SPECIES RICHNESS AND ABUNDANCE OF CLINID FISH (TELEOSTEI; CLINIDAE) IN INTERTIDAL ROCK POOLS

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ABSTRACT

Factors affecting species richness and abundance of clinid fish (Fam. Clinidae) in 19 intertidal rock pools near Muizenberg, South Africa, were investigated. Some measure of cover is the most important predictor of clinid species richness, abundance and biomass. Intraspecific partitioning of habitat by *Clinus superciliosus* was observed, and apparently occurs in *C. cottoides* as well. Fish were observed to move between pools during high tides, and some individuals showed fidelity to particular pools. There is some evidence for suggesting that *C. superciliosus* might be a colonizing species.

INTRODUCTION

Clinids (Fam. Clinidae) are the most common intertidal fish along the west and south coasts of South Africa (Day 1969). Apart from the studies of Penrith (1965), who investigated the diet and reproduction of six species, research dealing with South African clinids has been restricted to their taxonomy and distribution (Smith 1945; Hubbs 1952; Penrith 1969, 1970). Despite a certain amount of vertical zonation in habitat preference, several species of clinids, and sometimes large numbers of individuals, may occur in the same pool during low tides (Penrith 1965). Gibson (1972), in a study of the factors affecting distribution and feeding of fish along the coast of France, found that only distance from the sea and surface area of the pool were statistically significant predictors of the numbers of fish in intertidal pools. The aim of our research was to determine some of the ecological factors influencing species richness and abundance of clinids in a group of intertidal rock pools near Muizenberg (34°08′S/18°30′E), South Africa.

METHODS

Data collection

During March–June 1976, 19 intertidal rock pools located about 0,4 km south-west of Muizenberg were denuded of fish and macroscopic algae. Variables measured for each pool included: surface area (*AREA*), perimeter (*PERIM*), mean depth (*DEPTH*), biomass of algae (*ALGAE BM*), percentage algal cover (*AC*), percentage rock cover (*RC*), distance from the sea

(*DIST*), biomass of clinids (*BOC*), number of species of clinids (*NOSC*) and number of clinids (*NOC*). Surface area was computed by dividing the surface of the pool into a group of geometric shapes, and calculating the sum of the areas of these shapes. The perimeter of each pool was measured at the water's edge with a flexible tape. Mean pool depth was calculated from ten measurements spaced evenly throughout the pool. The algal and rock cover in pools was estimated subjectively as a percentage of the total substrate area. All algae were removed and dried in an oven at 70°C and the biomass (dry) recorded. Distance from the sea was measured as the time taken for the sea to enter a pool after low tide. This variable was measured for all pools on the same day. Fish in the pools were caught using a 20% quinaldine solution in acetone (Gibson 1967*a*, *b*); all fish collected were identified to species level, counted, measured and their wet masses recorded.

In order to study recolonization of pools by fish and algae, 15 of the pools were resampled 12 weeks after the last pool had been denuded. Pools were sampled as above, but the algae were not weighed.

The behaviour of *Clinus superciliosus* and *C. cottoides* was observed during low-tide periods, i.e. when pools were isolated from the sea and each other. Five categories of behaviour were recognized: foraging, i.e. almost constantly swimming and feeding in the open; swimming in the open but not feeding; stationary in the open; stationary under cover of algae or rock; and aggressive encounters with other fish. Fish were observed for a total of 141 "fish hours" in two undisturbed pools. These two pools were situated in the balanoid zone and abundant cover was present in both. A "fish hour" is an unbroken period of one hour during which one particular individual fish was observed. For each "fish hour", notes were made of the species, number and age classes of all fish present and their positions and activities. Following Penrith (1965), clinids less than 4 cm long were classed as juveniles, those 4–5 cm long as intermediates, and those longer than 5 cm as adults.

Dispersal of *C. superciliosus* and *C. cottoides* was investigated by means of a mark-recapture method, similar to that used by Gibson (1967*b*). Fish in seven pools, within a 7 × 8 m area, were captured and marked by clipping different combinations of the pectoral fin rays. The marks were recognizable three months later. The fish were released into their "home" pools, and these pools were resampled at irregular intervals. During the period of resampling, fish which had not been captured previously were marked, and the locality of each marked fish was recorded.

