterwall I show the greatest species diversity, but overall numbers of individuals were low in each pond, being much lower than in the previous summer surveys. Two species were found in every pond, the larva of the damselfly, *Ischnura elegans* and a larva of the Chironominae (Diptera). Adults of *Ischnura elegans* have often been recorded during the summer months (Parsons, 2002). As in the previous surveys, *Asellus meridianus* was the most abundant invertebrate in Pondsbury, which also had several coleopteran species. As before, the water- boatmen (Hemiptera) favour the Quarterwall I pond. The pond-skater, *Gerris gibbifer* was abundant on the surface near the east sheltered wall of Quarry Pool and both adults and juveniles were present. A dipteran larva, the phantom midge, *Chaoborus crystallinus* occurred in the sweep samples of Pondsbury and the Quarterwall I pond. This larva, which had not been found in any of the previous summer surveys, was abundant in the Pondsbury plankton sample and also occurred in the plankton of the Quarterwall I pond and Quarry Pool.

PERMANENT PONDS: DISCUSSION

The investigation shows that, as in the previous surveys, considerable differences occur in the flora and fauna of the four ponds. These can be related to factors such as position and exposure of the ponds on the island, water chemistry, vegetation cover, amount of decaying organic matter and nutrients present, and the occurrence of algal blooms. Since the summer surveys of all the ponds in 1979 and 1986 (George & Stone, 1979, 1980; George & Sheridan, 1986) and the comprehensive July/August survey of Pondsbury by Claburn (1993a), dredging has occurred in two of the ponds. In September 1993, the deepest section of Pondsbury was dug out and the dredged material was used to heighten the dam that forms the western bank (Gibson, 1993 and R. Lovel, Pers. Comm.) In late summer of 1995, following the extreme drought when all stock were moved off the island, Pondsbury was again dredged in the open

Table 4. Species and numbers of individual macroinvertebrates in the plant beds and open water of the permanent ponds. Numbers of individuals relate to the five minute net sweep.

SPECIES		PONDSBURY	QUARRY	QUARTERWALL	ROCKET POLE
Annelida					
Oligochaeta:	<i>Lumbriculus variegatus</i> (Muller)	10	~	6	4
Hirudinea:	<i>Helobdella stagnalis</i> (L.)	~	~	7	~
Crustacea					
Isopoda:	<i>Asellus meridianus</i> Racovitza	26	10	12	~
Insecta					
Ephemeroptera:	<i>Cloeon dipterum</i> (L.) l.	5	~	3	~
Odonata:	<i>Ischnura elegans</i> (van der Linden) l.	12	3	10	4
	<i>Sympetrum striolatum</i> (Charpentier) l.	2	~	~	~
Hemiptera:	<i>Gerris gibbifer</i> Schum.	~	50	~	~
	<i>Notonecta marmorea viridis</i> Delcourt	8	~	6	~
	<i>Corixa punctata</i> (Illiger)	5	1	10	~
	<i>Sigara dorsalis</i> (Leach)	~	2	19	~
	Juvenile Corixidae	~	~	10	~
Coleoptera:	<i>Hydroporus pubescens</i> (Gyllenhal) a.	4	~	~	~
	<i>Hygrotus inaequalis</i> (Fab.) a.	3	~	~	~
	<i>Laccophilus minutus</i> (L.) a.	2	~	~	~
	Dytiscid Colymbetinae l.	~	2	~	~
Diptera:	Chironominae l.	15	5	5	6
	<i>Chaoborus crystallinus</i> (Deg.) l.	12	~	4	~
Mollusca					
Bivalvia:	<i>Pisidium personatum</i> Malm	~	2	~	~
Total no. of species		12	8	11	3
Total no. of individuals		104	75	92	14

Key. l=larva; a=adult; ~ = not found.

water area and extended. Also the bottom sediments from the larger pond at the Quarterwall were removed (Parkes, 1995 and R. Lovel, Pers. Comm.).

