A COMPARATIVE INVESTIGATION OF THE FRESHWATER FLORA AND FAUNA OF THE LUNDY PONDS

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INTRODUCTION

Until recently there has been little detailed research carried out on the flora and fauna of the Lundy freshwater habitats, although they have been well documented by Langham (1968). A preliminary survey of Pondsbury and the Quarterwall ponds in 1978 indicated that the ponds supported different invertbrate populations (George, 1978).

In August 1979 the authors, aided by grants from the World Wildlife Fund and the Lundy Field Society, carried out an investigation of the main Lundy ponds. All of the ponds are subject to 'drying-up' during droughts, and at the time of the survey five fairly large ponds were in existence together with one or two smaller, very shallow, bodies of water. The ponds investigated were: Pondsbury (1345, 4545) the two Quarterwall ponds (1361, 4493 and 1361, 4495), Rocket Pole pond (1348, 4366) and Quarry Pool (1375, 4503). In addition a very shallow pool in Western Sidings to the north of the Old Light was also briefly studied (1310, 4455). The results of the Pondsbury survey have already been written up (George and Stone, 1979 LFS report), and consequently this paper is concerned mainly with the other ponds.

The *aims* of the survey were as follows:

i To determine the plant species growing in and at the edges of the ponds, and to investigate their distribution and abundance.

ii to examine the plankton community and to assess species and numbers of macro-invertebrates living in the vegetation and open water and in the bottom mud of each pond.

iii To determine whether there are any differences in the floral and faunal communities of the Lundy ponds and to suggest possible reasons for any differences found.

DESCRIPTION OF PONDS

Quarterwall Pond 1 (Plate 1)

This is the larger of the two Quarterwall ponds and has been formed from an excavation in the rock. It is an open body of water with fairly steep rocky banks and only a few weed beds. It is situated at a fairly high level on the island and probably receives little surface drainage; there is no outlet.

Quarterwall Pond 2 (Plate 2)

This is a shallower pond with a dense weed cover and no open water. Although there are a few large rocks the edges are mainly marshy and the pond has no through drainage.

water (Winkler chemical method); turbidity (Secchi disc). Depth profiles of the ponds were also plotted. A snorkel diver was used to measure depths and to take water and bottom samples in the deeper Quarry pool.

Rocket Pole Pond (Plate 3)

This fairly deep pond with strong granite sides has been formed from an excavation in the rock. It is an open body of water with no through drainage.

Quarry Pool (Plate 4)

This is a true quarry pool, a deep body of water overshadowed by steep rocky walls and some trees. An outflow is present on the eastern side of the pool.

Pool north of Old Light (Plate 5)

This small, very shallow pool forms part of the stream system flowing down Western Sidings. In August 1979 there was a small through flow of water, and a fairly dense cover of vegetation had been established.

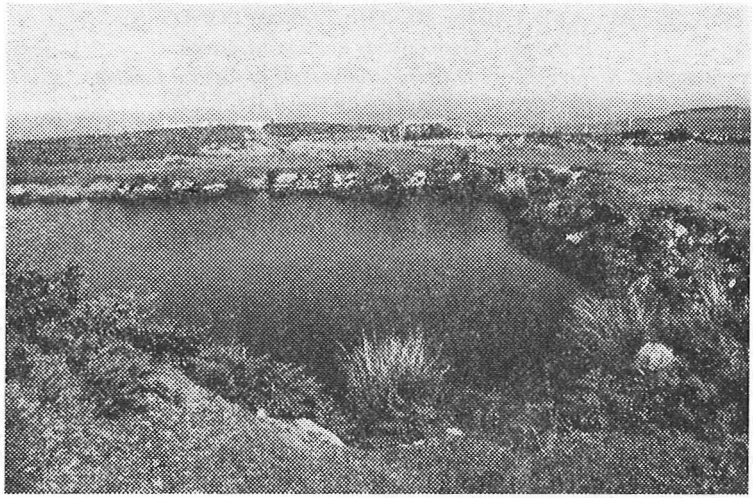

PLATE 1. Quarterwall pond 1. View of the larger pond looking east toward the Quarterwall cottages.

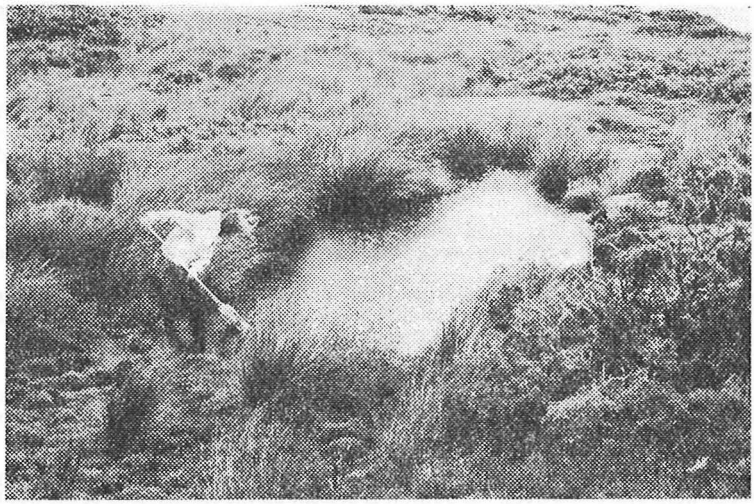

PLATE 2. Quarterwall pond 2, with one of the authors (J. J. G.) sampling the weeds for invertebrates.

