The occurrence and feeding of *Pomatomus saltatrix* (elf) and *Lichia amia* (leervis) juveniles in two Cape south coast estuaries

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The seasonal occurrence of *Pomatomus saltatrix* and *Lichia amia* juveniles in a permanently open (Knysna) and a periodically open (Swartvlei) estuary is described. *P. saltatrix* was caught only in Knysna from September to April. *L. amia* was found in both systems intermittently throughout the year. Small juveniles were most abundant from November to February in Knysna and from December to February in Swartvlei. Prey selected varies with size and species although there is some overlap. Behavioural and morphological differences are discussed in relation to prey selection.
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Die seisoenale voorkoms van *Pomatomus saltatrix* en *Lichia amia* vingerlinge in 'n getymonding wat permanent oop is (Knysna) en een wat net met tye oop is (Swartvlei) word beskryf. *P. saltatrix* is slegs gedurende die tydperk September tot April gevang. *L. amia* is in albei sisteme met tussenposes teenwoordig. Klein vingerlinge was in Knysna vanaf November tot Februarie en in Swartvlei vanaf Desember tot Februarie in groot getalle teenwoordig. Alhoewel die prooi waaraan voorkeur verleen word oorvleuel, varieer prooivoorkeur met liggaamsgrootte en spesies. Morfologiese en gedragsverskille word met betrekking tot prooivoorkeur bespreek.
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Estuarine research has indicated the importance of estuaries as nurseries for some species of juvenile teleosts, which may benefit from the reduced predation and higher food availability (Blaber & Blaber 1980; Blaber 1981; Day, Blaber & Wallace 1981). Day (1951) subdivided the fish using estuaries into five categories, of which marine migrants, which spend only part of their life history in estuaries, formed the major group. Juvenile *Pomatomus saltatrix* and *Lichia amia* form part of this group. They are rarely encountered in Natal (Day & Morgans 1956; Wallace & van der Elst 1975; van der Elst 1976) but are more abundant in the Eastern Cape (Blaber 1974; Wallace & van der Elst 1975; Winter 1979), which suggests that more temperate areas may form important nurseries for elf and leervis. The present study describes the occurrence and feeding of juvenile elf and leervis in Knysna (permanently open) and Swartvlei (periodically open) estuaries, which are situated on the southern Cape coast.

Methods

Monthly sampling began in July 1978 and continued until December 1980 using a 15-m anchovy net with 5-mm mesh and a seine-net of 30 m with wings of 25-mm mesh and purse of 5-mm woven mesh. Sampling was conducted throughout the systems from Charlesford Rapids to Knysna mouth (Figure 1) and from the road bridge to Swartvlei mouth (Figure 2). Fish were measured immediately following removal from the net and fork lengths are used throughout. Specimens required for stomach analysis were labelled and preserved in alcohol. Alcohol was used in order to prevent erosion of the prey otoliths. The stomachs were removed for examination under a binocular microscope. Prey items were sorted, identified and

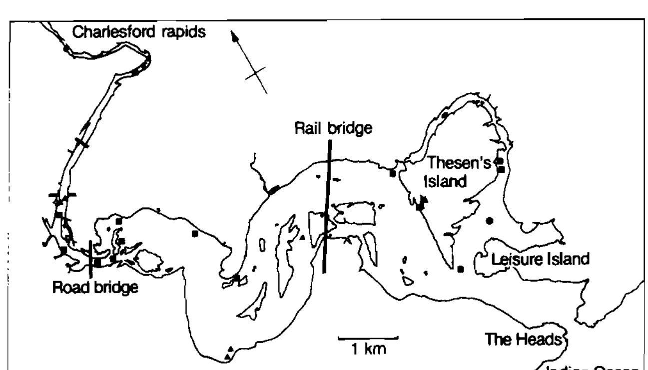

Figure 1 The distribution of sampling stations at which *P. saltatrix* (■) and *L. amia* (▲) were caught in Knysna estuary.

