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Lepeophtheirus salmonis (Copepoda: Caligidae) on farmed salmon in Ireland

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Abstract

The investigation of specific characteristics of *Lepeophtheirus salmonis* populations on farmed salmon was made possible by the examination of the parasite infestation parameters of regular non destructive samples taken for up to six years in five bays. Perennial persistence of seasonal patterns of infestation as exhibited by intensity, prevalence and abundance was examined. Site specific characteristics were detected which appeared to be independent of inter-annual variations. Seasonal variations in individual lice size and fecundity, and temporal variation in population dynamics on the farmed fish in the five bays are considered in the context of the not inconsiderable changes in husbandry and lice control practices which have been introduced in the industry over the six year period.

Contents

Introduction

Monitoring of the levels of sea lice infestation on salmonid farms in Ireland commenced in 1991. When monitoring commenced in 1991 the main treatment employed in the control of sea lice was Nuvan 500 EC, a 50% solution of Dichlorvos. This is a bath treatment and the limitations to its efficacy and usefulness are described in Jackson and Costello (1991). The results of monitoring in 1991 and 1992 showed that lice burdens on two sea-winter fish were significantly higher than on one sea-winter fish (Jackson and Minchin, 1993). The lice on two sea-winter fish were considered to be a reservoir of infection for one sea-winter fish and smolts on multi-generation sites. On the basis of these results, a new initiative in salmon farm management was put in place by the Department of Marine. This involved the separation of generations, annual fallowing and the early harvest of two sea-winter fish to reduce vertical and lateral transmission of lice infestations. A parallel initiative to optimise treatment regimes was undertaken jointly by the industry and the regulatory authorities. These changes in husbandry practices had a profound impact on the pattern of lice infestations on farmed salmon in Ireland (Jackson et al. 1997). Despite the major changes which have occurred in lice management and control over this period, certain characteristics of *Lepeophtheirus salmonis* (Krøyer) populations on farmed salmonids have persisted. These are presented here by reference to records from five bays sampled as part of the national sea lice monitoring programme in Ireland.

Materials and methods

The sampling methodology, the regime of annual sampling of salmonid farms in Ireland and the protocol for the handling and analysis of samples is set out in Jackson et al. (1997). Generally two cages of fish were sampled for each population of

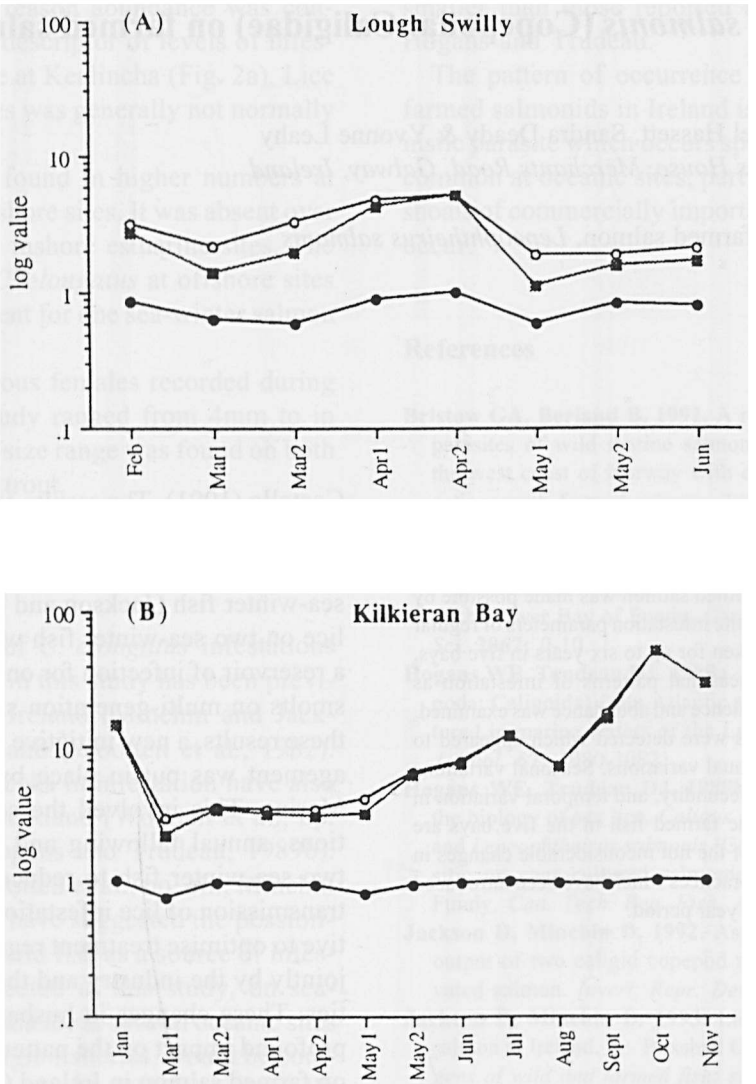
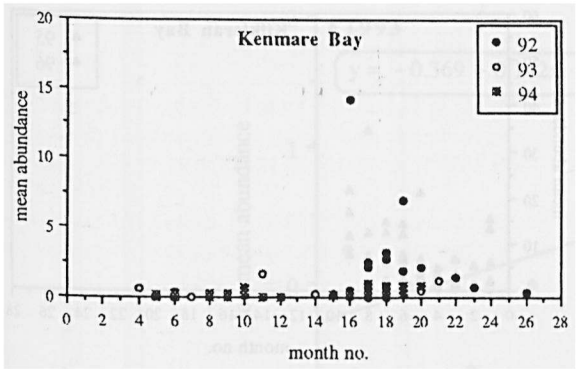