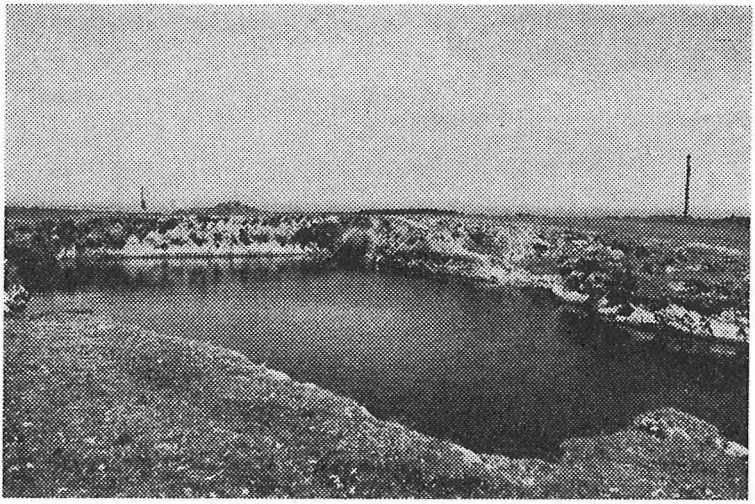

PLATE 3. Rocket Pole Pond, with its steep granite sides.

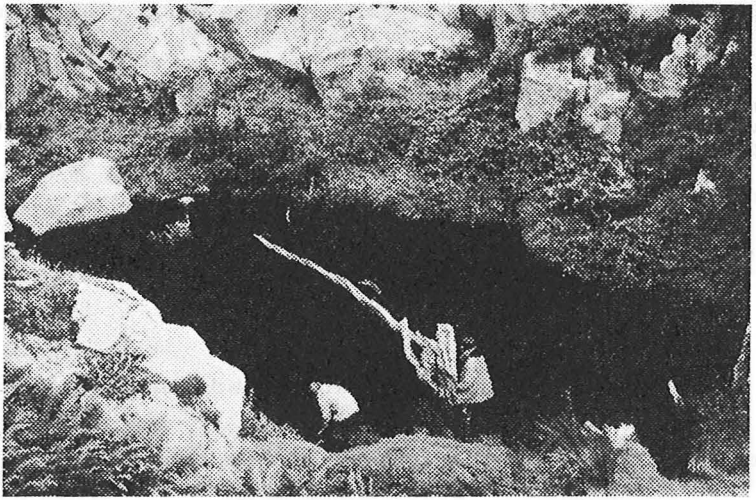

PLATE 4. Quarry pool, with the authors beginning their survey.

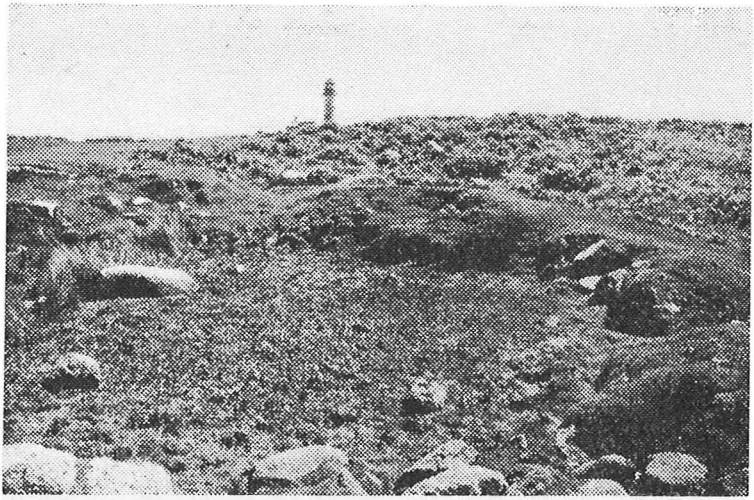

PLATE 5. 'Old Light' pond. Shallow weedy pool in stream system north of 'Old Light' in Western sidings.

PARAMETERS AND METHODS

1. Physical and Chemical

The following parameters were measured: air, surface and bottom water temperatures; pH (BDH pH papers); oxygen content of surface and bottom water (Winkler chemical method); turbidity (Secchi disc.) Depth profiles of the ponds were also plotted. A snorkel diver was used to measure depths and to take water and bottom samples in the deeper Quarry pool.

2. 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 (Figs. 1-5).

A subjective estimation of relative abundance of each species (in terms of biomass) was made on a scale of 1-5 as follows:

Score	*Relative abundance* (Biomass)
1	Rare (One or a few plants only)
2	Infrequent
3	Frequent
4	Common
5	Very abundant (numerous plants dominating and of ten in large clumps or colonies).

Similarly, a subjective estimation of percentage cover was also made for each species using a scale of 1-5 as follows:

Score	*Percentage cover*
1	Less than 1%
2	1-5%
3	6-10%
4	11-50%
5	51-100%

Relative abundance and percentage cover results for species at each pond are given in Table 3.

'Total scores' for relative abundance and percentage cover were also calculated for each species at all five ponds (Table 3).

3. Plankton

Plankton was collected with a phytoplankton net (aperture 0.075 mm) and two hauls were taken across each of the ponds. Estimation of relative abundance of organisms was made on a scale of 1-5:

Score	
1	One or two organisms only
2	3-25 organisms
3	26-100 organisms
4	101-500 organisms
5	over 500 organisms

4. Fauna

Invertebrate animals were collected from the plant beds, open water and from the bottom mud and gravel. A standard FBA net (aperture 0.96 mm) was used for a 5 minute period in the plants and open water, and bottom samples were taken with a net and quadrat over a $\frac{1}{3}m^2$ area to a depth of 2 cm in the mud.

Fish, if present, were noted, but due to lack of suitable collecting equipment, no attempt was made to assess population numbers in this survey.

RESULTS

1. Physical and Chemical

Table 1 shows the physical and chemical characteristics of the ponds.