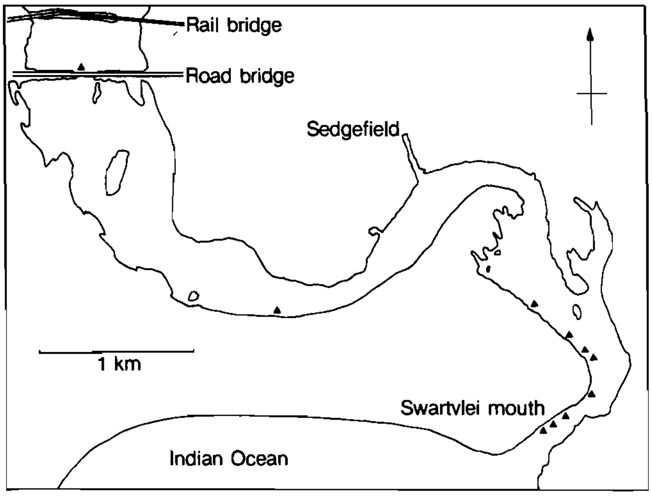

Figure 2 The distribution of sampling stations at which *L. amia* (▲) was caught in Swartvlei estuary.

counted. Teleost prey were measured (total length) and identified from otoliths by comparison with the reference collection housed at the Port Elizabeth Museum. The prey items were dried at 60 °C to constant mass and weighed to the nearest 0,001 g.

Results

Pomatomus saltatrix

Elf were widely distributed throughout Knysna (Figure 1). They were collected from below the 'ebb and flow' (Charlesford Rapids) at a salinity of 12°/oo to Leisure Isle point, at a salinity of 35°/oo. The largest catches were taken above the railway bridge in mixed estuarine waters. No juveniles were found in Swartvlei.

The length frequency of catches made over the 30-month study is shown plotted by month in Figure 3. Juvenile elf smaller than 45 mm were recorded from September and the influx of juveniles continued through to December, during which time the increase in size range may be accounted for by growth. The modal progression from September to February of 40 to 130 mm may indicate continued growth although no juveniles were captured in January. This growth rate appears to agree with van der Elst's (1976) age study. The wide size range recorded in February and March may be a function of variable growth rate of individuals of the same age or may represent individuals recruited in two years. Fish at the large size extreme appear to be one year old, while those at the small extreme, less than one year old (van der Elst 1976). Elf of less than 100 mm were not caught after December.

The stomach contents of elf are shown in Table 1. The prey of those below 100 mm is predominantly small Crustacea (81,7% by dry mass) but the diet of elf over 100 mm consists mainly of teleosts (96,8% by dry mass). *Hepsetia breviceps*, the common estuarine atherinid, was the single most important species (42,8% by dry mass) whilst unidentified teleost remains were second. The reason for the preponderance of unidentified teleosts was that all the larval or post-larval stages which were too digested to identify from the remains, had unidentifiable otoliths. Gobiidae and juvenile Sparidae were only identified to family level because of the similarity of the otoliths of juvenile sparids and the complexity of the Gobiidae. However, the gobies commonly captured in nets, were *Caffrogobius multifasciatus* and *Psammogobius knysnaensis*.