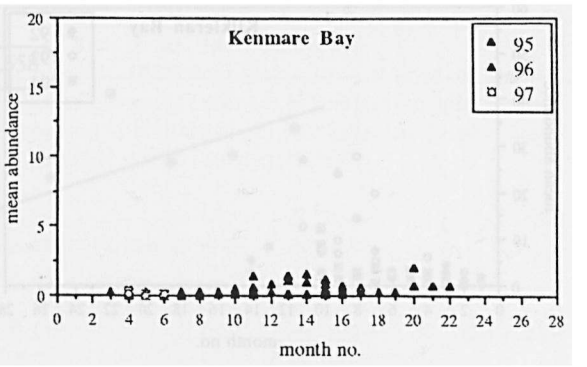
Fig. 1. Prevalence, mean intensity and mean abundance of *Lepeophtheirus salmonis* on 1 sea-winter salmon (*Salmo salar*) in (a) Lough Swilly and (b) Kilkieran Bay. –●– prevalence; –○– mean intensity; –■– mean abundance.

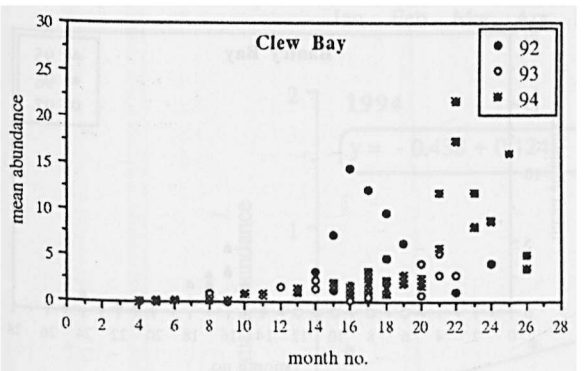
fish on site; a standard cage,which was sampled at each inspection, and another cage selected at random at each inspection. Different year classes of fish were considered as different populations, as were different species (*i.e. Salmon salar, Oncorhynchus mykiss*).

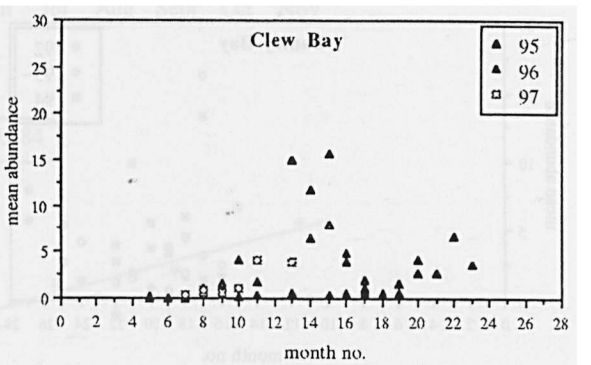
The two tailed t-test, corrected for multiple testing (Bonferoni method), was used for testing significance of somatic size and egg string length was analysed using Spearman's rank correlation.

Lice counts presented in this paper are based on arithmetic means obtained according to the following protocol: A sample of approximately thirty fish was taken from a single cage. The fish were anaesthetised and all mobile lice were removed and preserved in alcohol. All lice remaining in the anaesthetic after the sample was processed were retained and included in the sample. All lice were identified and staged. For each sample a mean number of lice in each category was obtained by dividing the number of lice recorded by the number of fish examined.