Table 1

Parameter	Quarter-Wall 1	Quarter-wall 2	Rocket Pole	Quarry	Old Light
Maximum depth. m.	0.4	0.2	1.9	1.64	0.13
Air temperature. °C	20.5	20.5	14.0	19.0	18.0
Water temp.—surface °C	18.5	20.0	15.0	17.0	17.0
Water temp. — bottom °C	17.0	18.0	15.0	15.0	**
Light penetration. m.	0.12	*	0.29	0.42	**
pH	5.0	5.0	5.0	5.0	5.0
Oxygen — surface. mg/1	10.4	10.1	8.0	7.5	6.4
% age saturation	114	113	82	101	68
Oxygen — bottom. mg/1	9.2	1.5	7.6	4.8	**
% age saturation	98	16	78	49	

* No open water present

**Pond too shallow for readings to be taken

All five ponds are acidic with water temperatures similar throughout the body of water. There is no apparent thermocline in any of the ponds and their water temperatures are closely related to ambient air temperature. Light penetrates furthest in the deep Quarry Pool and the shallower Quarterwall Pond 1 (approximately into top 25% of water column), whereas light penetration is comparatively poor in the deepest pond, Rocket Pole, (approx. 16%).

The surface waters of the four larger ponds are well oxygenated (82-114% saturation), and the Quarterwall 1 and Rocket Pole ponds retain fairly high levels of oxygen in the water immediately above the bottom mud. However, in two ponds, Quarry Pool and the Quarterwall 2 pond, the oxygen drops markedly as the bottom is approached (49% and 16% saturation respectively).

Table 2 Combined Taxonomic List for the Flora of Five Lundy Ponds

SPECIES	POND				
	Quarterwall 1	Quarterwall 2	Quarry	Rocket Pole	Old Light
(1) **Water**					
Fontinalis sp.	0	0	1 (S)	0	0
Juncus effusus L. Soft Rush	1 (E, Fl)	1 (E)	1 (E)	1 (E)	1 (E)
Eleocharis palustris L. Roemer and Schultes Common Spike Rush	1 (E)	0	1 (E)	1 (E)	0
Potamogeton polygonifolius (Pourret) Bog Pondweed	0	1 (S, E, F)	1 (S, F)	0	1 (E, F)
Hydrocotyle vulgaris L. Marsh Pennywort	1 (F, S)	1 (E, F)	0	1 (F, S)	1 (E, F)
Callitriche sp. Starwort	0	0	1 (S, F)	0	0
Peplis (*Lythrum*) *portula* L. Water purslane	1 (F, S)	1 (S, E, F)	0	0	1 (E, F)
Myosotis scorpioides L. Water forget-me-not	1 (E)	1(S, E, F, Fl)	0	0	1 (E)
Anagallis tenella (L). Bog pimpernel	0	1 (E, Fl)	0	0	0
Ranunculus flammula L. Lesser Spearwort	0	1 (E, Fl)	1 (F, E, Fl)	0	1 (E, Fl)
Ranunculus omniophyllus Ten. Lenormand's water crowfoot	0	0	0	0	1 (E)
Total number of Species	5	7	6	3	7
	Quarterwall 1	Quarterwall 2	Quarry	Rocket Pole	Old Light
(2) **Bank**					
Juncus effusus	1	1	1	1	1
Myosotis scorpioides	1	1	0	0	0
Erica cinerea L. Bell Heather	1	0	0	1	0
Ranunculus flammula	0	1	1	0	0
Hydrocotyle vulgaris	0	1	0	1	1
Peplis(*Lythrum*) *portula*	0	1	0	0	1
Rumex sp.	0	0	0	1	0
Fern sp.	0	1	1	1	0
Ulex sp. Gorse	0	0	0	1	0
Calluna vulgaris (L.) Heather	0	0	0	1	0
Ononis natrix L. Large Yellow Rest-Harrow	0	0	1	0	0
Thistle	0	0	1	0	0

1 = Present, S = Submerged, F = Floating, O = Absent, E = Emergent, Fl = Flowering

2. Flora

Table 2 shows the presence and absence of both water and bank species at all five ponds. The distribution and location of the main plant species in each pond are given in Figures 1-5. and the relative abundance and percentage cover scores of plants are listed in Table 3.

TABLE 3

RELATIVE ABUNDANCE AND PERCENTAGE COVER SCORES OF SPECIES AT FIVE LUNDY PONDS

Species	POND										Rel. Ab. Total Score	% Cover Total Score
	Quarterwall 1		Quarterwall 2		Quarry		Rocket Pole		Old Light			
	Rel. Ab.	% Cov.	Rel. Ab.	% Cov.	Rel. Ab.	% Cov.	Rel. Ab.	% Cov.	Rel. Ab.	% Cov.		
Fontinalis sp.	0	0	0	0	2	1	0	0	0	0	2	1
Juncus effusus	2	1	4	2	2	1	2	1	2	2	12	7
Eleocharis palustris	5	1	0	0	2	2	4	1	0	0	11	4
Potamogeton polygonifolius	0	0	5	5	5	4	0	0	5	4	15	13
Hydrocotyle vulgaris	5	2	1	1	0	0	5	2	4	4	15	9
Callitriche sp.	0	0	0	0	1	1	0	0	0	0	1	1
Peplis (*Lythrum*) *portula*	4	2	4	4	1	1	0	0	3	2	12	9
Myosotis scorpiodes	1	1	3	4	0	0	0	0	1	1	5	6
Anagallis tenella	0	0	1	1	0	0	0	0	0	0	1	1
Ranunculus flammula	0	0	1	1	3	2	0	0	4	4	8	7
Ranunculus omniophyllus	0	0	0	0	0	0	0	0	4	2	4	2
% Cover Total 'Score'		7		18		12		4		19		

3. Plankton

Species present, together with their relative abundance are listed in Table 4.