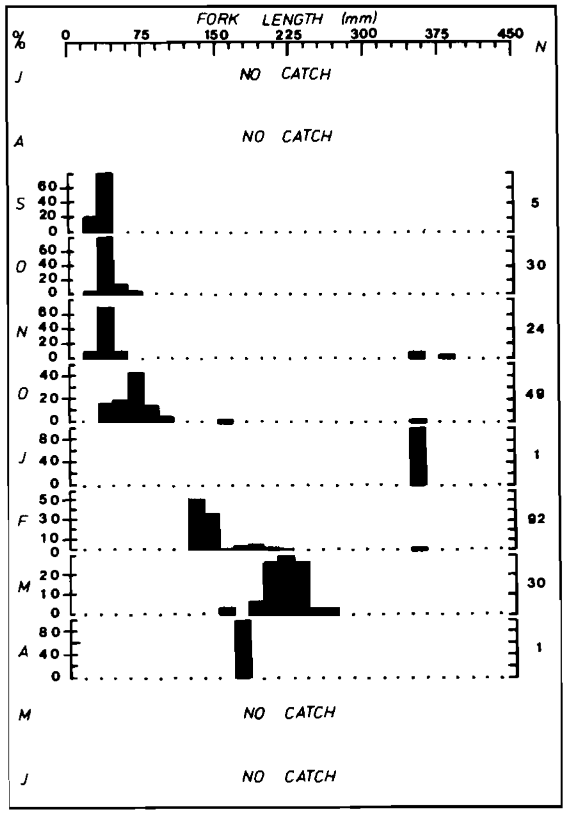

Figure 3 Percentage length composition of monthly catches of *Pomatomus saltatrix* taken in Knysna; data are combined for July 1978 to December 1980. *N* is the number sampled.

The limited data on prey size shows that crustaceans taken by smaller fish were about 20% of the body length. The prey of larger elf were between approximately 30% and 50% of the body length. Occasionally parts of prey were found in the stomachs and these had obviously been severed with the sharp cutting teeth of this predator.

Lichia amia

The localities at which *L. amia* were caught in Knysna are illustrated in Figure 1. Caught from just below the 'ebb and flow' at a salinity of 16°/oo through to Leisure Isle at a salinity of 35°/oo, they were particularly common near the Thesen Power Station warm-water outflow, where juvenile mullet were often concentrated. The smaller fish were found close to aquatic macrophyte beds in the shallows and larger fish were usually in slightly deeper water or associated with schools of similar-sized mullet. In Swartvlei (Figure 2) most small juveniles were caught near the mouth region, whilst larger fish were caught higher up the estuary in salinities down to 10°/oo.

The monthly length-frequency distribution of *L. amia* caught in Knysna is shown in Figure 4. It appears that recruitment occurs from November to January with juveniles being most prolific in December. The modal progression from November to June of 50 – 350 mm may indicate continued growth. A single specimen of 515 mm, caught in March, is not included in Figure 4. Only large fish were occasionally recorded in the shallows in March, May, June and September. In Swartvlei, juvenile leervis were caught in December and January (Figure 5). Recruitment to this system is dependent on the estuary mouth being open to the sea at a time which coincides with the presence of juveniles in the sea. The mouth is opened mechanically whenever flooding of riparian properties is imminent. During this study Swartvlei mouth was closed at the

Table 1 Stomach contents of *Pomatomus saltatrix* caught in Knysna estuary. The mean length, range and number of each size group are shown

Taxa	*P. saltatrix* < 100 mm FL $\bar{l}$=59(37 – 79 mm) *N*=28 % Frequency occurrence	% Number	% Dry mass	*P. saltatrix* > 100 mm FL $\bar{l}$=258(158 – 389 mm) *N*=9 % Frequency occurrence	% Number	% Dry mass
Polychaeta	3,6	0,5	1,1	–	–	–
Crustacea						
Mysidacea, *Mesopedopsis slabberi*	32,1	8,3	15,6	–	–	–
Macrura, Penaeidae	25,0	27,3	17,5	–	–	–
Macrura, Caridea	21,4	59	48,6	–	–	–
Mollusca						
Cephalopoda, *Loligo* sp.	–	–	–	11,1	7,7	3,2
Pisces						
Gilchristella aestuarius	7,1	1,0	6,0	–	–	–
Engraulidae	3,6	0,5	7,7	–	–	–
Sparidae	–	–	–	11,1	7,7	9,5
Hepsetia breviceps	3,6	1,5	0,5	44,4	46,2	42,8
Gobiidae	–	–	–	11,1	7,7	11
Unidentified teleosts	10,7	2,0	3,0	44,4	30,8	33,5
Totals	*N*=28	*N*=205	*m*=0,374 g	*N*=9	*N*=13	*m*=3,148 g