Three of the ponds, Quarry, Rocket Pole, Quarterwall 1, being formed from excavations in the rock, maintain their shape, although their water levels fluctuate, but Pondsbury, the largest body of freshwater on the island, is surrounded by *Sphagnum* bog, heathland and rough pasture, and it regularly changes shape due to varying water levels. In October 2003, water levels in all four ponds were lower than in the previous surveys due to the very dry summer and early autumn.

The composition of the flora reflects the acidic nature of the ponds, with the rushes, *Juncus effusus* and *Eleocharis palustris* being characteristic of bogs and marshes. The differences recorded in this autumn survey may simply reflect the fact that it was carried out more than two months later than the previous surveys, and several of the plants would be dying-back.

The largest changes were apparent at Pondsbury where there was far more open water than in the previous summer investigations, probably due to the dredging that had occurred in 1993 and 1995. The 'islands' of vegetation dominated by *Hypericum elodes* were no longer present and this may have favoured the growth of the pondweed, *Potamogeton polygonifolius*, which was more prevalent this time. *Potamogeton polygonifolius* is a perennial plant characteristic of acidic upland waters. Notably the species was absent this time from the Quarry Pool and it may be that the conditions here had become more eutrophic which is not favourable to this species.

Although there were seasonal differences in the composition and numbers of macroinvertebrates, the fauna of all four ponds showed similarity in species composition to the previous surveys of 1979, 1986 and 1993. For instance, in spite of the dredging in Pondsbury, the isopod crustacean *Asellus meridianus* was again the dominant member of the fauna, with the Coleoptera (beetles), Hemiptera (water-bugs) and Chironominae (midge larvae) again well-represented groups in this water body. The Quarterwall 1 pond, which had also been dredged in 1995, had still retained its good species diversity of notonectids and corixids (water boatmen) and its *Asellus meridianus* population.

In 2003, as in 1979 and 1986, the Rocket Pole Pond had the lowest species diversity of all the ponds, whereas the Quarry Pool showed a similar species composition to that seen in previous years. The low numbers of macroinvertebrates in Rocket Pole can be attributed to the large population of mirror carp, *Cyprinus carpio*, that still exists and the nutrient enrichment from faeces of the fish and the ducks that frequent this pond (ten ducks were present during the week of sampling). Increased nutrients lead to algal blooms (blue-green algae in the summers of 1979 and 1986 and green algae in the autumn of 2003) that lower the light levels in the pond, thus affecting plant growth, which was minimal in 2003, except at the edges of the pond. Plants

provide both shelter and food for many macroinvertebrates *e.g. Asellus* spp., insect larvae, and it is not surprising that these species are absent or very rare in this habitat.

It was interesting to note that the Quarry Pool retained its large population of the pond skater, *Gerris gibbifer*, with both adults and juveniles present. *Gerris gibbifer* overwinters in cracks and crevices in rock and the sheltered Quarry Pool with its steep rocky walls provides an ideal habitat for this species.

Seasonal differences were observed in all four ponds. Water temperatures were on average 3 or 4 °C colder than in the summer surveys. Due to the strong easterly winds blowing throughout the week of sampling the waters were well mixed, with little evidence of the thermal stratification that had occurred in the summer. However oxygen levels in the surface waters were greater due to turbulence caused by the wind, often with supersaturation occurring.

Fewer macroinvertebrate individuals were found, particularly in the species that had dominated during the summer months, *e.g. Asellus meridianus*. The platyhelminth flatworm, *Polycelis nigra* that was abundant in Pondsburry in 1979 and 1993 was not found, and neither was the water spider, *Argyroneta aquatica*, that was common in the weed beds in the previous summer surveys. The larva of the phantom midge, *Chaoborus crystallinus*, was found in Pondsburry and the Quarterwall sweep samples and this species had not been recorded previously in any of the three summer surveys. *Chaoborus crystallinus* was particularly abundant in the Pondsburry plankton and was also present in the Quarry and Quarterwall plankton samples. This obvious seasonal difference is discussed in the paper on the plankton (George *et al.*, this volume, p 99). Another species not found previously was the leech, *Helobdella stagnalis*, in the Quarterwall pond, with some adults having young attached to their ventral surfaces. Rocket Pole Pond had even fewer macroinvertebrates, both species and numbers, than in the summer surveys.