TABLE 4

ORGANISMS PRESENT IN THE PLANKTON OF THE PONDS
(Old Light Pond too shallow for samples to be taken)

	SPECIES	ABUNDANCE 1-5			
		Quarter-Wall 1	Quarter-Wall 2	Quarry	Rocket Pole
Algae:	Filamentous green	3	—	4	2
	Closterium sp.	4	2	—	—
	Microcystis sp.	—	—	—	5
	Arthrospira sp.	—	—	—	5
Rotifers:	*Brachionus calyciflorus* Pallas	—	—	—	3
	Brachionus rubens (Ehrb.)	3	—	3	4
	Keratella valga (Ehrb.)	—	—	2	—
	Keratella quadrata (Muller)	—	—	—	3
	Filinia longiseta (Ehrb.)	2	—	2	—
Cladocera:	*Daphnia obtusa* Kurz	4	2	—	—
	(*Daphnia* ephippium)	—	3	—	—
	Simocephalus vetulus (Müller)	—	3	—	—
	Bosmina longirostris (Müller)	—	—	—	1
	Chydorus sphaericus (Müller)	—	2	—	—
Copepoda:	*Cyclops* sp.	4	2	3	—
	Immature cyclopids	5	3	5	2
	Cyclopid nauplii	3	2	4	—
	Harpacticoids	—	2	1	—
Ostracoda–	Cypridid	—	1	—	—
Ephemeroptera–	*Cloeon dipterum l.*	1	—	—	—
Diptera	Chironomid l.	—	1	2	—
TOTAL NO. OF SPECIES		7	8	7	8

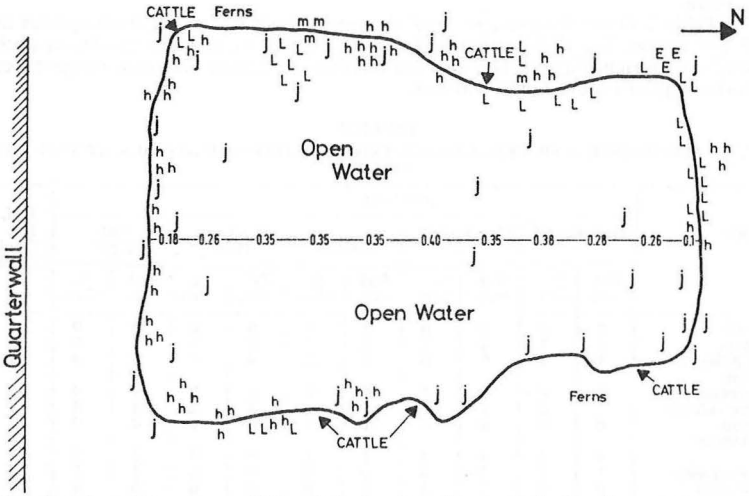

Fig. 1. Map of Quarterwall Pond 1 showing the main beds of vegetation and depth profile in metres. (Key: j = *Juncus effusus*, h = *Hydrocotyle vulgaris*, L = *Peplis* (*Lythrum*) *portula*, m = *Myosotis scorpioides*, E = *Erica cinerea*) Scale 0.1 m = 1 metre.

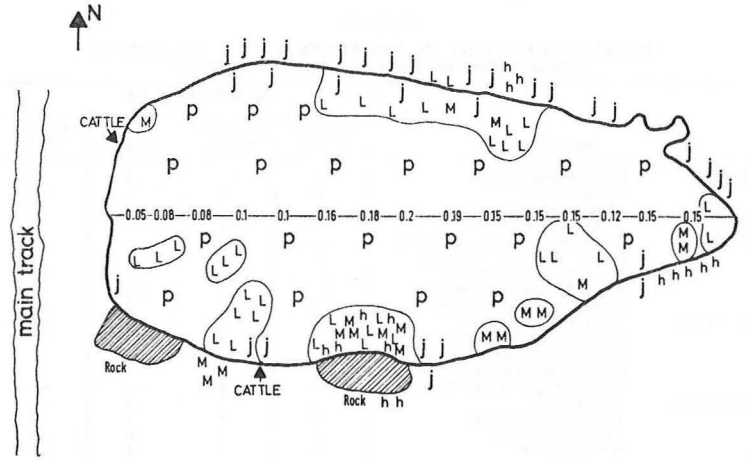

Fig. 2. Map of Quarterwall Pond 2 showing the main beds of vegetation and depth profile in metres. (Key: j = *Juncus effusus*, h = *Hydrocotyle vulgaris*, L = *Peplis portula*, M = *Myosotis scorpioides*, P = *Potamogeton polygonifolius*) Scale 0.2 m = 1 metre.

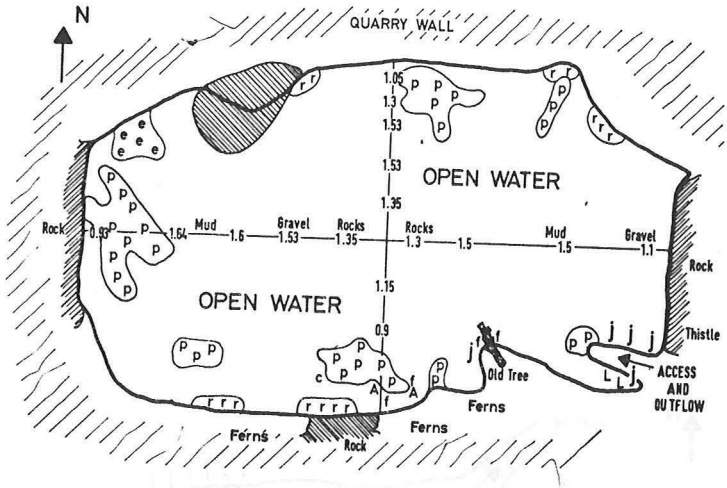

Fig. 3. Map of Quarry Pool showing the vegetation beds and depth profile in metres. (Key: j = *Juncus effusus*, L = *Peplis portula*, P = *Potamogeton polygonifolius*, r = *Ranunculus flammula*, e = *Eleocharis palustris*, c = *Callitriche sp*, f = *Fontinalis sp.*, A = *filamentous algae*). Scale 0.1 m = 1 metre.

