International Council for the Exploration of the Sea

C.M.1972/F:27.
Demersal Fish (Northern) Committee
Ref. Fisheries Improvement Committee

The effect of population density on the growth of juvenile sole, *Solea solea* (L).

by

B. R. Howell
MAFF, Marine Hatchery, Port Erin,
Isle of Man.

and

O. Ledoux
Societe Civile Exploitation Agricole du Domaine de Certes,
33-Audenge, France

INTRODUCTION

An important factor in determining the feasibility of commercial fish farming is the weight of fish which can be produced per unit of tankage. For each size of fish, production will depend on a number of factors, the most important being tank size, water flow and stocking rate. The evaluation of each of these factors should enable predictions to be made concerning economic output.

In this paper the effect of stocking juvenile sole in small tanks at various densities under conditions of constant water exchange is examined. At the outset of the experiment little was known of the influence of accumulations of fish waste products, so that a water exchange rate which would prevent any impairment of growth could not be selected. However, concentrations of ammonia, and its oxidized derivatives, were monitored and their possible effect is discussed in relation to more recent investigations.

METHODS

The fish were held in 60 x 30 x 30 cm black polythene tanks illuminated from above by 30W daylight fluorescent tubes for 12 hours in each day. The tanks were gently aerated and received a flow of 5-7 litres per hour of fresh sea water. Air temperature was controlled at 15.0 ± 1.0°C, but because the temperature of the incoming seawater was not adjusted tank temperatures fluctuated, and decreased from 15-16°C at the beginning to 12-13°C at the end of the experiment. For this reason it was not possible to prevent the differential accumulation of metabolites by irrigating each tank in proportion to the weight of fish it contained. The tanks were arranged in two series of 8 and one of 7 and stocked with the following approximate numbers of fish:

Series C	20	20	40	60	80	100	200	
Series B	150	200	100	80	60	40	20	20
Series A	20	20	40	60	80	100	200	150

The fish used had been reared from a single egg collection and had been weaned on to a diet of live *Lumbricillus*, a food which allows good growth of plaice (Kirk and Howell, 1972). A random sample of 168 fish were weighed and measured at the beginning of the experiment. Subsequent weighings were confined to series A and B at about 40 day intervals but staggered so that series A was weighed after 17 days, series B after 34 days, series A after 50 days etc. The experiment was terminated after 134 days, when all fish were weighed and measured. To facilitate the measurements and to avoid damage the fish were first narcotized with an 80 parts/10^6 solution of MS222 (Sandoz). They were returned to a cleaned tank filled with fresh sea water.

The stock was fed an *ad libitum* diet of *Lumbricillus*. Following the weighings of fish in Series A and B after 50 and 34 days respectively, the food added to each tank, and any food removed, was weighed so that food conversion ratios could be calculated. Temperatures were recorded daily, and a high standard of hygiene was maintained by frequently siphoning accumulated debris from the tanks.

RESULTS

a) Mortality

Mortalities throughout the experiment were low and un-related to density.

b) Growth

At the end of the experiment, after 134 days, the fish at the lowest density had achieved a mean weight of around 8 g while those at the highest density had reached a mean weight of less than 4 g. The relationship between mean weight and density was similar in the three series but the data have not been combined, because the fish in each series had grown at slightly different rates (Figure 1). The development of this relationship for series A is shown in Figure 2. The equations of the curves were determined from linear regression analyses of logarithmic values of each parameter.

c) Relative variability

The population of fish used to stock the experiment was very variable in weight, as indicated by the coefficient of variation of approximately 59%. The greatest change occurred over the first 50 days, when there was a general decrease in variability which was density-dependent. Fish held at the lower densities became less variable than those held at the higher densities. There was little further change during the remainder of the experiment and the final relationship between density and variability is shown in Figure 3. There was a significant positive correlation between logarithmic values of density and the coefficient of variation for series A and C ($P \leq 0.01$ and $P < 0.05$ respectively), but that of series B was not significant ($P < 0.1$).

d) Food conversion ratio

In both series of tanks in which food intake was measured, fish held at high density converted their food into body tissue less efficiently than those at low density (Figure 4). Food conversion ratios, calculated from wet weights of food and fish, ranged from 4.0:1 to 2.7:1.