The fish that are known to inhabit three of the ponds, Rocket Pole, Quarry and Pondsburry, were not investigated due to lack of suitable sampling equipment. However mirror carp, *Cyprinus carpio*, were evident in the Rocket Pole Pond in considerable numbers, and a golden carp, *Carassius auratus*, was observed in the Quarry Pool. A few years ago a large (5 kg,) crucian carp, *Carassius carassius*, was caught (and returned) in the Quarry Pool (R. Lovel, Pers. Comm.).

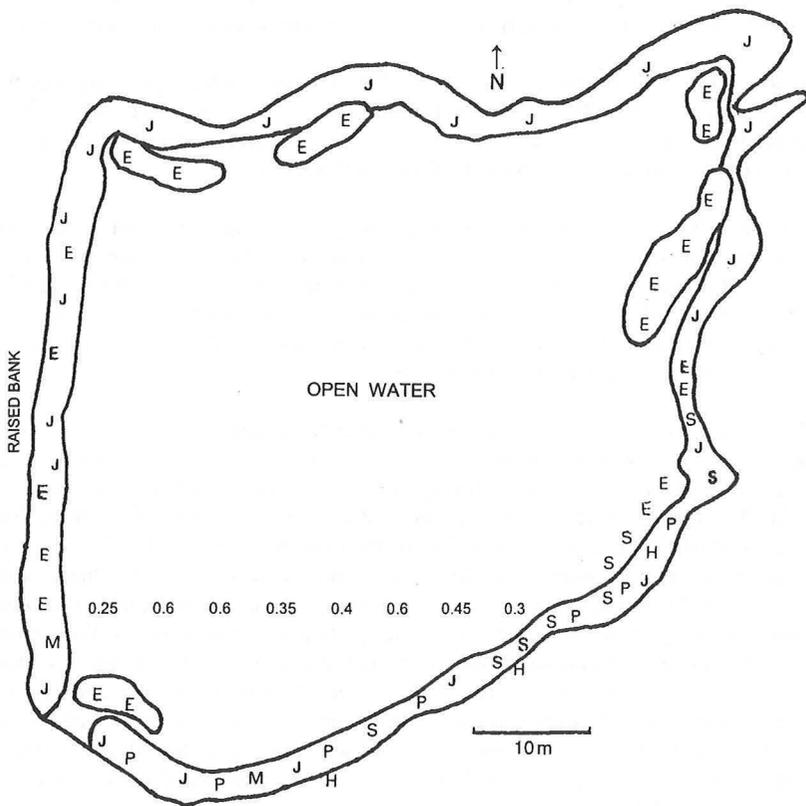


Figure 1. Map of Pondsbury showing the main beds of vegetation and spot depths in metres.

Key. J=*Juncus effusus*, E=*Eleocharis palustris*, M=*Myosotis scorpioides*, H=*Hydrocotyle vulgaris*, P=*Potamogeton polygonifolius*, S=*Sphagnum cuspidatum*.

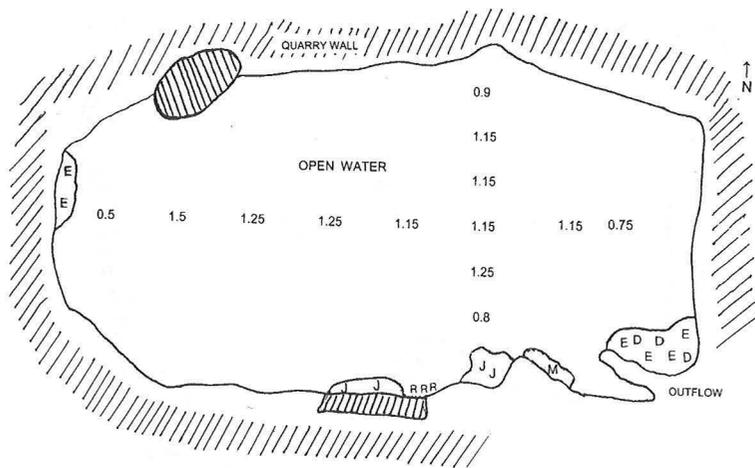


Figure 2. Map of Quarry Pool showing the main beds of vegetation and spot depths in metres. Pool dimensions: 22m long by 11m wide.