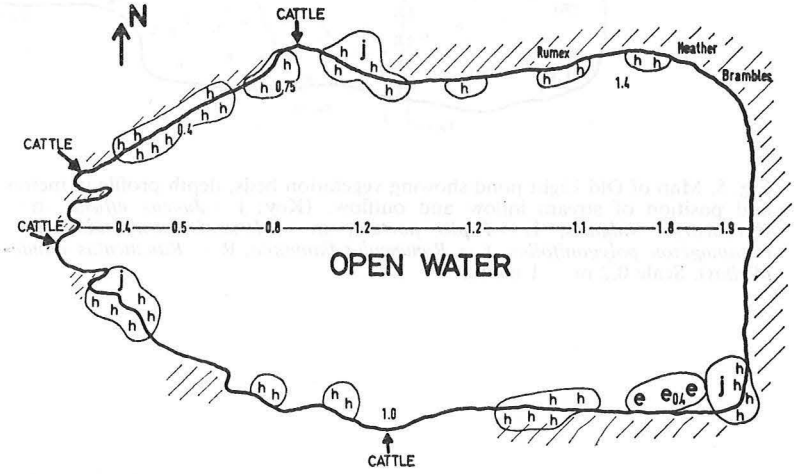

Fig. 4. Map of Rocket Pole pond showing the vegetation beds and depth profile in metres. (Key: j = *Juncus effusus*, h = *Hydrocotyle vulgaris*, e = *Eleocharis palustris*). Scale 0.1 m = 1 metre.

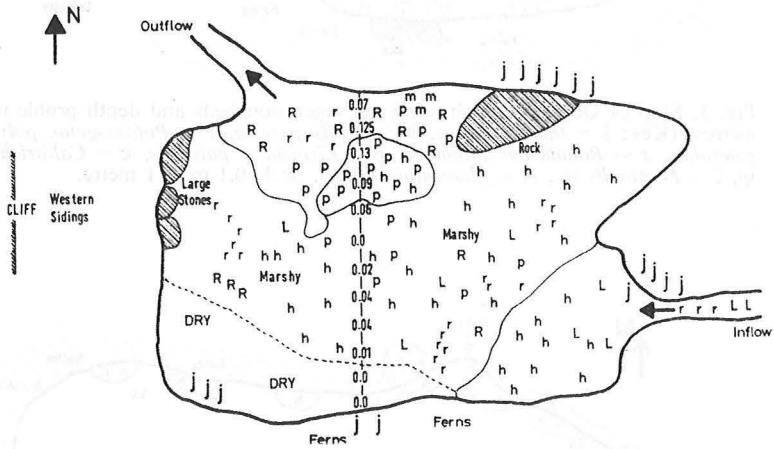

Fig. 5. Map of Old Light pond showing vegetation beds, depth profile in metres and position of stream inflow and outflow. (Key: j = *Juncus effusus*, h = *Hydrocotyle vulgaris*, L = *Peplis portula*, m = *Myosotis scorpioides*, P = *Potamogeton polygonifolius*, r = *Ranunculus flammula*, R = *Ranunculus omniophyllus*). Scale 0.2 m = 1 metre.

4. Fauna

The species and numbers of the macroinvertebrate fauna of the plant beds and open water are given in Table 5, and species and numbers of invertebrates in the bottom mud of each pond are listed in Table 6.

TABLE 5
THE SPECIES AND NUMBERS OF MACRO-INVERTEBRATES IN THE PLANT BEDS AND OPEN WATER OF THE FIVE PONDS (5 mins. sampling time)

SPECIES (*on surface) (l. = larva)	Quarter-Wall 1	Quarter-Wall 2	Quarry	Rocket Pole	Old Light
NEMATODA	—	1	—	—	3
ANNELIDA:					
Lumbriculus variegatus (Müller)	8	18	—	2	9
CRUSTACEA:					
Daphnia obtusa	—	18	—	—	—
Harpacticoid copepods	—	2	—	—	—
Asellus meridianus Racovitza	18	935	10	—	1
UNIRAMIA-CHELICERATA:					
Hygrobatid mite	—	3	—	—	—
UNIRAMIA-INSECTA:					
Ephemeroptera–					
Cloeon dipterum (L.) l.	—	—	—	3	—
Odonata–					
Sympetrum striolatum (Charpentier) l.	—	—	1	—	—
Ischnura elegans (Van der Linden) l.	—	1	4	3	—
Hemiptera–					
Gerris gibbifer Schum. adults*	8	—	15	—	—
Gerris gibbifer Schum. juveniles*	2	—	4	—	—
Notonecta obliqua Thunb. adults	6	—	—	—	—
Notonecta obliqua Thunb. juveniles	20	—	—	—	—
Corixa panzeri (Fieb.)	96	—	—	—	—
Sigara nigrolineata (Fieb.)	—	—	—	3	—
Callicorixa praeusta (Fieb.)	14	—	—	—	—
Immature Corixids	8	3	1	—	—
Coleoptera–					
Gyrinus substriatus Stephens*	—	—	6	—	—
Haliplus lineatocollis (Marsham)	—	—	—	—	1
Hydroporus pubescens (Gyllenhal)	—	1	—	—	—
Ilybius quadriguttatus L.	—	1	2	—	—
Dytiscid larva	—	1	—	—	—
Helophorus grandis Illiger	—	36	—	—	—
Trichoptera–					
Limnephilus vittatus (Fab.) l.	13	4	—	—	1
Diptera–					
Chironomid larva and pupa	—	1 l.	3l. + 1p.	35l. + 3p.	—
Limnophora pupa	—	1	—	—	—
TOTAL NOS. OF SPECIES	7	14	8	5	5
TOTAL NOS. OF ORGANISMS	193	1026	47	49	15