DISCUSSION

It is not possible to attribute the described differences in growth, relative variability and food conversion efficiency to population interaction alone, because the equal water exchange rates at all stocking densities resulted in a differential accumulation of waste products. This was most marked in series C, in which a complete water change was not made during the experiment (Table 1). Recent work (Alderson, unpublished) indicates that these levels of ammonia are unlikely to have had any deleterious effect. Although there is no evidence to suggest that the high levels of nitrite and nitrate are harmful, the low pH values, which indicate high carbon dioxide concentrations, are more likely to have had an adverse effect on the fish.

REFERENCES

KIRK, R. G. and HOWELL, B. R., 1972. Growth rates and food conversion in young plaice (Pleuronectes platessa L.) fed on artificial and natural diets. Aquaculture 1 (1): 29-34.

TABLE 1. Ammonia, nitrite, nitrate and pH values for series C towards the end of the experiment.

	Density					
	20	40	60	80	100	200
pH (127 days)	7.9	7.8	7.7	7.6	7.4	7.3
Ammonia (128 days) (mg ammonia N/l)	0.20	0.34	0.44	0.44	1.06	1.06
Nitrite (134 days) (mg atom/l).	1.3	1.5	8.6	16.9	25.0	40.4
Nitrate (134 days) (mg atom/l).	14.7	16.7	23.0	36.2	42.5	50.3

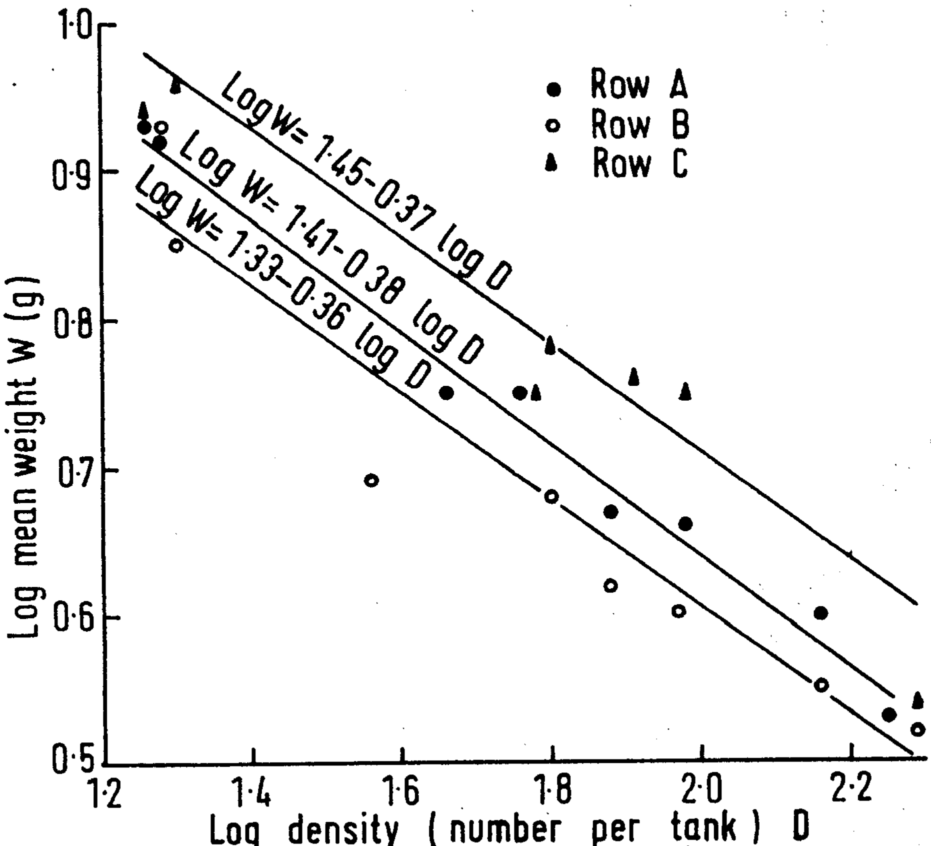

Fig.1 Regression of mean weight on density after 134 days for the 3 series of tanks.

