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CHAPTER 4

THE SYSTEMATICS OF JUVENILE SCARIDS, WITH NOTES ON THE ONTOGENY AND
FUNCTIONS OF THEIR COLOUR PATTERNS.

4.1 Introduction

Recent studies have resolved many of the problems associated with the systematics of adult scarids (explained in Section 3.1), with field oriented studies and published colour plates (in: Randall & Ormond, 1978; Randall & Choat, 1980; Randall & Bruce, 1983) greatly assisting in field identifications. The systematics of juvenile scarids, however, remains unresolved. The few published descriptions of juvenile colour phases include:

Bolbometopon muricatum by Smith (1953); *Cetoscarus bicolor*, *Hipposcarus harid* (Forsskål), *Scarus frenatus* [as *S. randalli* Schultz], *S. gibbus* [as *S. microrhinos* Bleeker], *S. niger*, *S. spinus* [as *S. formosus* Valenciennes], *S. taenurus* Valenciennes, *S. sordidus*, *S. brevifilis* and *S. terti* (as *S. croicensis* Bloch) by Schultz (1958); *H. harid* by Smith (1959); *S. guacamata* Cuvier and *S. coelestinus* Valenciennes by Randall (1963); *S. frenatus* [as *S. servittatus* Rüppell, *S. niger*, *S. sordidus*, *S. ghobban* and *S. gibbus* [as *S. microrhinos*] by Choat (1969); *Ypsiscarus ovifrons* by Masuda and Tanaka (1962) and Masuda et al. (1975); *S. koputea* Randall and Choat and *S. longipinnis* by Randall and Choat (1980); *C. bicolor*, *H. harid*, *S. falciipinnis* (Playfair), *S. ferrugineus* Forsskål, *S. frenatus*, *S. gibbus* and *S. niger* by Randall and Bruce (1983).

In addition, there are several published colour plates of juvenile scarids in popular books, for example, *Cetoscarus bicolor* (as *Bolbometopon bicolor*) in Burgess and Axelrod (1971a, p 154 and 1971b, p 458); *Calotomus spinidens?* (Quoy and Gaimard), *S. gibbus* (as *Scarus* sp.) and *S. rubroviolaceus* (as unnamed juvenile scarid, plate no. 84) in Burgess and Axelrod (1973, pp 628, 631); *C. bicolor* (as *B. bicolor*), *Leptoscarus vaigiensis?* (Quoy and Gaimard) (this identification is questionable, it may be a *Scarus* species), *S. frenatus*, *S. tricolor/forstent?* (as *S. leptodus* Jenyns) and *Calotomus japonicus* (Cuvier and Valenciennes) in Burgess and Axelrod (1974, p 984-995).

With the exception of the notes on *S. sordidus* and *S. brevifilis* by Schultz (1958), accounts of the ontogeny of juvenile colour patterns are almost completely lacking. The notes of Schultz (1958) are of limited use as the descriptions were based only on preserved material.

There has been considerable confusion in the identification of juvenile scarids. Fortunately, only a few juveniles have been described as new species, thus alleviating some of the problems encountered in the identification of adults where different names have been ascribed to the sexually dichromatic adult phases. However, several examples have been noted: *S. barborus* Jordan and Evermann, which represents the juvenile of *S. perspicillatus* Steindachner (Schultz, 1958, p 59); *S. randalli* Schultz, the description of which was based upon the juvenile and initial phase stages of *S. frenatus*; *S. ocellatus* Valenciennes and *S. ophthalmistius*, which are the juvenile phase of *Cetoscarus*

bicolor (Randall & Bruce, 1983), and *S. leucotaeniata* Fowler, which is a juvenile of an unknown species (Randall & Bruce, 1983).

When identifying juvenile scarids, one is immediately faced with the main problem in scarid systematics, that is, the lack of suitable external taxonomic characters. This problem is more apparent in juveniles than in adults as distinctive adult characteristics (e.g. coloured dental plates, humps, and filamentous extensions on the caudal fins) are absent and colour patterns are less consistent. In juveniles, the colour pattern changes with size. In many species, a wide range of patterns may be displayed depending upon the situation, with solitary, schooling or shocked individuals displaying different patterns, some of which may be shared by several species (Table 4.1). In addition, in most species, the juvenile colour patterns bear little resemblance to the initial phase or terminal phase colour patterns.

Meristic data can only be used in identifying juvenile scarids above 14-17 mm S.L. as the scale and pectoral fin ray counts above this size differ little from those of the adult. However, despite the problems noted above, the major distinguishing feature of most juvenile scarids is the colour pattern, as this is the only available character for field identifications and is relatively distinctive in many species.

Descriptions of the colour patterns of juvenile scarids in this chapter are based on live and preserved material and where possible, changes in the colour pattern throughout ontogeny are described. Notes on the behaviour and habitat preference of juvenile scarids in the study area are included as aids for field identifications.

Table 4.1 Variability in the colour patterns of some juvenile *Scarus* species.

Colour pattern †	<i>S. bleekeri</i>	<i>S. gibbus</i>	<i>S. sordidus</i>	<i>S. flavipectoralis</i>	<i>S. ghobban</i>	<i>S. globiceps</i>	<i>S. longipinnis</i>	<i>S. psittacus</i>	<i>S. rivulatus</i>	<i>S. rubroviolaceus</i>	<i>S. schlegelii</i>	<i>S. spinus</i>	<i>S. tricolor</i>	<i>S. sp.</i>
Uniformly black	(+)(+)(+)										'+'(*)			
Black; white C. and C.P.	(+)													
Black; white ring on C.P.														
Black; pale crescent on C.P.														
Three dark stripes (III)					+	+	+		+	+	+		'+' +	
III; medial lines fuse in C.P.					+				+				.	
III; pectoral line absent on cheek													+	
III; white belly						+	+		+	+			+	
III; golden lines, white belly						+							.	
III; golden body						+							.	
III; golden snout													.	
III; golden anterior orbital stripe													.	
III; golden C. and C.P.					+								.	
Four dark stripes (IV)	+	+					+		+	+			.	
IV; black stripes and black fins													.	
IV; medial fuse at caudal													.	
IV; pale C. and C.P.													.	
IV; very dark pectoral stripe													'*'	
IV; one dark vertical band													'*'	
Five dark stripes (V)													'*'	
V; 2 medial stripes dark at caudal extremity													'*'	
V; dorsal division dashed													+	
V; white ring in C.P.													+	
Pale; metallic brown stripes †													'*'	
Pale; metallic blue bands													+	
Golden; metallic blue bands													+	
Vertical bands (4-7) = V.B.	(+)				(*)	*					(+)		.	
Dark body; pale V.B.											(+)		.	
Brown body; pale C., C.P. and bands	(+)												.	
Golden body; blue V.B.													.	
Pale body; dark V.B.													.	
Pale body; dark V.B. and C.													.	
Dark brown; pale belly													.	+
Golden; pale belly													.	
Olive hue													.	
Olive hue, dark scale edges													.	
Brown; red fins													.	
Uniformly fawn/tan													.	
Fawn; brown dots ⊙													.	
Golden hue													.	
Uniformly brown													.	
Uniformly pale brown													.	
Dark; grey snout													.	
Dark; golden snout													.	
Brown/grey; dark scale edges													.	
Golden; pale belly, yellow C.													.	
Olive; pale belly													.	
Pale; dark mid C.													.	
Dark brown; dark mid C.													.	
Fawn; pale yellow C.													.	
Pale olive; yellowish C., C.P. & flank													.	