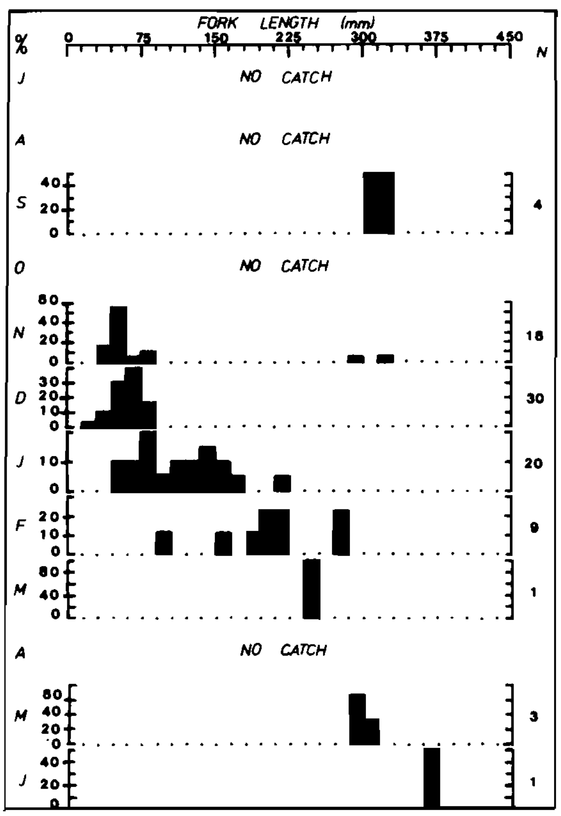

Figure 4 Percentage length composition of monthly catches of *Lichia amia* taken in Knysna; data are combined for July 1978 to December 1980. *N* is the number sampled.

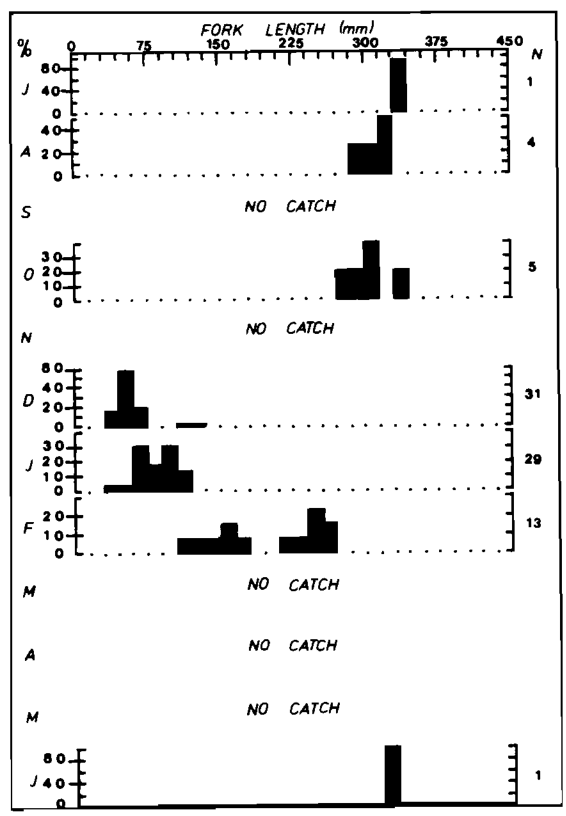

Figure 5 Percentage length composition of monthly catches of *Lichia amia* taken in Swartvlei; data are combined for July 1978 to December 1980. *N* is the number sampled.

commencement of sampling in July 1978 but was subjected to three artificial openings. It was open from mid-November 1978 till May 1979, from 27 July 1979 till 9 July 1980 and from 29 October 1980 till after December 1980 when sampling ceased.