Key.

J=*Juncus effusus*, E=*Eleocharis palustris*, R=*Ranunculus flammula*, M=*Myosotis scorpioides*, D=*Lemna minor*.

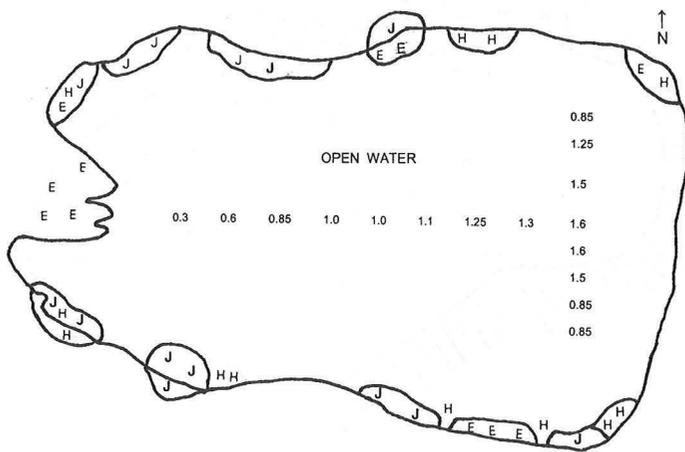


Figure 3. Map of Rocket Pole Pond showing the main beds of vegetation and spot depths in metres. Pond dimensions: 25.8m long by 11.7m wide.

Key. J=*Juncus effusus*, E=*Eleocharis palustris*, H=*Hydrocotyle vulgaris*.

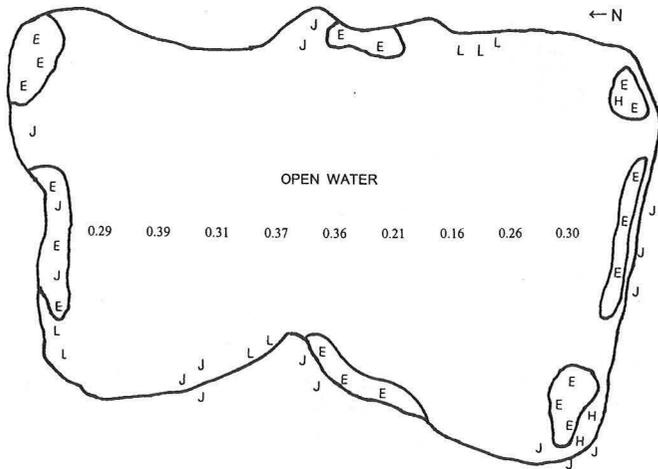


Figure 4. Map of Quarterwall Pond showing the main beds of vegetation and spot depths in metres. Pond dimensions: 19.5m long by 12.8m wide.

Key. J=*Juncus effusus*, E=*Eleocharis palustris*, H=*Hydrocotyle vulgaris*, L=*Lythrum portula*.