Legend:

- . - infrequent ' ' - particularly small individuals (< 20 mm S.L.)
 + - frequent () - particularly large individuals (> 20 mm S.L.)
 * - predominant ⊙ - parasites or parasitic scars
 C. - Caudal fin C.P. - Caudal Peduncle
 † - Some colour patterns may occur simultaneously. Only major colour patterns are included. Some species-specific patterns are included.
 ‡ - Occupying the site of previously pale interspaces.

4.2 Materials and Methods

The main study and collection areas were on reefs around Lizard Island (14°38'S, 145°28'E.), although specimens were collected from several other reefs in the vicinity of Lizard Island, Cairns and Townsville. The study period extended from June 1981 to January 1984, with field work being concentrated during the summer months (i.e. November to January, the peak settlement period). Field observations were made using S.C.U.B.A., with notes recorded on PVC sheets. Size and individual variations in colour pattern enabled individuals of some species to be recognised for periods of up to two years. Schooling species or those with variable colour patterns were tagged using subcutaneous injections of paint, following the technique of Thresher and Gronell (1978). Several species were maintained in aquaria to follow changes in their colour patterns during ontogeny.

Specimens were collected using a variety of techniques. Fish under 11 mm S.L. were collected using small (220 X 125 mm), clear self-seal polythene bags. These were held open and the fish guided into the bag by hand. Fish between 11 and 35 mm S.L. were captured using large, clear polythene bags (940 X 615 mm). These bags were used as traps, with the mouth held open by coral or coral rubble. This technique is most efficient for smaller fishes. Above 35 mm S.L. the fish were either speared, using a modified Hawaiian sling and multiprong spear or caught using a small mesh (14 mm) barrier net and hand-net. Specimens were fixed in 10% seawater-formalin and stored in 70% alcohol.

Photographic records were taken of representative specimens of each species using a modified "Randall technique". Specimens were killed by placing them in a deep freeze. Immediately after death, specimens were placed on a polystyrene base. Their fins were raised and held in place by strips of polythene secured by pins and irrigated with 40% formaldehyde for approximately 5 minutes. Care was taken to keep the eye moist, but not fixed. The specimens were then photographed in a vertical photographic tank.

4.3 Results

4.3.1 Meristic Data

The most useful meristic data for identifying species of juvenile scarids are the pectoral fin rays, median predorsal scales, number of cheek scale rows and number of scales in each row. Detailed analyses of median predorsal and cheek scales (in Choat & Randall [in prep]) have revealed consistent differences between most G.B.R. species. These data are of considerable value in identifying juvenile scarids. Pectoral fin ray counts may be used at any size. The median predorsal scales are the first head scales to develop and may be counted at approximately 14 mm S.L. The cheek scales give consistent results in specimens above 17 mm S.L.

Juvenile scarids may be separated from labrids by the dorsal, anal and caudal fin ray counts, and in larger individuals, by the presence or absence of protruding canine teeth (the fin ray data for both families are summarized in Leis & Rennis, 1983).

4.3.2 Field observations

Field identifications were based on both behaviour and colour patterns. The behaviour is of particular value in separating recently settled scarids and labrids. *Scarus* species have a characteristic form of swimming, especially when disturbed, with the rear part of the body curled into a 'C'-shape. In this position, they drift from cover to cover propelled by the pectoral fins, periodically reversing the flexation of the body. Labrids may curl in similar manner, but typically do so for much shorter periods of time. Labrids primarily swim in short spurts with the body remaining straight, or with a slow undulating motion. Some species (e.g. *Coris variegata* (Rüppel)) occasionally oscillate vertically between spurts of movement. The 'C'-shaped position was displayed by all *Scarus* species observed. This behaviour ceases at about 11-12 mm S.L. after which a typical labridiform swimming motion predominates. The swimming motion of *Calotomus*, *Cetoscarus* and *Hipposcarus* differs from *Scarus* species, and will be described in Section 4.3.4. Solitary or schooling behaviour is relatively consistent within a species and aids in field identifications.

The colour patterns of juvenile scarids fall into two main groups, those that are species specific (in the study area) and those that are shared by several species. Species with species specific colour patterns include: *S. brevitllis*, *S. dimidiatus*, *S. frenatus*, *S. niger*, *S. oviceps*, *Calotomus carolinus*, *Cetoscarus bicolor* and *Hipposcarus longiceps*. Species which share some, but not all, colour patterns include: *S. bleekeri*, *S. gibbus*, *S. sordidus*, *S. flavipectoralis*, *S. ghobban*, *S. globiceps*,

S. longipinnis, *S. psittacus*, *S. rivulatus*, *S. rubroviolaceus*,
S. schlegeli, *S. spinus*, *S. tricolor (forsteni)* and *Scarus* sp.
(cf. *lunula*).

Species in the first group are easily recognized even at a small size. For example, *S. frenatus* and *S. niger* can be identified shortly after settlement (the colour patterns closely resemble those of the individuals in Figs 4.7 A and 4.11 A). Likewise, *Calotomus* and *Cetoscarus* can be identified by their color patterns at 12 and 11 mm S.L. respectively.