Stomach content data of *L. amia* are presented in Table 2, separated according to locality and size. In Knysna (Table 2a), those below 100 mm feed on Gobiidae, carid shrimps and juvenile Mugilidae with almost equal frequency, although Gobiidae and Caridae were more important with respect to dry mass (43% and 31% respectively). Gobiidae were the most important prey of larger leervis by all methods of analysis (14% by dry mass). *Hepsetia breviceps* and Mugilidae were also major components of the diet which was dominated by 10 species of schooling teleosts and gobies. In Swartvlei (Table 2b), unidentified larvae (15% by dry mass), (which may have been the prolific *Hepsetia breviceps*) and positively identified *H. breviceps* (58% by dry mass), were the major components of

Table 2a Stomach contents of *Lichia amia* caught in Knysna estuary. The mean length, range and number of each size group are shown

	L. amia < 100 mm FL $\bar{l}$=75(49–99 mm) N=33			*L. amia* > 100 mm FL $\bar{l}$=209(111–515 mm) N=32		
Taxa	% Frequency occurrence	% Number	% Dry mass	% Frequency occurrence	% Number	% Dry mass
Crustacea						
Mysidacea, *Mesopedopsis slabberi*	3	19,3	0,5	–	–	–
Macrura, Caridea	30,3	25,3	30,9	9,4	8,7	2,8
Macrura — unidentified	6,1	4,8	1,8	9,4	6,5	1,9
Pisces						
Etrumeus teres	–	–	–	6,3	3,3	3,3
Gilchristella aestuarius	–	–	–	6,3	3,3	12,6
Engraulidae	–	–	–	3,1	2,2	8,8
Hemirhamphus (?)	–	–	–	3,1	1,1	1,7
Diplodus sargus	–	–	–	3,1	1,1	6,9
Sarpa salpa	–	–	–	6,3	5,4	10,7
Spondyliosoma emarginatum	–	–	–	3,1	4,3	12
Mugilidae	30,3	16,9	16,1	25	10,9	13,2
Hepsetia breviceps	3	2,4	1,0	28,1	16,3	8,8
Gobiidae	33,3	19,3	43,1	40,6	30,4	14,3
Unidentified teleosts	21,2	12,0	6,6	15,6	6,5	3,1
Totals	N=33	N=83	m=2,223 g	N=32	N=92	m=18,24 g

Table 2b Stomach contents of *Lichia amia* caught in Swartvlei estuary. The mean length, range and number of each size group are shown

	L. amia < 100 mm FL $\bar{l}$=57(40–97 mm) N=17			*L. amia* > 100 mm FL $\bar{l}$=216(107–329 mm) N=12		
Taxa	% Frequency occurrence	% Number	% Dry mass	% Frequency occurrence	% Number	% Dry mass
Crustacea						
Macrura, Caridea	11,8	10,5	12,5	8,3	3,4	2,7
Pisces						
Gilchristella aestuarius	5,9	5,3	1,8	16,7	6,9	6,6
Monodactylus falciformis	–	–	–	8,3	6,9	2,7
Mugilidae	5,9	5,3	3,2	–	–	–
Hepsetia breviceps	17,6	21,1	58,0	33,3	44,8	63,1
Gobiidae	11,8	10,5	9,2	58,3	34,5	19,1
Unidentified teleosts	47,1	47,4	15,2	8,3	3,4	5,7
Totals	N=17	N=19	m=0,281 g	N=12	N=29	m=1,493 g

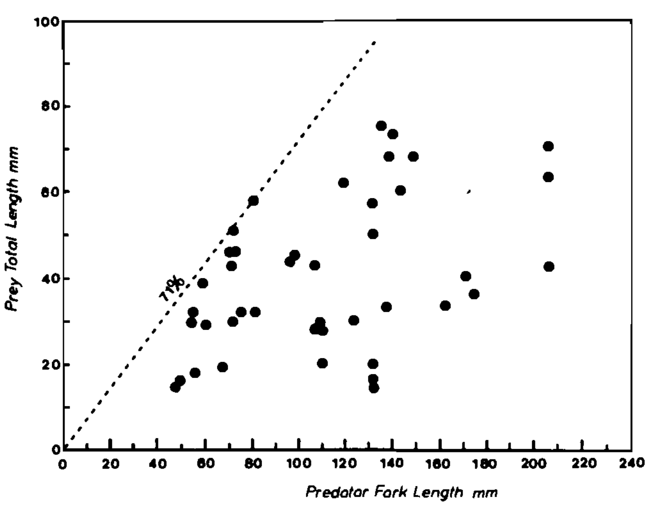

Figure 6 Scatter diagram of the relationship between *Lichia amia* fork length and prey total length, showing the maximum prey/predator relationship of 71%.

the small leervis diet. Carid shrimps were very much less important compared with Knysna and no other crustacean species were found. The larger leervis in Swartvlei had taken *Hepsetia* (63%), gobies (19%) and *Gilchristella* (7% by dry mass). *Monodactylus* juveniles and carid shrimps were taken infrequently.