Table 6
The Species and numbers of Invertebrates in or on the Bottom Mud of the Five Ponds
(Nos/m²)

Species	Quarter-Wall 1	Quarter-Wall 2	Quarry	Rocket Pole	Old Light
ANNELIDA:					
Lumbriculus variegatus (Müller)	153	—	45	36	36
Nais elinguis (Müller)	54	—	—	—	—
CRUSTACEA:					
Harpacticoid copepods	—	90	—	—	—
(*Daphnia* eggcase-ephippium)	(9)	—	—	—	—
UNIRAMIA: INSECTA					
Limnephilus vittatus (Fab.)1.	63	135	—	—	—
Chironomid 1.	27	—	18	—	—
Total no. of species	4	2	2	1	1
Total no. of organisms/m²	297	225	62	36	36

DISCUSSION

The Lundy ponds are acidic bodies of water similar to those found on the mainland. However there are differences between the five ponds and these relate to parameters such as depth, degree of exposure and presence of vegetation.

All of the ponds were fairly turbid with relatively poor light penetration. The very low level of light penetration in the deepest pond, Rocket Pole, was probably due to the large bloom of blue-green algae which dominated the pond at the time of the survey.

The oxygen content of the water overlying the bottom varied considerably in the ponds and can be related to their degree of exposure. The Rocket Pole and Quarterwall 1 ponds are situated fairly high on the island and are exposed to the elements. The water in these ponds remains reasonably well mixed from top to bottom. On the other hand, Quarry Pool is an extremely well sheltered body of water and little mixing of the water occurs here. The oxygen content of the deeper water layers gradually falls due to decomposition and there is little replenishment from the well-oxygenated surface water layers. The oxygen levels encountered in the shallow Quarterwall 2 pond, partly sheltered by *Juncus* beds, are probably due to the excessive plant growth in the pond. During the daytime the surface water is supersaturated with oxygen due to plant photosynthesis (113%). However in the bottom mud where there is much decaying vegetation the oxygen is being used up rapidly and this explains the low oxygen saturation values (16%) which were found in the water at the bottom of the pond.

Eleven different plant species were found growing in the ponds, with the most diverse flora occurring in the Quarterwall 2 and Old Light Ponds (7 species in each, Table 2). Rocket Pole pond contained the lowest number of plant species.

The Quarterwall 2 and Old Light ponds were covered with vegetation with no stretches of open water present (Figs. 2 and 5, Table 3 — % cover scores). The Quarry pool possessed some reasonably-sized plant beds (Fig. 3), but the least vegetation cover occurred in the Quarterwall 1 and Rocket Pole ponds which both had large stretches of open water (figs. 1 and 4).

The only plant common to all ponds was the emergent soft rush, *Juncus effusus*, (Table 2). It was not the dominant species at any one pond, although being fairly abundant at Quarterwall 2 where it fringed almost the whole pond, giving it considerable shelter (Fig. 2).

Taking all five ponds into consideration, *Potamogeton polygonifolius* and *Hydrocotyle vulgaris* were the two most important plant species, both having total relative abundance scores of 15. The higher % cover total score of *Potamogeton* reflects its greater adaptation to aquatic habitats.

The bog pondweed, *Potamogeton polygonifolius* was the dominant macrophyte at Quarterwall 2, Quarry and Old Light Ponds, but was absent from Quarterwall 1 and Rocket Pole pond. At Quarterwall 2 it was widespread across the pond (Fig. 2) covering 95% of the surface and it was the only plant to colonize the deepest part of the pond. This compares with the survey of George (1978) who found in July that the pond had a dense weed cover consisting mainly of *Potamogeton*. At the margins of the pond it was in direct competition with the water forget-me-not, *Myosotis* and the water purslane, *Peplis*.

At Quarry pool, *Potamogeton* never extended more than 4 metres out into the open water, confining itself to the shallower water where it could gain a 'foothold' in the mud; the substratum being more rocky in the centre of the pond (Fig. 3). At the most 'temporary' of the ponds, Old Light, *Potamogeton* covered about 20% of the water (Fig. 5) but had far greater competition with other species at this very shallow pond. The habit of *Potamogeton* at Quarterwall 2 and Quarry pool was floating and submerged whilst at the Old Light pond it was mainly floating and emergent due to the extreme shallow nature of the pond. Fruits were present on *Potamogeton* at all ponds being particularly abundant at Quarterwall 2.

Potamogeton polygonifolius is a perennial plant characteristic of upland oligotrophic acidic waters. There is evidence that it prefers more sheltered

conditions and this helps to explain its absence from the more exposed Quarterwall 1 and Rocket Pole ponds. Although nutrients were not measured it does appear from the plankton samples that the latter ponds are more eutrophic than the other three, again making them less favourable for growth of *Potamogeton*.