Species in the second group are more difficult to identify in the field. At a small size (<15 mm S.L.), they have a 'typical' scarid pattern (described in Section 4.3.3) and at this stage, few species are distinguishable. In addition, some labrids closely resemble scarids during the early post-settlement period. The two families can, however, be separated to some extent by colour patterns, as many juvenile labrids possess ocelli on the dorsal and anal fins. Such ocelli are lacking in scarids, with the exception of *Cetoscarus bicolor*. Labrids also have a more angular snout. Some juvenile labrids have distinctive colour patterns. Striped juvenile labrids have only three main stripes, with the middle (orbital) one being most marked (Masuda & Tanaka, 1962). The ventral stripe of scarids, as described below, is lacking. To identify larger individuals of the species in the second group in the field, it is often necessary to follow an individual for some time to discover the range of colour patterns exhibited. In some species, the range of colour patterns and their frequency of occurrence are characteristic of the species, even though the

individual colour patterns may be shared by several other species. The range of colour patterns displayed by the species in the second group is shown in Table 4.1.

4.3.3 Colour patterns

All the species of *Scarus* examined share a common colour pattern. This is most apparent shortly after settlement but varies in extent between species. Recently settled scarids possess a row of pale dots along the base of the dorsal and anal fins and on the caudal peduncle (Fig. 4.1 A). Shortly thereafter, two additional rows are apparent on either side of the midline (Figs 4.1 B, 4.7 A). The pattern of dots forms both vertical and horizontal rows. As the fish grows, the areas between the rows of pale dots darken especially along the horizontal rows (Fig. 4.1 C). This results in four dark dashed lines (Fig. 4.1 D).

Depending on the species, these dashes may fuse to form dark longitudinal stripes (the medial rows fusing first) as in *S. gibbus*, *S. psittacus*, *S. rivulatus* and *S. globiceps*, or subdivide to produce further dashed lines which then fuse, as in the dorsal stripe of *S. sordidus* and *S. spinus* (Figs 4.1 A, 4.14 A). Alternatively, the dashes may become diffused and form vertical bands as in *S. dimidiatus* and *S. longipinnis*. These patterns are not fixed as individuals of several species display both striped and vertically banded patterns or a mixture of the two, as in *S. frenatus* and *S. rubroviolaceus* (Figs 4.8 B, 4.15 A, B). *S. niger* is an exceptional species in that although the pale dots are apparent, the dashed lines do not form. In this species, the characteristic dark ventral surface and pale spots develop shortly after settlement

Figure 4.1

A series of diagrams showing the ontogenetic changes in the colour pattern of juvenile *Scarus* species leading to the formation of the four primary stripes shown in Figure 4.2. These diagrams are based on *S. frenatus* and *S. spínus*. Approximate lengths: A) 9-10 mm S.L. B) 10-11 mm S.L. C) 11-13 mm S.L. D) 13-16 mm S.L. E) 20 mm S.L.

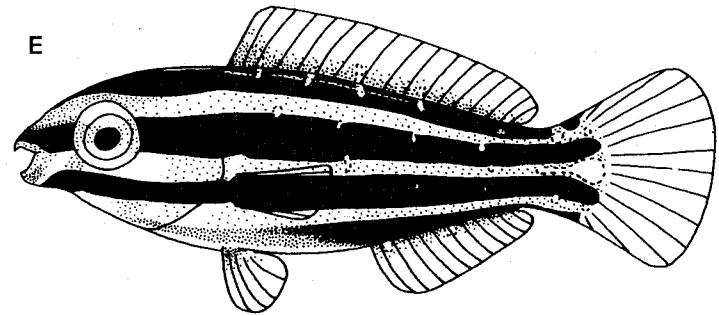
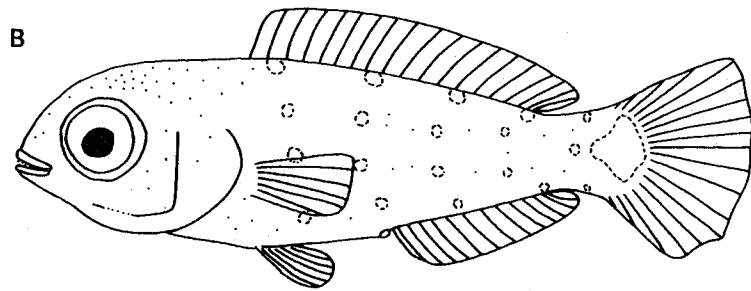
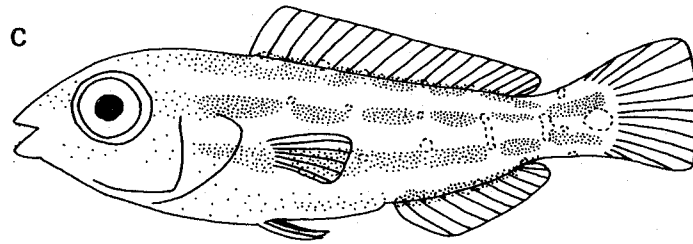
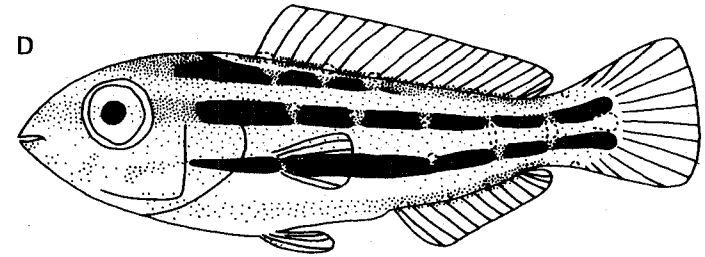
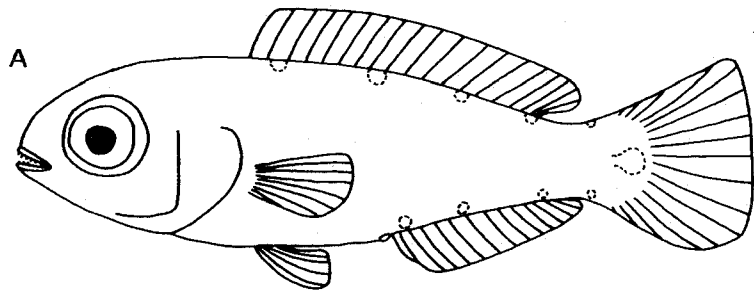
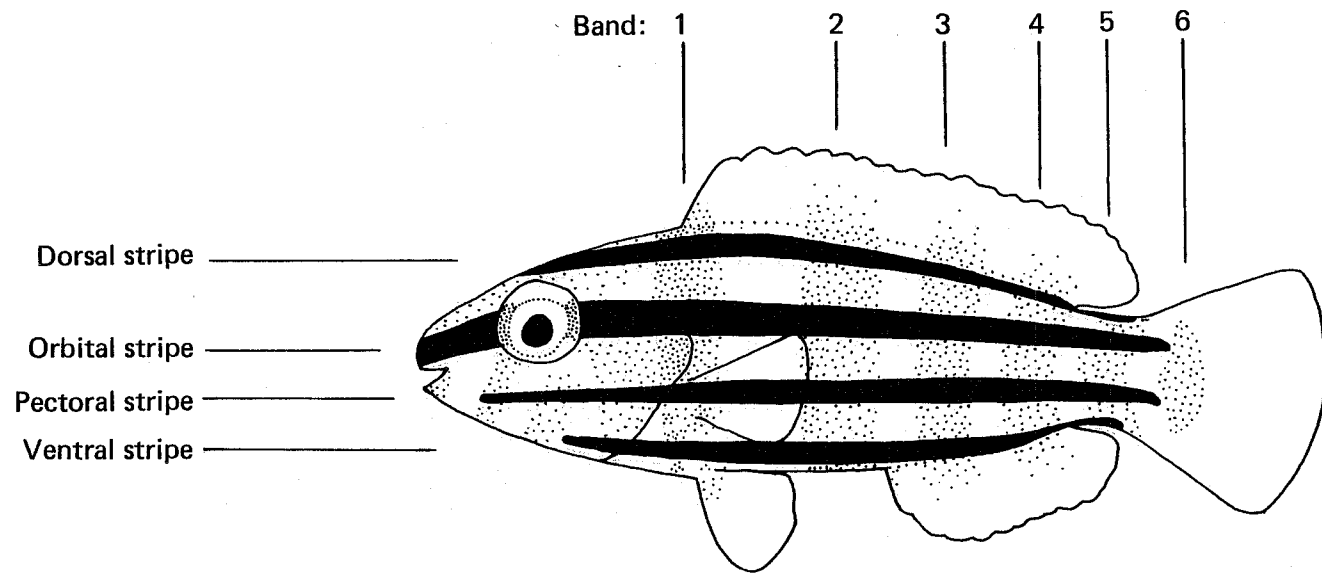