Data analyses

Stepwise multiple regression analysis was used to determine which environmental factors (independent variables) were significant predictors of number of clinid species, and clinid abundance and biomass, in a pool (dependent variables). The multiple regression analysis programme used was STEPREG I (Allen 1973). In this programme, at each step, the independent variable with the highest partial correlation coefficient of all the variables not yet in the equation is added into the regression. The multiple coefficient of determination (R^2) is used as an index of predictive value, since it is an estimate of the amount of variation in a dependent variable due to variation in an independent variable (Sokal & Rohlf 1969). Log-

log and log-linear (only environmental factors log-transformed) were used, as well as linear models to detect possible non-linear relations between dependent and independent variables. Sepkoski & Rex (1974) discuss the statistical limitations of multiple regression analysis of ecological data. All computations were carried out at the Computer Centre of the University of Cape Town.

TABLE 1.

Number of clinid species caught in 19 pools and number of pools in which the fish were caught.

Species	No. fish	No. pools
Clinus cottoides	84	16
C. superciliosus	15	5
C. dorsalis	7	4
C. acuminatus	15	3
C. capensis	1	1
Blennioclinus brachycephalus	10	3

TABLE 2.

Summary of stepwise multiple regression analyses.

Dependent variable	Independent variables* included	Contribution to R^2	Total R^2	Model
Number of clinid species	Algal cover	0,2440	0,2440	Linear
	Algal cover	0,2508	0,2508	Log-linear
	Algal cover	0,2411	0,2411	Log-log
Number of clinids	Total cover, rock cover	0,7219; 0,1343	0,8562	Linear
	Total cover	0,6271	0,6271	Log-linear
	Total cover	0,6999	0,6999	Log-log
Biomass of clinids (wet mass)	Total cover	0,6890	0,6890	Linear
	Total cover	0,5101	0,5101	Log-linear
	Total cover, mean depth	0,6269; 0,1107	0,7376	Log-log

*Making a significant ($P < 0,05$) contribution to the regression (F test).

RESULTS

Clinids were found to be the most abundant fish in the pools. Only two other fish species, *Blennius cornutus* (two specimens) and *Caffrogobius caffer* (28 specimens), were found. The latter species was confined to three of the pools farthest from the sea. Six clinid species were found in the pools (Table 1). More than half of the pools harboured only one species of clinid. Results of regression analyses are summarized in Table 2. The percentage of algal cover is the only significant predictor of number of clinid species. The number of species/algal cover relation is positive, and a log-linear model gives only a slightly better prediction of number of species than linear and log-log models.

Total cover and rock cover are significant predictors of the abundance of clinids (Table 2). Total cover alone explains more than 72% of the variance in the number of clinids. The relation between these variables and the number of clinids is positive, and a linear model gives the best prediction. Total cover and mean depth are the only significant predictors of

TABLE 3.

Percentage algal cover and mean number, size and mass of clinids in 15 pools at first (1S) and second (2S) sampling.

Pool no.	Algal cover %		No. clinids		Length clinids (cm)		Wet mass clinids (g)		Sampling interval 1S–2S (weeks)
	1S	2S	1S	2S	1S	2S	1S	2S	
3	1	1	8	2	8,0	7,0	51,3	6,2	24
4	65	40	15	5	5,5	3,6	34,9	3,4	23
5	2	2	2	0	6,6	0,0	11,0	0,0	22
6	65	15	11	0	5,8	0,0	22,2	0,0	22
7	30	10	8	6	5,5	4,9	28,3	13,5	22
8	30	25	13	8	5,7	4,3	60,8	11,8	22
10	20	20	8	9	5,0	3,3	15,6	7,9	22
11	10	10	3	6	3,3	3,1	2,3	2,9	22
12	25	25	9	9	5,4	5,9	15,6	27,7	15
14	25	25	9	3	5,0	3,7	16,1	2,5	15
15	15	2	2	0	7,9	0,0	42,7	0,0	15
16	40	5	11	10	5,4	5,9	68,0	33,7	13
17	15	15	7	10	4,2	3,4	8,0	6,6	12
18	10	10	4	4	3,2	4,4	2,3	5,5	12
19	15	5	6	2	4,6	3,7	9,5	3,0	12
TOTAL			116	74			388,6	124,7	

biomass of clinids. More than 62% of the variance in biomass of clinids is accounted for by total cover alone. The relation between both independent variables and biomass of clinids is positive, and a log-log model gives the best prediction.