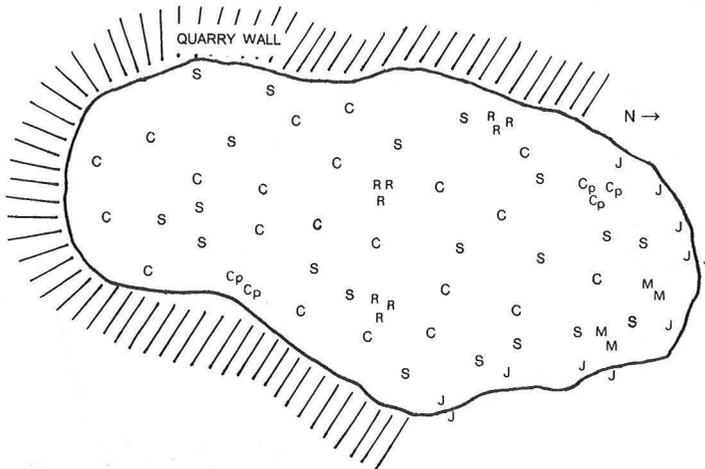


Figure 5. Map of North Quarry Pool 1 showing the main beds of vegetation. Pool dimensions: 6m long by 3.5m wide.

Key.

J=*Juncus effusus*, C=*Callitriche stagnalis*, S=*Sphagnum cuspidatum*, M=*Myosotis scorpioides*, R=*Ranunculus flammula*, Cp=*Caldesia parnassifolia*.

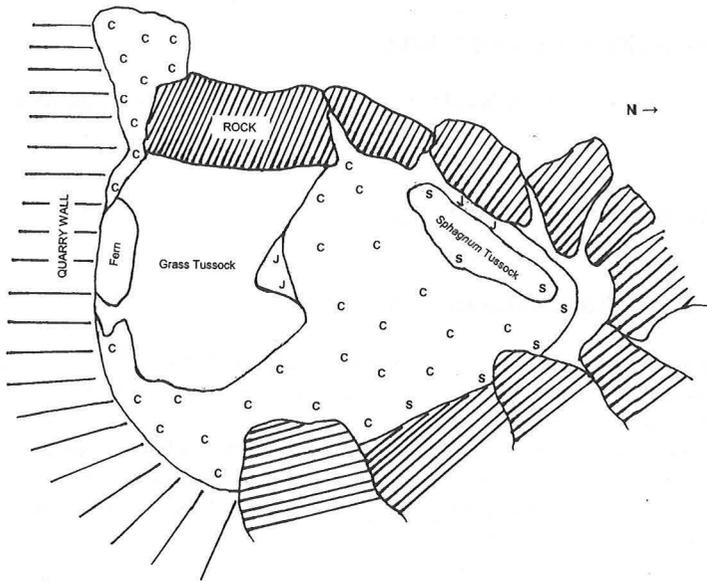


Figure 6. Map of North Quarry Pool 2 showing the main beds of vegetation. Pool dimensions: 2.9m long by 1.7m wide.

Key. J=*Juncus effusus*, C=*Callitriche stagnalis*, S=*Sphagnum cuspidatum*.

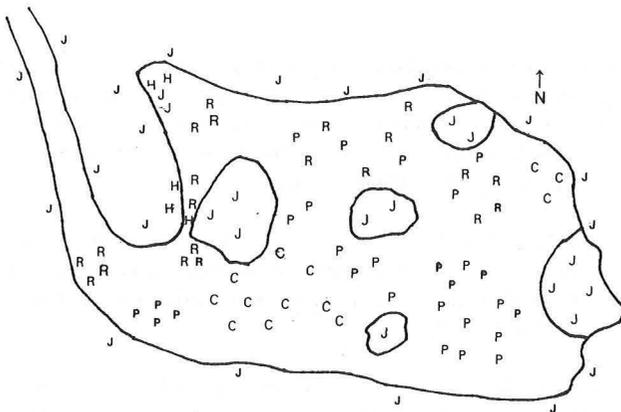


Figure 7. Map of David's Pool showing the main beds of vegetation. Pool dimensions: 5.3m long by 3.4m wide.

Key. J=*Juncus effusus*, C=*Callitriche stagnalis*, R=*Ranunculus omiophyllus*, H=*Hydrocotyle vulgaris*, P=*Potamogeton polygonifolius*.

TEMPORARY POOLS: METHODS

The methods used were identical to those described in the section on the permanent ponds.