The size of the prey of *L. amia* is compared to the body length in Figure 6. The largest prey approach 71% of the leervis length and a high proportion are between 20 and 60%. This is at least partially explained by the wide gape of the predators.

Discussion

Relatively little is known about the spawning, recruitment or nursery areas of *P. saltatrix*, although van der Elst (1976) reported elf spawning on the Tugela Bank in late winter and early spring (September to January with a peak in November), after migrating northwards from the Cape (van der Elst 1981). The extent of the spawning grounds and the existence of other spawning areas is unknown. Larvae are thought to move south with the Agulhas current which sweeps down from Natal to the southern Cape coast (Heydorn, Bang, Pearce, Flemming, Carter, Schleyer, Berry, Hughes, Bass, Wallace, van der Elst, Crawford & Shelton 1978) where some of the larvae enter estuaries. However, considering the number of estuaries available and the relatively low numbers of juveniles caught in estuaries, it would appear unlikely that they are the only nursery areas for this species. Furthermore, recent trawling surveys in shallow southern Cape coastal areas by the Port Elizabeth Museum have shown the presence of large marine nursery areas, especially in Algoa Bay (Smale unpubl.; Lasiak 1981). A similar situation has been reported from the North American east coast where estuaries are thought to provide only part of the nursery area for *P. saltatrix* (Kendall & Walford 1979), despite the large number and size of estuarine systems in that area.

Juveniles were shown to recruit into Knysna from September to December, and grow rapidly in the shallows. Fish approximately one year old (van der Elst 1976) are caught from February to April, although these could be part of the September cohort. Their absence from Swartvlei is notable considering the simultaneous availabaility of *L. amia* juveniles which do recruit. A few large *P. saltatrix* species have been recorded in Swartvlei (Coetzee, D.J.; van Wyk, N.; Whitfield, A.K.; pers comm. 1981) and these probably enter as large fish.

Lichia amia exhibits a similar migration to Natal waters to breed (van der Elst 1981). Its larvae are probably transported by the Agulhas current to the South Cape coast, as juveniles are very infrequently encountered in Natal (Wallace & van der Elst 1975; Blaber, S.J.M. pers comm. 1981), although they have been sampled in the Transkei and the Kromme River (Wallace & van der Elst 1975). Winter (1979) has reported leervis from 5 – 37 cm ($n = 26$ in three years) in the estuary, near the mouth of Swartkops River, mainly in December and January.

The importance of estuaries to juvenile *L. amia* is uncertain, mainly because of the limited research on juvenile fish in the marine environment. Juveniles have been recorded in rock pools in False Bay by Barnard (1927), in Algoa Bay surf zone by Lasiak (1981), and Norman & Irvine (1947, in Smith-Vaniz & Staiger 1973) recorded small specimens in seine-net catches along the west African Gold Coast. In view of the rarity of marine records of this species, it seems likely that estuaries are extremely important in its life history, and small juveniles may prove to be dependent on them.

Estuaries are known to be important to many species of fish (Day *et al.* 1981; Blaber 1981). Even though the importance of estuaries cannot be quantified and compared with marine waters, they are very rich and productive areas (Day *et al.* 1981). Their careful conservation can only benefit the productivity of coastal areas and assist the recruitment of ecologically and recreationally important marine species such as *P. saltatrix* and *L. amia*. The notable lack of *P. saltatrix* recruitment into Swartvlei estuary could result from the possible unsuitability of the depth and configuration of the mouth. Furthermore, estuarine recruitment is probably influenced by a variety of factors including inshore marine currents, turbity and salinity, and the absence of *P. saltatrix* from Swartvlei suggests that elf nurseries may be more typically marine than estuarine, while the reverse holds for *L. amia*. This in turn indicates that both large and small estuarine systems are ecologically important and that both merit careful management.