The average length, mass and number of clinids were significantly lower ($P < 0{,}05$; one-tailed paired t test) at the second sampling occasion than at the first (Table 3). The algae regenerated completely in 50% of the pools. The number of *C. superciliosus* increased, and decreases occurred in numbers of all other clinid species except *C. dorsalis* (Table 4). The species composition of the clinid community was significantly different ($P < 0{,}001$; χ^2 test) between first and last sampling.

Information on the behaviour of *C. superciliosus* and *C. cottoides* is summarized in Table 5. Juvenile *C. superciliosus* spent all of their time foraging in the open; intermediate and adult classes progressively spent more time under cover. Although the data for *C. cottoides* were obtained from at most four fish, it appeared that juveniles of this species also spent more time in the open than adults. Elements of aggressive behaviour were observed only in members of *C. superciliosus*, and took the form of chases between juveniles and chasing of juveniles by fish in the intermediate age class.

Amongst a total of 43 individually-marked fish, 16 (37%) were never recaptured. Fifty-seven recaptures were made of 27 fish. Twelve (21%) of these recaptures were of fish which had moved into new pools. Half of these emigrants had moved no farther than the pool adjacent to the one in which the initial capture had been made (Figure 1). Twelve (44%) of the 27 individuals were recaptured in pools other than the 19 which were sampled intensively. New, unmarked fish were found in the pools on every sampling occasion.

TABLE 4.

Species composition of clinid communities in 15 pools at first (1S) and second (2S) sampling. All figures are percentages based on totals of 116 (1S) and 74 (2S) fish.

Species	1S	2S
Clinus cottoides	64	52
C. superciliosus	11	37
C. dorsalis	5	10
C. capensis	1	0
C. acuminatus	11	0
Blennioclinus brachycephalus	7	1

TABLE 5

Time in "fish hours" and percentage time (in parentheses) spent by *Clinus superciliosus* and *C. cottoides* of different age-size classes in four categories of behaviour (see text for definitions of categories of behaviour and age-size classes).

Species	Foraging	Swimming	Stationary	Under cover
C. superciliosus				
Juvenile	76,0 (100)	0	0	0
Intermediate	0	2,0 (19)	1,5 (14)	7,0 (67)
Adult	0	0,2 (0,5)	2,0 (4)	44,2 (95,5)
C. cottoides				
Intermediate	0	0,6 (9)	0,8 (13)	5,1 (78)
Adult	0	0,02 (0,4)	0,3 (6)	3,7 (93,6)

DISCUSSION

Some measure of cover appears to be the best, or only significant, predictor of species richness, abundance and biomass of clinids in the pools investigated. However, correlation does not mean causation, and a direct link between protective cover from predators and fish should not be inferred. Predation could affect the abundance and distribution of clinids. The major predators of intertidal fish are probably other fish and birds (Gibson 1969). Skead (1966) noted that little egrets (*Egretta garzetta*) and kelp gulls (*Larus dominicanus*) feed in rock pools at low tide. Cover for clinids is also cover for many of the fishes' major prey items, such as isopods, amphipods and molluscs (Penrith 1965). More information on the relation between clinids and their predators and prey is needed before definitive conclusions about cover can be drawn.

Relatively few members of *C. cottoides* were seen swimming in the pools at low tide. However, the species was found to be the most abundant clinid in the present study, as well as in others (Jackson 1950; Penrith 1965). These phenomena may be correlated with cover-seeking behaviour, since brief visual surveys of pools known (from capture experiments) to hold significant numbers of *C. cottoides* almost invariably failed to reveal any specimens. Hence, it is likely that members of this species remain under cover during the low-tide period. As this species' diet includes barnacle legs (Jackson 1950; Penrith 1965), it must feed out of cover at high tide. This indicates interspecific temporal partitioning of the habitat, since *C. superciliosus* is known to be active during low tides. Several species of intertidal fish possess endogenous rhythms in activity, with increased activity occurring during high tides (Gibson 1969). Other species seem to be affected more by the intensity of light (Gibson 1969). Other than that presented herein, there are no quantitative data on clinid activity rhythms.