TEMPORARY POOLS: RESULTS

Physical and chemical characteristics

The two pools in the North Quarry (OS grid reference SS13833 45597) were shallow and covered with aquatic plants (Figures 5 and 6). The maximum depth in Pool 1 (the pool nearest to the quarry entrance on the south side) was 0.73m and the maximum depth in Pool 2 (adjacent to the steep granite wall on the south side and completely surrounded by large rocks) was 0.95m. Water temperatures of 13°C in both pools related to the ambient air temperatures (14°C) and the oxygen content in both was 4.2 mg/l. Both pools were acidic with a pH of 5.0.

David's Pool, which was situated adjacent to the Pondsburry raised dam on the western side, was also covered in plants (Figure 7). It had a maximum depth of 0.6m. Water temperatures were similar throughout its depth, 11.5°C which was slightly above the ambient air temperature, 10°C. The oxygen content was fairly high, 8.6mg/l, and as expected it had the same pH as Pondsburry, 5.0.

Flora

Table 5 shows the relative abundance and percentage cover scores for the flora of the three temporary pools. Eleven macrophyte species were recorded, with submerged aquatic species being of more importance than emergents. The greatest diversity was recorded for North Quarry 1 where seven species were recorded and the lowest diversity was in the nearby North Quarry 2 pool.

Callitriche stagnalis occurred in all three water bodies. This species, as well as being found in lakes, is a common coloniser of ditches, puddles and depressions which are prone to drying out, since it can live as a terrestrial species. *Juncus effusus* was also recorded at all three pools.

The vegetation of North Quarry 2 was dominated by *Callitriche stagnalis*, which virtually covered the whole surface. Some *Sphagnum cuspidatum* was present with *Juncus effusus* at the margins together with grass tussocks. This pool was in a very sheltered location. *Sphagnum cuspidatum* was also present in North Quarry 1 as

Table 5. Relative abundance and percentage cover scores for the flora of the temporary Lundy pools.

SPECIES	DAVID'S POOL		NORTH QUARRY 1		NORTH QUARRY 2	
	Rel.Ab Score	% Cover (Score)	Rel.Ab. Score	% Cover (Score)	Rel.Ab. Score	% Cover (Score)
<i>Sphagnum cuspidatum</i> Ehrh. Bog moss			4	5	2	2
<i>Hypericum elodes</i> L. Marsh St. John's wort	1	1				
<i>Hydrocotyle vulgaris</i> L. Marsh pennywort	1	2				
<i>Caldesia parnassifolia</i> Parnassus Water plantain			3	2		
<i>Ranunculus omiophyllus</i> Ten. Lenormand's water-crowfoot	4	5				
<i>Ranunculus flammula</i> L. Lesser spearwort			3	4		
<i>Callitriche stagnalis</i> Scop. Mud water starwort	3	4	5	5	5	5
<i>Potamogeton polygonifolius</i> (Pourret) Bog pondweed	5	5				
<i>Juncus effusus</i> L. Soft rush	2	2	3	3	2	2
<i>Myosotis scorpioides</i> L. Creeping water forget-me-not			1	2		
<i>Lemna minor</i> L. Duckweed			1	1		

were *Juncus effusus* and *Callitriche stagnalis*, but as this pool was larger and shallower it provided niches for some additional plant species, *Myosotis scorpioides*, the water forget-me-not, *Caldesia parnassifolia*, the water plantain, *Lemna minor*, duckweed, and *Ranunculus flammula*, the lesser spearwort.

The diversity and floral composition in David's Pool reflected its close proximity to Pondsburry. The submerged macrophytes, *Potamogeton polygonifolius*, bog pondweed, and *Ranunculus omiophyllus*, water crowfoot, were the dominant species. The latter, although not recorded in Pondsburry during this survey, was recorded in 1979 and 1993.

Macroinvertebrates

The species composition and numbers of individuals are shown in Table 6.