Figure 4.2

The 'typical' colour pattern of a juvenile *Scarus* species showing the position of the four primary dark longitudinal stripes (solid) and the six vertical bands (stippled).



(Fig. 4.11 A). The pale dots are lost with increasing size in most species, but remnants are retained in *S. rubrovittaceus*, *S. tricolor*, *S. brevilittis* and some colour phases of *S. sordidus*.

The fusion of the four dashed lines produces four dark body stripes. These are designated here as the dorsal, orbital, pectoral and ventral stripes (Fig. 4.2). The dorsal stripe extends from the dorsal part of the snout, passes along the dorsal flank, near to the base of the dorsal fin, and terminates either at the posterior extremity of the dorsal fin base or on the dorsal edge of the caudal peduncle. The orbital stripe arises from the snout, passes through the orbit and terminates on the dorsal part of the caudal peduncle at the base of the caudal fin. The pectoral stripe extends from the lower jaw articulation, passes over the cheek, through the pectoral fin base and terminates on the ventral part of the caudal peduncle at the base of the caudal fin. The ventral stripe extends from the base of the operculum (in the interopercular region), passes along the ventral flank (belly) and terminates either at the base of the anal fin or on the ventral edge of the caudal peduncle. Pale spots which correspond with the pale dots found in recently settled and early dashed phase individuals may remain in either the dark stripes or the pale interspaces.

Most *Scarus* species possess the four primary juvenile stripes, although there is some degree of between-species variation in the form, location, size and intensity of these stripes. The main variation in form is found in the dorsal stripe. As noted above, it may divide during the dashed phase to produce two stripes. In this situation the ventral division remains in the normal dorsal stripe

position, whereas, the dorsal division arises from a point between the orbits and passes along the dorsal mid-line at the base of the dorsal fin, before fusing with the ventral division at the posterior base of the dorsal fin (Fig. 4.1 E). When viewed from above, the dorsal division appears as a single stripe.

Variation in the location of stripes is also most notable in the dorsal stripe. In most species, there is a distinct gap between the dorsal stripe and the base of the dorsal fin although in some species, the dorsal stripe remains relatively close to the base of the dorsal fin (e.g. in *S. rubrovolaceus* and *S. frenatus*). Variations in the size and intensity of these stripes are complex, often as a result of changes during ontogeny. However, in some species, the size and intensity may be diagnostic or characteristic, as in *S. rubrovolaceus* and *S. psittacus*.

It should be noted that the stripes described above are lost with growth and are not related to scale row stripes present in the initial phases of some species (e.g. *S. frenatus*).

As with juvenile body stripes, vertical bands, if present, have a 'typical' *Scarus* pattern (Fig. 4.2), which reflects the pattern of pale dots found in recently settled and small dashed phase individuals (as in *S. oviceps*, Fig. 4.9 B, *S. longipinnis*, Fig. 4.10 B and *S. schlegelii*, Fig. 4.13 B). The maximum number of vertical bands displayed by most species is six, although there may be up to seven dark vertical bands as in *S. longipinnis* (Fig. 4.10 B). The first band passes from the region of the first dorsal spine to the base of the pelvic fin, passing through the base of the pectoral fin. The second band passes from the dorsal fin to an area

mid-way between the pelvic fins and anal fin, occasionally extending to the first spine of the anal fin. In species with seven bands, it is the second band that subdivides dorsally to produce the extra band. The third band passes from the mid/posterior part of the dorsal fin to the mid/anterior part of the anal fin. The fourth band connects the posterior regions of the dorsal and anal fins. The fifth band crosses the caudal peduncle, and the sixth band lies at the base of the caudal rays. This band may be triangular in shape with an anteriorly pointing apex.