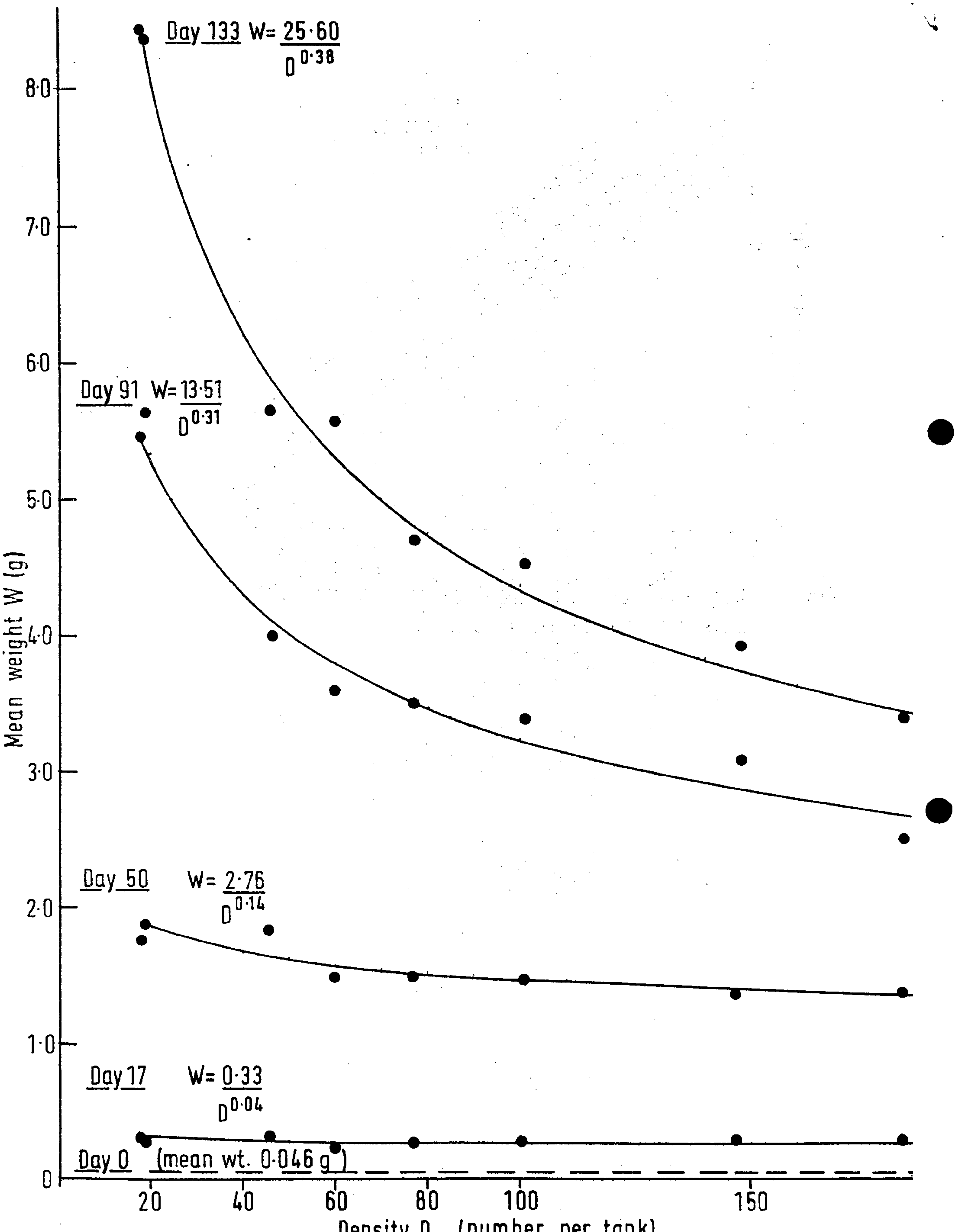

Fig. 2 The progressive relationship between mean weight and density for series A

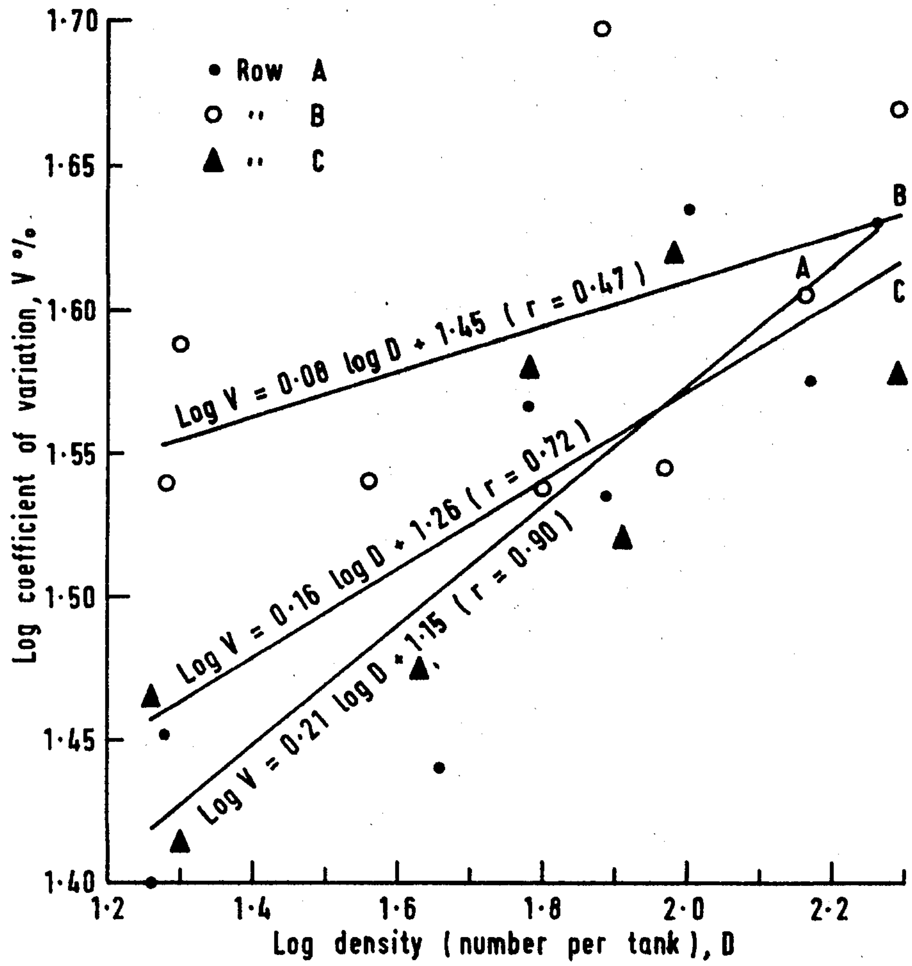

Fig.3. Regressions of log coefficient of variation on log density