The greatest number of species, thirteen, was found in David's Pool, which had several of the species found in Pondsburry e.g. cladocerans, *Chaoborus crystallinus*, and the Chironominae larvae. *Asellus meridianus* occurred in all three pools. Aquatic beetles (Coleoptera) favoured the pools in the North Quarry, which also had a caddis larva (Trichoptera), *Plectrocnemia conspersa* which was not found in any of the permanent ponds. This larva is common in acid streams and occurred in the Punchbowl stream in 1986 (George & Sheridan, 1986) and in 1993 (Long, 1993). Long (1993) found it in all of the six island streams he studied, four on the west side of the island and two on the east side. This net-spinning caddis also occurs in upland pools and lakes (Edington & Hildrew, 1995), where it catches mainly terrestrial prey and emerging chironomids in its surface net.

TEMPORARY POOLS: DISCUSSION

These small acid pools that were present in October 2003 are affected by weather conditions, particularly rainfall, and at first sight it is surprising that they still contained water after the long dry summer and autumn (*c.f.* the smaller pond at Quarterwall that had dried up). However, all three pools are sheltered and receive drainage water.

The dense weed cover in all the pools provided good shelter for macroinvertebrates, particularly *Asellus meridianus*, a detritus feeding animal, and aquatic beetles that can fly to other waters if conditions deteriorate. All of the macroinvertebrates, with two exceptions, have been found in the permanent ponds in previous investigations or in the present survey. *Plectrocnemia conspersa* larva has already been discussed and the other exception is a dipteran ptychopterid larva which occurred in David's Pool. This larva is characteristic of shallow pools where it uses its long posterior

Table 6. Species and numbers of individual macroinvertebrates in the plant beds of the temporary pools. Numbers of individuals relate to the five minute net sweep.

FAUNA		NORTH QUARRY 1	NORTH QUARRY 2	DAVID'S POOL
Annelida				
Oligochaeta:	<i>Lumbriculus variegatus</i> (Muller)	4	5	2
	Family Naididae	~	~	1
Crustacea				
Cladocera:	<i>Daphnia obtusa</i> Kurz	~	~	2
	<i>Bosmina longirostris</i> (Muller)	~	~	25
Copepoda:	<i>Cyclops</i> sp (female with egg sacs)	~	~	5
Isopoda:	<i>Asellus meridianus</i> Racovitza	12	9	9
Insecta				
Odonata:	<i>Ischnura elegans</i> (van de Linden) l.	~	~	1
Trichoptera:	<i>Plectrocnemia conspersa</i> (Curtis) l.	3	15	~
Coleoptera:	<i>Hygrotus inaequalis</i> (Fab.) a.	~	5	1
	<i>Agabus bipustulatus</i> (L.) a	1	2	~
	<i>Hydroporus pubescens</i> (Gyllenhal) a.	2	5	~
	<i>Platambus maculatus</i> (L.) a.	~	1	~
	SF Dytiscinae l.	~	~	2
Diptera:	Chironomid l.	~	~	3
	Chironomid p.	~	2	~
	Ptychopterid l.	~	~	1
	<i>Chaoborus crystallinus</i> (Deg.)	~	~	3
	Culicid l.	~	~	1
Total no. of species		5	8	13
Total no. of individuals		22	44	56

Key. l=larva; a=adult; p=pupa; ~ =not found.

siphon to obtain air from the surface. It may be *Ptychoptera albimana* (phantom crane-fly), the adult of which was found in July 1972 by Lane (1977).

CONCLUSIONS

The flora and macroinvertebrate fauna of the Lundy freshwater habitats are typical of acidic waters on the mainland. This investigation supports the findings from previous years in that the floral and faunal composition is restricted compared to that on the mainland and that there are no endemic species present. The research shows that over the last twenty-four years there has been remarkable stability in the populations, in spite of the dredging in two of the ponds and the droughts that have occurred.

The ponds still display interesting differences in their flora and fauna and these can be related mainly to the position of each pond on the island, and hence the consequent exposure to the elements, and the input of nutrients.

The autumn survey has shown differences in species composition to the previous summer surveys, with the overall numbers of organisms much lower and a very reduced amount of aquatic vegetation. The apparent disappearance of the long-standing water spider, *Argyroneta aquatica*, which was recorded firstly by Galliford (1953) and found in the 1979, 1986 and 1993 surveys may be illusory, as it may have been sheltering well down in the *Sphagnum* moss, to avoid the strong easterlies that blew continuously across the island throughout the week of the survey.