Between each vertical band, the pale interspaces follow the pale dots described in newly settled and early dashed phase individuals. These pale dots frequently remain as pale highlighted areas in larger juveniles. In some species (e.g. *S. ghobban* and *S. schlegelii*), these interspaces are relatively narrow and give an overall appearance of thin pale vertical bands on a darker background. The vertical bands may be straight as in *S. bleekeri* and *S. ghobban*, but in most species, they have a medial curve or flexation. The bands typically extend over the dorsal and ventral halves of the body, but may be lost ventrally as in *S. dimidiatus* and *S. oviceps*. As with the juvenile stripes, the full number of vertical bands is not always present. The bands may represent one of a series of possible colour patterns as in *Scarus* sp., or be incompletely formed as in *S. dimidiatus* and *S. oviceps*. The bands on the caudal peduncle, in particular, are often poorly developed or absent as in *S. schlegelii*, *S. bleekeri*, *S. dimidiatus* and *S. oviceps*. Vertical bands are, however, retained in the initial phase of some species (e.g. *S. bleekeri*, *S. dimidiatus*, *S. ghobban*, *S. longipinnis*, *S. oviceps*, *S. schlegelii* and *S. sptnus*) and in the

terminal phase of *S. longipinnis*.

4.3.4 Species descriptions

The species descriptions in this section follow a standard format, with sub-headings: Material examined, Meristics, Diagnosis, Ecological notes and Remarks.

The *Material examined* refers to the fixed specimens examined in this study. In addition, numerous live specimens were examined in the field and in aquaria. The colour notes are based primarily upon live specimens.

The *Meristics* refer to scale and fin ray counts of the fixed specimens noted above. The terminology follows that of Randall and Bruce (1983). Pectoral fin ray counts are therefore, expressed as 15 rather than ii, 13.

The *Diagnosis* is a summary of the main diagnostic or characteristic features of the species and is intended as a basic guide for field identifications.

The *Ecological notes* are brief notes on the ecology of the species which aid field identifications. Unless specified otherwise, they refer to observations on reefs around Lizard Island.

The *Remarks* include: detailed notes of the colour patterns, notes on the ontogeny of the colour patterns, records of any unusual behaviour or ecological traits, additional notes on how to separate the species from closely related species and notes on the colour patterns of preserved specimens.

Species Descriptions

Scarus bleekeri (de Beaufort)

(Figs 4.3 A, B, C)

Material examined: 4; 33-54 mm S.L.

Meristics: Median predorsal scales 4, no anterior pair, anterior 2 scales largest; cheek scale rows 2; pectoral rays 15.

Diagnosis: Small individuals have four dark brown primary stripes, larger individuals have a dark brown body, occasionally with pale vertical bands. All sizes with distinct pale, off-white caudal fin and caudal peduncle.

Ecological notes: Uncommon; solitary, occasionally joining small multispecific schools; site attached. Found in the lagoon (1 specimen, 3 m, Lizard Island) but typically on reef slopes at depths between 3 and 9 m, in gullies or areas of complex coral rubble. On seaward slopes at Lizard Island and back reefs of outer barrier reefs.

Remarks: This species closely resembles *S. sordidus*, but can be distinguished from this species by the pale caudal fin and caudal peduncle, and the lack of a dorsal division of the dorsal stripe. Below 25 mm S.L., the orbital and pectoral stripes in the caudal region are pale. Above 25 mm S.L., the striped pattern is less distinct and caudal fin and caudal peduncle are uniformly pale. Above 40 mm S.L., these areas begin to darken and a range of colour patterns may be displayed (Table 4.1), including some initial phase patterns (e.g. pale vertical bands on the body).

In alcohol, the live patterns are retained but the pale areas turn grey and the dark areas or stripes fade.

Scarus gibbus ["]Ruppell

(Figs 4.4 A, B, C)

Material examined: 22; 12.5 to 90 mm S.L.

Meristics: Median predorsal scales 4, no anterior pair, anterior 2 scales largest; cheek scale rows 3, 3 to 8 scales in ventral row; pectoral rays 15 to 17 (usually 16).

Diagnosis: Four dark primary body stripes, thin in small individuals, relatively wide in large individuals. The dorsal, anal and caudal are black above 20 mm S.L. The pale interspaces are white in small individuals and creamy-white to yellowish in larger individuals.

Ecological notes: Moderately common; solitary, although may join small multispecific schools when small; site attached. Usually occurs in deep water (4 to 12 m), most frequently on, or at the base of, the reef slope, over coral rubble. A few individuals have been observed in the lagoon and on the reef crest at Lizard Island.

Remarks: A complete series of specimens from 12.5 mm to 90 mm S.L. has been examined (and from 11 mm to 180 mm in the field). In the dashed phase the body is white with black dashes and the fins are hyaline. The dashed lines on the body fuse at about 13 - 14 mm S.L. Above this size, the dashed lines in the dorsal and anal fins fuse and begin to expand. With growth, the black body stripes become relatively broader and the black bases of the dorsal, anal and caudal fins expand. At 20 mm S.L., the dark body stripes and pale interspaces are of approximately equal size (Fig. 4.4 A). Above this length, the overall appearance is one of pale stripes on a black background. Above 40 mm S.L. these

pale interspaces darken, resulting in a uniform black pattern. This uniformly black phase continues until about 80 mm S.L. when a pale crescent appears in the caudal fin. Above 80 mm S.L., the dark body slowly fades, giving way to the initial phase colour pattern which appears at about 150 mm S.L.

In alcohol, the patterns resemble those of live specimens, although the black stripes fade to dark grey and the pale interspaces turn pale grey.

Scarus sordidus Forsskål

(Figs 4.5 A, B)

Material examined: 49; 8.2 to 14.6 mm S.L.

Meristics: Median predorsal scales 4, no anterior pair, anterior scale largest; cheek scale rows 2; pectoral rays 14-16 (usually 15).

Diagnosis: A variable species, typically bearing five dark stripes on body, upper division of dorsal stripe dashed when small (< 21 mm S.L.) and lying along dorsal mid-line. Caudal extremities of orbital and pectoral stripes dark, fusing in larger specimens. Caudal base and caudal peduncle often pale with the exception of the dark caudal extremities of the orbital and pectoral stripes.

Ecological notes: Common; in small (5-15) mono- or multispecific schools, occasionally solitary or in large (25+) schools, site attached when small. Found in all reef habitats over all substratum types from 1-14 m, with the exception of open sand. At Lizard Island, it is abundant in the lagoon. Present on inner mid- and outer shelf reefs.