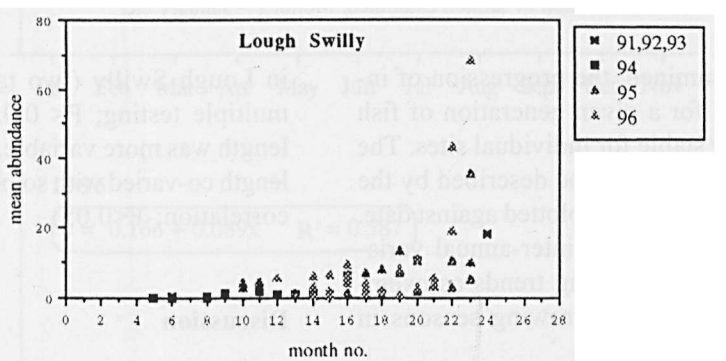


Fig. 2. Mean abundance of *Lepeophtheirus salmonis* on salmon of separate generations from Kenmare Bay, Clew Bay and Lough Swilly. Year numbers refer to the generation of salmon examined. Month 1 = January etc.

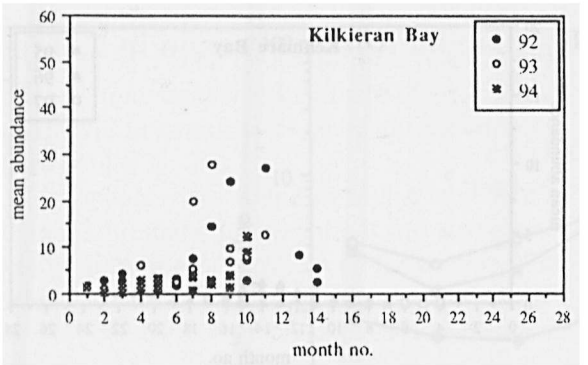
Results

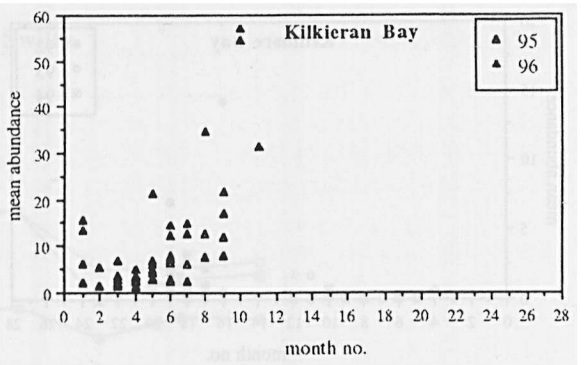
Infestation parameters

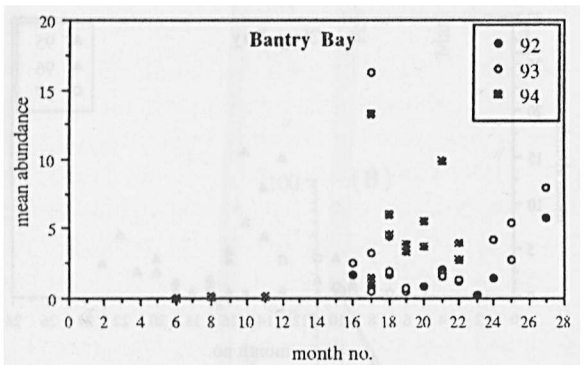
Data were examined from farms in five bays along the west coast; Lough Swilly, Clew Bay, Kilkieran Bay, Kenmare Bay and Bantry Bay. Examination of prevalence, intensity and abundance data for the five bays showed that abundance was a good descriptor of lice infestation. Even where percentage prevalence was less that 100%, intensity data closely mirrored trends in abundance values (Fig. 1).

Infestation relative to host sea-age

Lice infestation for six generations of farmed salmon is shown in terms of mean abundance in Figure 2.