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REFERENCES

- Alexander, K.N.A., 1991. The Hemiptera of Lundy. *Annual Report of the Lundy Field Society* 42, 101-105.
- Brendell, M., 1975. Coleoptera of Lundy. *Annual Report of the Lundy Field Society* 26, 29-53.

- Bursche, E. M., 1971. *A Handbook of Water Plants*. London: Warne & Co. Ltd.
- Clabburn, P.A.T., 1993a. Freshwater biological surveys of Lundy, 1993: further studies of the fauna of Pondsburry. *Annual Report of the Lundy Field Society* 44, 73-83.
- Clabburn, P.A.T., 1993b. *Pondsburry, Lundy Island: the study of an acid pool*. Unpublished MSc thesis, University of Wales, College of Cardiff.
- Clapham, A.R., Tutin, T.G. & Warburg, E.F., 1968. *Excursion Flora of the British Isles*. Cambridge: Cambridge University Press.
- Edington, J.M. & Hildrew, A., 1995. *A Revised Key to the Caseless Caddis Larvae of the British Isles*. Freshwater Biological Association Scientific Publication, no.53. Cumbria: Freshwater Biological Association.
- Fraser Bastow, R., 1949. Freshwater diatom flora. *Annual Report of the Lundy Field Society* 3, 32-41.
- Galliford, A.L., 1953. Notes on the freshwater organisms of Lundy with especial reference to the Crustacea and Rotifera. *Annual Report of the Lundy Field Society* 7, 29-35.
- George, J.J., 1997. The freshwater habitats of Lundy. In R.A. Irving, A.J. Schofield & C.J. Webster (eds), *Island Studies. Fifty Years of the Lundy Field Society*, 149-164. The Lundy Field Society.
- George, J.J., McHardy (Stone), B.M. & Hedger, J.N., 2003. A comparative investigation of the plankton of the four permanent Lundy lentic freshwaters. *Annual Report of the Lundy Field Society* 53, 99-109.
- George, J.J. & Sheridan, S.P., 1986. Further investigations of the flora and fauna of the freshwater habitats. *Annual Report of the Lundy Field Society* 37, 35-46.
- George, J.J. & Stone, B.M., 1979. The flora and fauna of Pondsburry. *Annual Report of the Lundy Field Society* 30, 20-31.
- George, J.J. & Stone, B.M., 1980. A comparative investigation of the freshwater flora and fauna of the Lundy ponds. *Annual Report of the Lundy Field Society* 31, 19-34.
- Gibson, A., 1993. Wardens's report 1993. *Annual Report of the Lundy Field Society* 44, 7-9.

- Haslam, S., Sinkler, C. & Wolseley, P., 1975. British Water Plants. *Field Studies* 4, 243-351.
- Lane, R.P., 1977. The Diptera (two-winged flies) of Lundy Island. *Annual Report of the Lundy Field Society* 28, 15-31.
- Langham, A.F., 1968. Water courses and reservoirs on Lundy. *Annual Report of the Lundy Field Society* 19, 36-39.
- Long, P.S., 1993. A study into the macroinvertebrate fauna and water quality of Lundy Island's lotic environment. *Annual Report of the Lundy Field Society* 44, 59-72.
- Morgan, H.G., 1947. Aquatic habitats. *Annual Report of the Lundy Field Society* 1, 12-13.
- Parkes, E., 1995. Warden's report for 1995. *Annual Report of the Lundy Field Society* 46, 6-7.
- Parsons, T., 2002. Invertebrates (excluding Lepidoptera) on Lundy 2002. *Annual Report of the Lundy Field Society* 52, 110.
- Williams, W.D., 1962. The geographical distribution of the isopods, *Asellus aquaticus* (L.) and *Asellus meridianus* Rac. *Proceedings of the Zoological Society of London* 139, 75-96.