Remarks: A full series of juvenile *S. sordidus* from 8.2 to 146 mm S.L. have been examined, both in the field and in preserved

collections. There is little colour change during ontogeny, the body or pale interspaces remain off-white and the dark stripes remain black, brown or dark green-brown (Figs 4.5 A, B). The colour patterns, however, vary greatly. The basic colour patterns, follow the 'typical' scarid forms described in Section 4.3.3 (Figs 4.1, 4.2). The dashes in the orbital and pectoral lines start to fuse at about 12 mm S.L. with complete fusion of all lines (stripes) by 21 m S.L. At this size, a darkening of the caudal extremity of the orbital and pectoral stripes may be apparent in some individuals.

In progressively larger specimens, the body and fins darken, and above 32 mm S.L., the body and fins may be uniformly black. By 40 mm S.L., the fusion of the caudal extremities of the orbital and pectoral stripes forms a characteristic dark spot at the caudal fin base, which is surrounded by a pale off white ring (indistinctly visible in Fig. 4.5 B). At this size, a wide range of patterns may be displayed, from uniformly black to striped, with or without the characteristic dark spot at the base of the caudal fin (Table 4.1). This species frequently changes its colour patterns rapidly, often in less than two seconds. A double row of pale dots on the side of the body, as displayed by IPs, is occasionally displayed in juveniles above 50 mm S.L. The blunt snout becomes increasingly distinct in specimens above 30 mm S.L.

S. sordidus is easily identified when displaying the diagnostic dark spot at the caudal base surrounded by a pale ring. However, two common colour phases of *S. sordidus* are also displayed by other species (Table 4.1). When uniformly black,

S. sordidus may be mistaken for *S. schlegelii*, at sizes below 30 mm S.L., or *S. spinus*, *S. bleekeri* and *S. gibbus* at sizes above 30 mm S.L. *S. schlegelii*, *S. spinus* and *S. gibbus* can be separated from *S. sordidus* using meristics but they can also be separated in the field. *S. sordidus* has a more rounded snout and deeper body than *S. schlegelii* and *S. spinus*, although this may be difficult to assess in solitary specimens. For a positive identification of a uniformly dark specimen, prolonged observations are usually necessary. *S. schlegelii*, *S. bleekeri* and *S. gibbus* all possess unique colour patterns and *S. sordidus* frequently exhibits the unique pale ring on the caudal peduncle and caudal fin (>30 mm S.L.), especially if disturbed. If a uniformly black pattern is maintained by a large specimen (> 50 mm S.L.) for a prolonged period (hours or days), the specimen is likely to be *S. spinus*, although meristic analyses are required before a positive identification can be made.

In the striped colour phase, small (<30 mm S.L.) *S. sordidus* are difficult to distinguish from similarly sized *S. spinus* (see Remarks under *S. spinus*). There are, however, several slight differences that separate the two species. In *S. sordidus*, the dashes in the dorsal division of the dorsal stripe fuse earlier than in *S. spinus* (i.e. at about 20 mm S.L. cf. 27 mm S.L. in *S. spinus*), the dark stripes are often paler in *S. sordidus* and the dark caudal extremities of the orbital and pectoral stripes are less intense than in similarly sized *S. spinus*, especially in specimens below 20 mm S.L. In addition, *S. sordidus* typically has a deeper body and lacks the white patch at the base of the caudal fin, which is present in *S. spinus*. This patch is faintly

visible in Figure 4.14 B (cf. Fig. 4.5 A). Despite these differences, it is often necessary to collect the specimen for meristic analysis to ensure an accurate identification. Other species, which display a striped pattern with dark caudal extremities of the orbital and pectoral stripes include *S. globiceps* and *S. sp* (cf. *lunula*). These species may be initially confused with *S. sordidus*, however, this colour pattern is only rarely displayed by these species. Both species can be easily distinguished from *S. sordidus* (and *S. sptnus*) by their pale body and their lack of a dorsal division of the dorsal stripe.

In alcohol, small specimens of *S. sordidus* retain the dashes or stripes. The body is typically off-white or grey with dark grey stripes. The dark caudal extremities of the orbital and pectoral stripes remain and are often prominent. Larger specimens (> 40 mm S.L.), have a dark body and fins and typically bear a dark patch at the base of the caudal fin surrounded by a paler area.

The identification of extremely small *S. sordidus* (<15 mm S.L.) may be supported by an examination of the upper pharyngeal tooth rows. *S. sordidus* possesses three rows on each upper pharyngeal bone, whereas 'frenatus' group species (including *S. sptnus*) typically possess only two rows (Section 2.5). Detailed notes on the biology of juvenile *S. sordidus* are given in Chapter 6.

Scarus breviflilis (Günther)

(Figs 4.5 C, 4.6 A, B, C)

Material examined: 12; 15 to 54 mm S.L.

Meristics: Median predorsal scales 6, no anterior pair, scale sizes decrease anteriorly; cheek scale rows 3, usually 2-3 in ventral row; pectoral rays 15 (occasionally 14).

Diagnosis: Snout yellow-orange. Below 30 mm S.L. body and fins with black and white flecks. Above 30 mm, body grey to brown with white flecks; dorsal, anal and pelvic fins with dark flecks; caudal and caudal peduncle white.

Ecological notes: Uncommon; solitary, site attached and often aggressive to other scarids especially conspecifics. Occurs on back reef bommies of outer reefs. At Lizard Island, occasionally recorded in the lagoon but most often on moderately exposed reef slopes. Usually occurs in relatively shallow water (1-7 m).

Remarks: *S. breviflilis* is one of the more easily identified juvenile scarids. It has a distinctive colouration and does not undergo rapid colour changes. The yellow colouration of the snout is visible at 13 mm S.L. and persists throughout the juvenile phase. At 12 mm S.L., the body is pale with a few (5-7) large black and white flecks approximately the size of the orbit. These flecks decrease in relative size with growth and at 14 mm S.L. are about the size of the pupil. At this size, a white patch similar to that of larger *S. niger* (Fig. 4.11 B) is present at the base of the caudal fin rays. Above 15 mm S.L., this patch fades (the remnants are shown in Fig. 4.5 C), the flecks on the body fuse to form broken stripes (as in Fig. 4.5 C) and the dorsal, anal and pelvic fins become mottled.