Although these two species are the principal teleost piscivores in these systems, the low catches of elf and leervis juveniles suggest that these predators are not numerous in the estuaries despite the abundance of other juvenile teleosts which make up their prey (Kok unpubl.). Stomach content analyses revealed differences in prey selected by the two species and that these change according to predator size and locality. In Knysna, small *P. saltatrix* fed largely on swarming crustaceans and schooling fishes whilst *L. amia* of a similar size fed on both solitary prey (Gobiidae and carid shrimps) and schooling prey (Mugilidae). The prey taken by larger elf consisted predominantly of schooling teleosts. Large *L. amia* took a similar type of prey to smaller individuals, although bigger items and a broader range of species were taken. Despite the low number of predators, which suggests a low level of competition, different prey were selected by each species. This probably results from differences in feeding behaviour and morphology, and prey availability.

Comparison of prey selected by *L. amia* in Knysna and Swartvlei shows that the important prey such as Gobiidae and *Hepsetia* are markedly different in the two systems. This can be attributed to the differential availability of the prey species. *Hepsetia* was more prevalent in the diet of the small group in Swartvlei while leervis in Knysna fed more on Mugilidae and Gobiidae. This held too, for the large group when dry mass is compared, and results from the abundance of *Hepsetia* in the lower reaches of Swartvlei (Kok unpubl.). Another difference between the prey taken in the two systems is the greater numbers of species taken in Knysna, as was also found with seine-net catches (Kok unpubl.).

Coetzee (1982) found that *L. amia* of 173 – 734 mm caught by means of gill-nets in Swartvlei took different prey according to locality within the system. Localized variation in abundance of prey and the difference in size of predators may also account for differences in the importance of prey found in this study compared to his, for example between *H. breviceps*, *G. aestuarius* and crustaceans. On the other hand, the result of the current study agree with the finding of Ratte & Hanekom (1980 in Coetzee 1982) that *H. breviceps* is more abundant in the lower reaches of this system, although Coetzee (1982) found *G. aestuarius* to dominate his sample.

The variance in prey selectivity by the two predators can be partly explained by the difference in anatomy and behaviour between elf and leervis. *P. saltatrix* is a schooling species from juvenile to adult stages (personal observations), and the silver body coloration causes reflection of light at the same wavelength as that impinging on it (Edmunds 1974). This makes it difficult to see elf even in clear water and is the ideal coloration for midwater shoaling predatory fish. *P. saltatrix* is a typical example of a schooling predator as it takes shoaling prey and illustrates the features used to overcome the advantages gained by the prey schooling (Radakov 1973; Bruton 1979). Furthermore, its shearing dentition allows it to bite through prey, ingesting part of it. This not only increases the maximum size of prey available to it, but also favours schooling, as other members of the school may then take the incapacitated prey.

L. amia juveniles exhibit a disruptive colour pattern of black stripes on a yellow background (Smith 1972: Plate 25). This led to the juveniles being described as a different species, *Porthmeus argenteus* which was later synonomized under *Hypacanthus amia* (= *Lichia*) (Smith-Vaniz & Staiger 1973). The colour pattern fades with growth, becoming less yellow and more silvery between 100 and 150 mm and is finally lost after about 200 mm. Observations on fish kept in the Port Elizabeth Oceanarium showed that juveniles are ambush predators which either lurk close to macrophytes near the substrate, or float, resembling dead leaves near the surface. When prey approaches, a sudden lunge is made to capture it. In the estuary these fish were usually associated with *Zostera* or other aquatic macrophytes and they may lurk alone in these areas. Similar mimicry has been reported for other teleosts (Breder 1946; Randall & Randall 1960; Edmunds 1974). This behaviour changes with growth and loss of coloration, when leervis often associate with schools of similar-sized mullet, allowing them to approach prey unobserved until close enough to strike, a strategy not uncommon in tropical reef piscivores (Hobson 1979). This behaviour would be far less effective if the bright coloration was maintained.

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