The marsh pennywort, *Hydrocotyle vulgaris* was a co-dominant species at Quarterwall 1, dominant at Rocket Pole, and a common species at the Old Light pond. However it was rare at Quarterwall 2 being restricted to a small sheltered region on the southern margin, and absent altogether in the Quarry pool. *Hydrocotyle* is a 'typical' bog plant widely distributed throughout Britain in marshes, bogs and shallow waters up to 0.8 m in depth; why it is absent from the Quarry pool is not clear but probably the depth and the rather restricted muddy regions may be important factors.

The water purslane, *Peplis portula*, was a common species at the two Quarterwall ponds occupying a similar niche to *Hydrocotyle*, and it was also fairly widely distributed in the Old Light pond. *Peplis* is a prostrate creeping annual occurring in shallow water being particularly characteristic of temporary ponds. Depth is probably the reason for its absence from the Rocket Pole pond and it is interesting also to note that in the almost equally deep Quarry pool it only occurred in the very shallow muddy area near the outflow (Fig. 3).

Eleocharis palustris, the common spike rush, was present in the three deeper ponds, but absent altogether from the shallower Quarterwall 2 and Old Light ponds. This perennial with its creeping rhizome system frequently forms monodominant stands and this was the case in all of the ponds in which it occurred.

Ranunculus flammula, the lesser spearwort, with its bright yellow flowers, was common in the Old Light pond particularly near the stream inflow and outflow points. In Quarry pool it was confined to the edges only, very rare in Quarterwall 2 and absent from the exposed Quarterwall 1 and the Rocket Pole ponds. The water forget-me-not, *Myosotis*, was absent from the two deeper ponds, Quarry and Rocket Pole, while in Quarterwall 2 it occupied the same niche as *Hydrocotyle* and *Peplis* with both the blue and the rarer white-flowered form occurring here.

In conclusion, the *flora* of the five Lundy ponds and Pondsbury (George & Stone 1979) was similar in composition being mainly characteristic of acid upland waters. No endemic species or varieties appear to be present. The differences in diversity and abundance outlined above were due primarily to physical differences in the ponds, notably depth, profile and degree of exposure. The two shallowest ponds with their gently sloping banks, Quarterwall 2 and the Old Light ponds, possessed the greatest number of species in common (6), with vegetation occurring right across the ponds. The plant beds in the deeper ponds tended to be marginal particularly in Quarterwall 1 and the Rocket Pole, the two most exposed ponds. The well-sheltered Quarry pool, although deep, allowed a greater penetration of plants into the open water.

The *plankton* samples of the ponds showed a similar number of species but there were striking differences in their composition (Table 4). The Rocket Pole pond was dominated by a 'bloom' of two species of blue-green algae, *Microcystis* and *Arthrospira*. Such blooms indicate eutrophic conditions and nutrient build-up in the water. It has been noted on several occasions that this pond is used by ducks and other birds, and their droppings obviously contributed nitrogen and phosphorus salts to the water. Large blooms of these algae often cause extensive deoxygenation of the water and they also produce toxic substances which are repellent to other organisms. Apart from the small water flea, *Bosmina* and a few immature cyclopid copepods, the only animals able to tolerate living with the 'blue-greens' were the rotifers, notably *Brachionus rubens*, a form frequently found in eutrophic waters.

The Quarterwall 1 pond also showed evidence of eutrophy with its fairly large numbers of filamentous green algae and the desmid, *Closterium*. Cattle and ponies (Fig. 1) frequently use this pond as a watering place and obviously contribute nutrients to the water. The Cladoceran *Daphnia obtusa*, was abundant in this pond and the rotifer *Brachionus rubens* was commonly attached to it — an epizotic relationship which was noted by Galliford in this pond in 1952/3.

Cyclopid copepods were present in all ponds, but were particularly abundant in the Quarterwall 1 pond and the Quarry pool, where nauplii larvae and immature forms dominated the plankton. Calanoid copepods which are common on the mainland do not appear to occur in any of the Lundy ponds (Pondsbury included), but winter sampling is required (on the mainland they are more common in the winter months) before it can be stated that they are definitely absent from the Lundy fauna.

Cladocera were reasonably abundant in the weedy Quarterwall 2 pond, *Simocephalus* and *Chydorus* in particular preferring to live amongst vegetation rather than in open water. Conversely, Lundy rotifers prefer open stretches of water as they were completely absent from the Quarterwall 2 pond. The rotifer *Keratella valga* described by Galliford (1953) as one of the commonest rotifers on Lundy was found only in small numbers in Quarry pool.

The Quarterwall 2 pond possessed the greatest diversity and greatest numbers of *macroinvertebrates* (Table 5). An important factor controlling composition and size of animal communities in ponds is the quality and quantity of their plant growth. The large numbers found in Quarterwall 2 were due mainly to one animal, the water slater, *Asellus meridianus. Asellus* is a detritus feeder and this pond with its plentiful decaying vegetation proved an ideal habitat for this animal. It breeds from February to the end of October (Steel, 1961) and all stages of the life cycle were present in August. The closely-related species *A. aquaticus*, a common asellid on the mainland does not occur on Lundy and this is in accord with Williams (1962) who found only *A. meridianus* on British offshore islands. Also associated with the plants in Quarterwall 2 were four species of beetle which were not found in the nearby Quarterwall 1 pond. The most abundant beetle, *Helophorus grandis*, does not swim and is usually found crawling amongst dense vegetation, which explains its absence from the other more open water ponds.

The other pond possessing good plant growth, the Old Light pond, carried only a few species and low number of organisms. This pond is the most 'temporary' of all of the ponds, being situated in a shallow depression in the cliff and is part of a small stream system. It obviously dries up very quickly and consequently its lack of organisms is not surprising.