Above 27 mm S.L., the colour of the caudal and caudal peduncle slowly fades and turns white, the body darkens until only a few white flecks remain (although the motled pattern in the fins remains distinct) and the colour of the snout deepens to orange/yellow to tan (Fig. 4.6 C). Above 50 mm S.L., the body and fins darken and gradually take on the IP colouration which is complete at approximately 140 mm S.L.

In alcohol, the pale snout, caudal and caudal peduncle and the dark body flecks and mottling of the fins remain distinct. The white body flecks are most visible in large dark individuals.

Scarus dimidiatus Bleeker

(Fig. 4.9 A)

Material examined: 3; 17 to 53 mm S.L.

Meristics: Median predorsal scales 6, no anterior pair, scales subequal; cheek scale rows 3, 2-4 in ventral row; pectoral rays 14.

Diagnosis: Body yellowish to yellow, whitish ventrally with five broad slightly diagonal bands on the upper half of the body. These bands are wider than the interspaces and become increasingly distinct above 20 mm S.L.

Ecological notes: Uncommon; solitary, site-attached, occasionally joins small multispecific schools. In sheltered shallow (1-5 m) back-reef and lagoonal areas, in large stands of arborescent coral (*Acropora* spp). On the outer reefs, observed in back-reef and reef-flat areas in live coral (*Acropora* spp and *Porite cylindrica*).

Remarks: *S. dimidiatus* is a distinctive species, characterized by a yellow body and five dark bands in the upper half of the body.

These bands correspond to bands 1, 2, 3, 4 and 5 of the 'typical' scarid banding pattern (Fig. 4.2). The bands vary in intensity. In small specimens, they are often extremely faint and in large specimens, bands 4 and 5 are often indistinct. In specimens below 35 mm S.L., the bands may extend onto the lower half of the body (as in Fig. 4.9 A). In larger specimens, the bands are restricted to the upper half of the body and extend into the dorsal fin. The presence of 4-5 clearly visible bands and the lack of a dark orbital stripe separate this species from the closely related *S. outceps*.

In alcohol, the body is yellow-green to grey with brown bands. At 17 mm S.L., the bands are restricted to the dorsal part of the body near to the base of the dorsal fin. At 30.5 mm S.L., they extend (faintly) onto the lower half of the body, and at 53 mm S.L., were restricted to the upper half of the body and along the basal part of the dorsal fin.

Small specimens of *S. dimidiatus* were observed on several occasions in schools of yellow damselfishes (*Pomacentrus popei* and *P. ambionensis*), occasionally feeding within the school, possibly on damselfish faecal pellets, as recorded in adult *S. outceps* by Bailey and Robertson (1982).

Scarus outceps Valenciennes

(Figs 4.9 B, C)

Material examined: 3; 32 to 73 mm S.L.

Meristics: Median predorsal scales 6, no anterior pair, scales subequal; cheek scale rows 3, 2-3 ventral row; pectoral rays 14.

Diagnosis: Body yellow to yellowish, whitish ventrally, with dark orbital stripe from snout to opercular edge. A dark area dorsal to this stripe extends to the anterior rays of the dorsal fin. Four slightly diagonal bands present on upper half of body but often indistinct. The bands are wider than the interspaces.

Ecological notes: Uncommon; solitary, site attached. Recorded at Lizard Island and on outershelf reefs from the reef flat, back-reef and lagoon, in shallow water (1-5 m), in areas with a heavy cover of arborescent live coral (especially *Acropora* spp).

Remarks: In all the specimens of *S. oviceps* observed (smallest=25 mm S.L.), the short, dark orbital stripe was present. The dark area dorsal to this stripe includes the upper half of band-1 of the 'typical' scarid banding pattern (Fig. 4.2) and is of variable intensity. The dark bands on the upper half of the body, correspond to bands 2, 3, 4 and 5 of the 'typical' scarid pattern (Fig. 4.2). These bands are often indistinct, especially bands 4 and 5. The short, dark orbital stripe and dark area dorsal to it, distinguishes this species from the closely related *S. dimidiatus*. The dark bands of *S. oviceps* are also broader than those of *S. dimidiatus*.

In alcohol, the body is yellow-green to grey with brown bands. In the 32 mm S.L. specimen, the bands extended into the lower half of the body, in the 73 mm S.L. specimen, however, they were restricted to the upper half of the body. In both specimens, the distinctive orbital stripe and dark patch were retained.

Scarus flavipectoralis Schultz

(Figs 4.8 B, C)

Material examined: 4; 26.5 to 45 mm S.L.

Meristics: Median predorsal scales 4, no anterior pair, anterior scale largest; cheek scale rows 3, 1-2 in ventral row; pectoral rays 14.

Diagnosis: Body elongate, pectoral fin pale yellow. Dorsal, orbital and pectoral stripes present when small, the latter two being darkest. Larger specimens with pale body and dark grey caudal fin.

Ecological notes: Uncommon, solitary, occasionally joining small non-specific schools, may be site attached. At Lizard Island, only recorded from deeper waters (5-14 m). Occurs in exposed and sheltered areas, most frequently over coral rock or rubble near to the base of the reef slope.

Remarks: Small juveniles of *S. flavipectoralis* (<40 mm S.L.) are most easily identified by their elongate, spindle-shaped bodies and the prominent dark orbital and pectoral stripes (Fig. 4.8 B). These stripes may fuse slightly in the caudal peduncle. A dark dorsal stripe is present but is often indistinct and the belly is typically pale. Larger specimens (>40 mm S.L.) have a distinctive grey-brown body and a dark grey-brown caudal fin. The intensity of the caudal fin may, however, vary (it is not, for example, visible in Fig. 4.8 C). *S. flavipectoralis* is able to change its colour pattern (Table 4.1) but does so only infrequently. Changes in the colour pattern are most notable in specimens between 30 and 40 mm S.L., which may have either a striped or plain body colouration. The yellow pectoral fin is a

useful diagnostic feature but is often exceedingly pale in small specimens.

In alcohol, small specimens (26-33 mm S.L.) retain the dark orbital and pectoral stripes and a pale dorsal stripe. Larger specimens (44 + 45 mm S.L.) have a pale body with dark patches where the 'typical' scarid bands and stripes intersect (Fig. 4.2). The fins have no distinctive markings.