The results of the mark-recapture experiment suggest that individuals of both species show fidelity to particular pools in which they live, under cover, during low tides. Gibson (1969) also found that some intertidal fish return to the same pool on successive low tides. If most foraging takes place during high tides, and away from "home" pools, conceivably both inter- and intra-specific competition occurs for shelter during low tides. Aggression between juveniles and between juveniles and larger fish was observed for *C. superciliosus*, and it may result in relatively small fish being forced to occupy open areas where they are probably more vulnerable to predation.

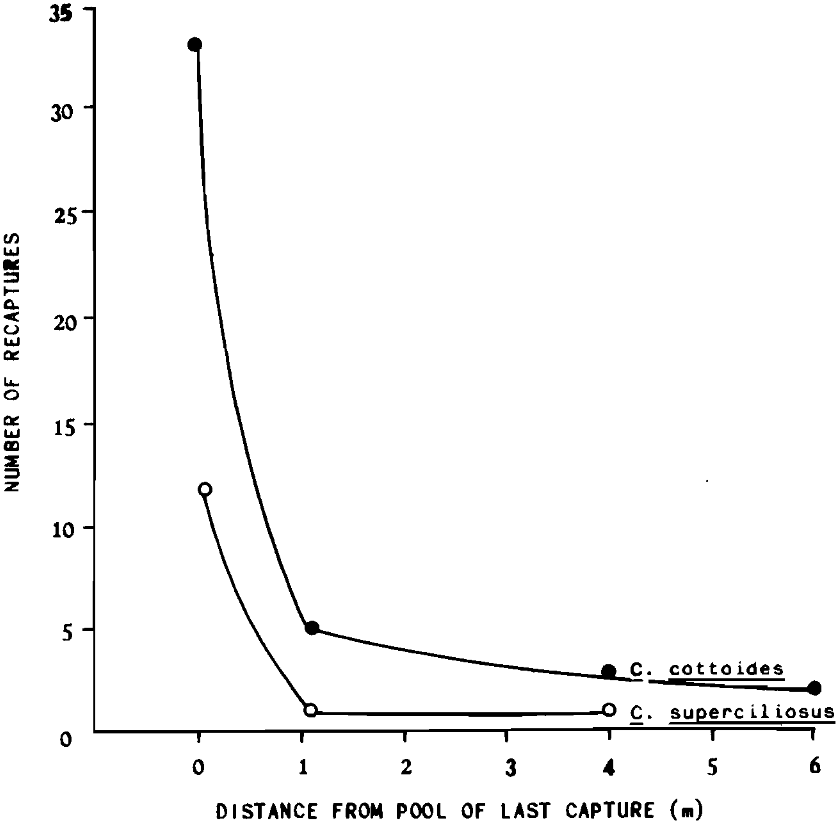

FIGURE 1.

The distance which individuals of *Clinus cottoides* and *C. superciliosus* moved between successive recaptures.

The clinid community regained its former abundance only in those pools in which algal cover had regenerated fully. However, the recolonized pools contained on average relatively small fish. Penrith (1970) observed that pools cleared of clinids were recolonized (after six to eight months) by small, maturing fish, and suggested that this may be due to dispersal of non-territorial individuals. Pools lacking algae may also fail to harbour large fish due to insufficient cover and/or the presence of prey animals which depend on the presence of algae. It is to be noted that no members of *C. acuminatus* were found in the recolonized pools. This species normally occupies pools in the *Littorina* zone at the top of the shore. Since this zone is not covered by the sea during every high tide, opportunities for dispersal of fish are reduced. The populations of *Blennioclinus brachycephalis* were also relatively small in the recolonized pools. This species is a "weed-dweller" (Penrith 1965), and it may not be able to live in pools which do not support extensive stands of algae. Only *C. superciliosus* increased its numbers in the recolonized pools, and it may be a colonizing species. *Clinus superciliosus* appears to have a relatively more varied diet when compared to other clinids (Penrith 1965), and has the widest distribution (extending into the sublittoral) of the clinids featured in this study. Thus it appears to be an adaptable species, and its aggressive behaviour may promote dispersal of individuals.

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