The larger Rocket Pole pond also possessed few macroinvertebrate species, although it was the only pond to contain the mayfly larva, *Cloeon dipterum*. More animal species were found in the 1978 survey and it is likely that the dense bloom of blue-green algae, present at this time, was having deleterious effects on other organisms in the pond. *Cloeon dipterum* is a fairly tolerant species occurring commonly in small productive ponds on the mainland, as is the lesser water boatman, *Sigara nigrolineata*, which also was present in the pond.

Surface-dwelling animals were only seen on two of the ponds, Quarterwall 1 and Quarry pool. This is unlikely to be a true picture as during the August 1979 sampling period gale force winds were very prevalent, and it is likely that they were sheltering under banks or amongst rushes in the other ponds. The pond-skater, *Gerris gibbifer*, and the whirligig beetle, *Gyrinus substriatus*, were fairly abundant on the surface of the very sheltered Quarry pool, and again this demonstrates the importance of exposure as an environmental factor in pond ecology. The *Gerris* from Quarterwall 1 were all taken from a net sweep through a *Juncus* bed in the SE part of the pond.

The Quarterwall 1 pond was noted for its numbers and species of water boatmen (hemipterans). The greater water boatman, *Notonecta* prefers stretches of open water and the species found here, *N. obliqua* is commonly found in acid upland waters on the mainland. Eggs are laid in plant stems from February to May, and young usually take 2-3 months to reach maturity. Immature forms were plentiful in Quarterwall 1 during August (Table 5). *Notonecta* is an active predator feeding on any swimming animal, including large beetle larvae and small fish. The lesser water boatmen (corixids) also occur in this pond with *Corixa panzeri* being particularly abundent. It is widely distributed throughout Britain and seems to prefer waters with little organic matter and few weed beds (Southwood & Leston, 1959). It mainly feeds on algae but will occasionally take chironomid larvae which were fairly common in the bottom mud of this pond

(Table 6). The other species found in this pond, *Callicorixa praeustra*, is a well-known migratory species and is often the first species to arrive in a new or temporary habitat. One dragonfly, *Sympetrum striolatum*, and one damselfly, *Ischnura elegans* occurred in the Lundy ponds. Larvae of *Sympetrum* occurred in the Quarry Pool and Pondsbury, (George & Stone, 1979). The adult, a strong flier is reasonably abundant in Southern Britain, often being the last dragonfly to be seen in the year (end of October). The occurrence of *Ischnura elegans* in the three widely different ponds, Quarterwall 2, Quarry and Rocket Pole, is difficult to explain but it is reported to be the commonest damselfly in Britain occurring not only in weedy ponds, but also in brackish and partly polluted waters (Hammond, 1977).

The bottom mud of the ponds was not particularly rich in species, containing oligochaete worms, harpacticoid copepods, chironomid larvae and on the mud surface, larvae of the caddis fly, *Limnephilus vittatus*. The worm, *Lumbriculus variegatus* occurred in all ponds except Quarterwall 2. It is tolerant of low oxygen conditions, so it is likely to be the large amounts of decaying organic matter which makes this pond unsuitable for this species. On the other hand, harpacticoid copepods who like much organic matter were present only in this pond.

Notable absentees from the five ponds were the molluscs and the water spider, *Argyroneta*. Most molluscs occur in alkaline calcareous waters and few species, can tolerate such acid conditions as are found in the Lundy freshwaters. The water spider, *Argyroneta aquatica* is very abundant in Pondsbury (George & Stone, 1979) and is a long standing member of the Pondsbury fauna. It prefers large bodies of standing water with a considerable amount of floating and submerged vegetation, and this probably explains its absence from the weedy small Quarterwall 2 and Old Light ponds, and the larger Quarterwall 1, Quarry and Rocket Pole ponds which have very little vegetation.

Fish were observed in two of the ponds. *Carassius auratus* (L.) (Golden carp/goldfish) in Quarry pool and *Carassius carassius* (L.) (Crucian carp) in Quarry pool and Rocket Pole pond. 15 golden carp were observed in Quarry pool but the number of Crucian carp are unknown. (Baillie & Rogers transferred 30 Crucian carp from Quarry to Pondsbury after the drought in 1976). Both carp species tolerate low oxygen conditions and feed on zooplankton, insects and the occasional plant material. Neither Quarry and Rocket Pole are highly productive ponds and it is speculative as to whether they can support large fish populations, particularly Quarry which contained at least 15 good-sized golden carp (up to 30 cm in length). Macan (1966) has shown that fish have a pronounced influence on the other fauna of upland ponds, and it is likely that the relatively low number of species occurring in both ponds can be partly attributed to these fish. *C. auratus* breeds in June/July and two very small golden carp were caught (and returned) in the plankton of Quarry pool in August.

The flora and invertebrate fauna of the Lundy ponds is fairly typical of acidic waters on the mainland. There appear to be no endemic species or varieties present which indicates a fairly frequent renewal of organisms from the mainland. However, as is often the case in island ecology there are some notable absentees from the fauna e.g. *Asellus aquaticus*, calanoid copepods and the predatory *Asplanchna* rotifers. An interesting member of the Lundy fauna is the water spider, *Argyroneta* which supports an extremely large population in the *Sphagnum* moss and *Hypericum* beds of Pondsbury. There are differences in the flora and faunas of all of the ponds and these mainly can be related to factors such as position and exposure of the pond, depth, vegetation cover, amount of decaying matter and algal blooms.

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N.B. This paper completes the investigation carried out in the summer of 1979. However, I am still interested in the flora and fauna of the Lundy freshwaters and would welcome any details (however small) of work carried out on them in the future. It is my intention to look further at the streams, *Argyroneta* and the fish populations. J. J. G.