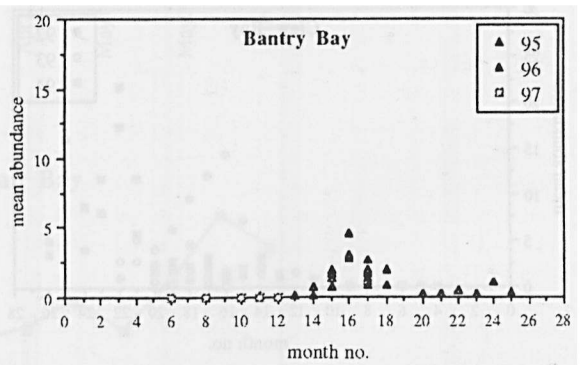


Fig. 2 (continued). Mean abundance of *Lepeophtheirus salmonis* on salmon of separate generations from Kilkieran Bay and Bantry Bay. Year numbers refer to the generation of salmon examined. Month 1 = January etc.

At the five sites examined, the progression of infestation over time for a given generation of fish was extraordinarily stable for individual sites. The progression in infestation can be described by the slope of the log lice abundance plotted against date. While there was considerable inter-annual variation, there were also underlying trends as exemplified by three consecutive growing seasons in Kilkieran Bay (Fig. 3).

Somatic size and egg string length

The somatic size of ovigerous female *L. salmonis* and egg string length, as an index of fecundity, were examined at five sites (Table 1). Somatic size rose from December through spring to an April maximum. Somatic size then progressively decreased through the summer into autumn. This change in mean somatic length was significant in all cases except between December and February in Lough Swilly (two tailed t-test, corrected for multiple testing; $P< 0.05$). The mean egg string length was more variable, but in general, egg string length co-varied with somatic size (Spearman's rank correlation; $P<0.05$).

Discussion

Recruitment of *L. salmonis* on the high seas has been reported from both the Pacific Ocean (Nagasawa, 1987) and the Atlantic Ocean (Jacobsen and Gaard, 1997). Jacobsen and Gaard (op. cit.) recorded the presence of both pre-adult and chalimus stages of *L. salmonis* on wild and escaped Atlantic salmon caught on long lines north of the Faroe Islands. They also found an increase in the abundance of lice with sea-age of the host. This conclusive evidence of high seas transmission of lice infestation far from spawning aggregations of hosts, suggests the presence of a low and probably vary-