after 134 days for the three series of tanks

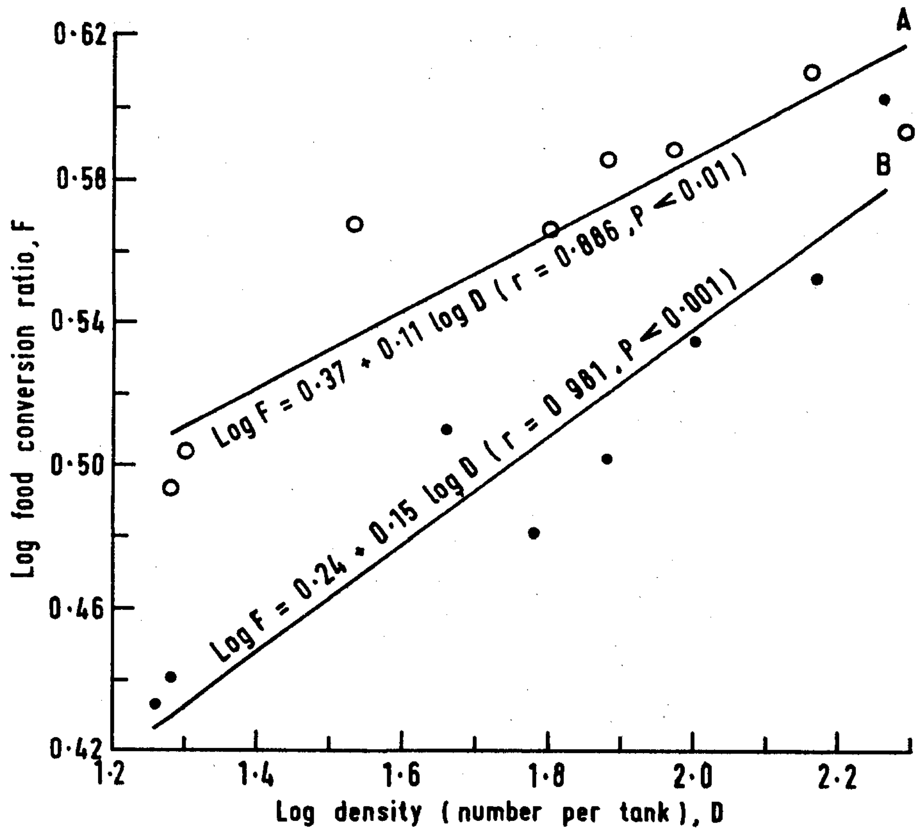

Fig.4. Regressions of log. food conversion ratio on log. density for series A and B over the last 84 and 64 days of the experiment respectively.