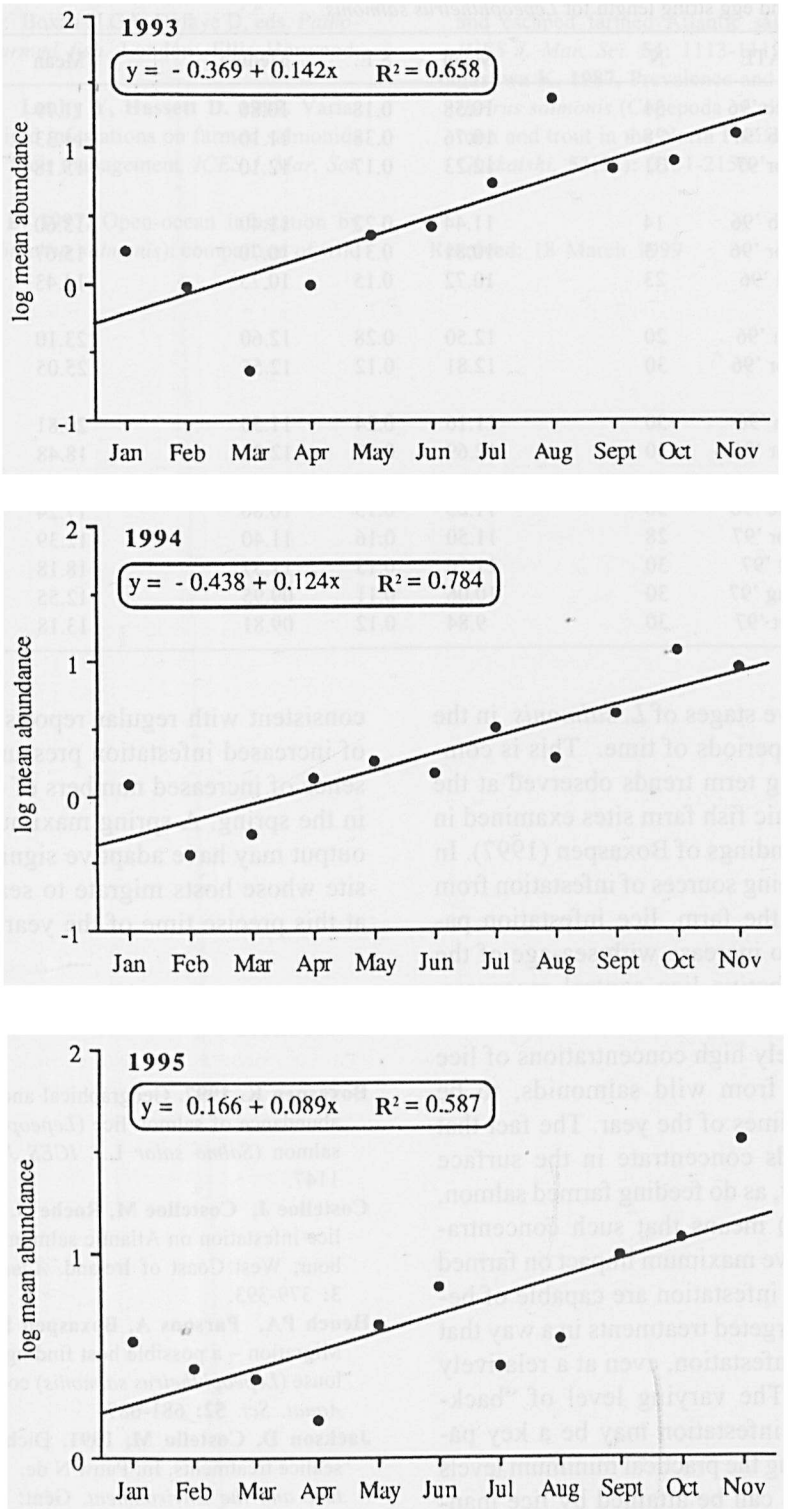


Fig. 3. Monthly log mean abundance for *Lepeophtheirus salmonis* for three consecutive years in Kilkieran Bay.

Table 1. Somatic size and egg string length for *Lepeophtheirus salmonis.*

SITE	DATE	N	Mean	S.E.	Median	Mean	S.E.	Median
Lough Swilly	Dec '96	31	10.58	0.18	10.80	11.79	0.64	11.20
	Feb '97	28	10.76	0.38	11.10	14.33	0.64	14.70
	Apr'97	31	12.23	0.17	12.10	15.18	0.37	15.40
Clew Bay	Feb '96	14	11.44	0.22	11.40	13.60	1.06	13.10
	Apr '96	3	10.81	0.31	10.70	15.67	2.70	16.50
	Jul '96	23	10.72	0.15	10.75	14.43	0.76	15.62
Killary Hbr	Jan '96	20	12.50	0.28	12.60	23.10	1.34	24.70
	Apr '96	30	12.81	0.12	12.55	25.05	1.01	26.50
Mannin Bay	Jan '96	30	11.16	0.24	11.50	20.81	0.85	20.35
	Apr '96	30	12.69	0.17	12.70	18.48	1.06	18.40
Kilkieran Bay	Dec '96	30	11.05	0.15	10.86	17.24	0.48	17.03
	Apr '97	28	11.50	0.16	11.40	12.39	0.79	11.24
	Jul '97	30	11.26	0.13	11.37	18.18	0.56	18.57
	Aug '97	30	10.06	0.11	09.95	12.55	0.41	13.24
	Oct '97	30	9.84	0.12	09.81	13.18	0.37	13.16

ing level of infective stages of *L. salmonis* in the open sea over long periods of time. This is compatible with the long term trends observed at the five relatively oceanic fish farm sites examined in this study and the findings of Boxaspen (1997). In the presence of ongoing sources of infestation from within and outside the farm, lice infestation parameters will tend to increase with sea-age of the host in spite of effective lice control measures. Costelloe et al. (1995) concluded that there was a potential for relatively high concentrations of lice larvae, originating from wild salmonids, to be present at specific times of the year. The fact that infective copepodids concentrate in the surface layers during the day, as do feeding farmed salmon, (Heuch et al. 1995) means that such concentrations are likely to have maximum impact on farmed fish. Such pulses of infestation are capable of being neutralised by targeted treatments in a way that a constant level of infestation, even at a relatively low level, cannot. The varying level of "background" sources of infestation may be a key parameter in determining the practical minimum levels of infestation which can be attained by lice management strategies as outlined in Jackson et al. (1997).

The spring maxima in somatic size and associated egg string length reported in this study are consistent with regular reports from fish farmers of increased infestation pressure, often in the absence of increased numbers of ovigerous females, in the spring. A spring maximum in reproductive output may have adaptive significance for a parasite whose hosts migrate to sea in large numbers at this precise time of the year.

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