Scarus frenatus Lacepède

(Figs 4.7 A, B, C, 4.8 A)

Material examined: 18; 9.0 to 80 mm S.L.

Meristics: Median predorsal scales 6 (rarely 7), scales decrease in size anteriorly, preceded by a pair of nonlaterally overlapping scales; cheek scale rows 3, 2-4 in ventral row; pectoral rays 14 (rarely 15).

Diagnosis: 9-12 mm S.L., yellow green body; 12-24 mm S.L., 3 broad lime green stripes broken by paler dots and irregular pale interspaces; 24-40 mm S.L., body olive green with pale interspaces visible on head, posterior part of body, caudal peduncle and caudal fin pale blue, dorsal and anal fins with red and white flecks; above 40 mm S.L., body olive green to pale red-brown (especially large individuals), pale interspaces on head give impression of a dark longitudinal stripe passing through the orbit, caudal fin and caudal peduncle pale blue to off-white, dorsal and anal fins with prominent red and white flecks.

Ecological notes: Uncommon; solitary, site attached and aggressive towards other scarids, especially conspecifics. In shallow water (1-5 m) in all reef habitats. At Lizard Island and other

mid-shelf reefs, most abundant in the upper reef slope and reef crest region. On outer reefs, recorded from shallow areas of the back reef region.

Remarks: *S. frenatus* is a striking species, with a series of distinctively coloured stages. It is one of the few scarid species that can be accurately identified when recently recruited. From 9 to 12 mm S.L., it is pale yellow-green with a white dot at the base of the caudal fin, and may display a series of small dots (visible in Fig. 4.7 A). At this size, it may be confused with *S. oviceps*, *S. dimidiatus* and at least one species of labrid (*Haltichoeres chloronotus* ?). The latter can be identified in the field by its pointed snout and swimming mode, and by meristics. The two scarid species have not been observed at very small sizes but the smallest specimens examined had a canary-yellow colour rather than the lime-yellow colour of *S. frenatus*.

Between 12 and 24 mm S.L., the overall appearance is of a lime green body with pale narrow lines and dots (Fig. 4.7 B). These lines are the interspaces between broad longitudinal stripes. They give the head an angular appearance, with a pale line above and below the eye, and one down the midline from the base of the dorsal fin into the snout. At this size, white and red flecks are present in the anterior bases of the dorsal and anal fins.

Between 20 and 40 mm S.L., the body darkens and the rear part of the body, the caudal peduncle and the caudal fin turn pale blue. The pale interspaces are only visible on the head and the flecks in the dorsal and anal fins are more extensive (Fig. 4.7 C). Above 40 mm S.L., the body darkens further slowly taking

on a red-brown hue. The caudal and caudal peduncle darken, turning off-white and the pale interspaces on the head fade (Fig. 4.8 A). The intensity of these pale interspaces varies, sometimes highlighting the relatively dark orbital stripe, which passes from the operculum to the snout. The flecks in the dorsal and anal fins are still distinctive but slowly fade as the initial phase colouration develops. The IP colouration is complete at 120 mm S.L.

In alcohol, small specimens (< 20 mm S.L.) have a colour pattern similar to that of live specimens, but with a pale yellow-grey body and broad grey-brown stripes. In some specimens between 10 and 15 mm S.L., the pectoral stripe is wider and darker than the other stripes, and may give the specimen a superficial resemblance to similarly sized *S. rubroviolaceus*. In larger specimens (> 20 mm S.L.), the pale caudal fin and caudal peduncle are indistinct, but the flecks on the body and fins are retained.

Detailed notes on the biology of this species are given in Chapter 6.

Scarus ghobban (Forsskål)

(Fig. 4.10 A)

Material examined: 6; 53 to 86 mm S.L.

Meristics: Median predorsal scales 6, no anterior pair, scale size decreases anteriorly; cheek scale rows 3; 1 in ventral row; pectoral rays 15.

Diagnosis: Dark orange-yellow caudal fin especially below 35 mm S.L., body pale with yellow hue and five narrow pale blue/white vertical bands.

Ecological notes: Uncommon; in small multispecific schools.

Recorded in lagoon (1-3 m) at Lizard island and occasionally over reef flat sargassum beds off Magnetic Island, Townsville.

Remarks: *S. ghobban* displays several colour patterns (Table 4.1) and is able to change colour patterns rapidly. When in schools, this species can be most easily distinguished by its yellow hue, which is more distinct (especially in the fins) and of a deeper shade than that displayed by other schooling juvenile scarid species. The main diagnostic feature is, however, the possession of five narrow pale blue/white vertical bands (Fig. 4.10 A). In juveniles, the intensity of these bands may change rapidly and may on occasion, appear as two rows of pale spots rather than discrete vertical bands. In larger individuals (>50 mm S.L.), blue lines develop along the dorsal and ventral edges of the caudal fin and around the mouth and orbit.

In alcohol, the pale vertical bands are visible but faint. Specimens often possess darker patches corresponding with the 'typical' scarid stripes and bands (Fig. 4.2).

Scarus longipinnis Randall & Choat

(Figs 4.10 B, C)

Material examined: 2; 39 to 75 mm S.L.

Meristics: Median predorsal scales 4, no anterior pair, antermost scale largest; cheek scale rows 3, 1-3 (usually 2) in ventral row; pectoral rays 14.

Diagnosis: Small individuals have seven dark brown vertical bands, larger individuals have a uniform pale mahogany brown body (banding variable). All sizes with distinct dark spot at base of dorsal fin between first two spines and a dark crescent-shaped

patch in the middle of the caudal fin. Long dorsal spines and rays are notable at 75 mm S.L.

Ecological notes: Rare; both specimens in small multispecific schools. The 39 mm S.L. specimen was collected over algal covered rubble (4 m) at Mermaid Cove, Lizard Island. The 75 mm S.L. specimen was collected between large coral boulders at the base of a backreef coral 'bommie' at Carter Reef (9 m).

Remarks: Randall and Choat (1980) recorded this species only from deep water (below 15 m). In this study, only two juveniles were observed and caught, although few observations were made below 15 m. Adults were only recorded on outer barrier reefs below 25 m. Randall and Choat (1980) describe a 35 mm paratype as pale with exceedingly faint dark bars as in adults.

In alcohol, the dorsal spot and dark caudal patch remain. The dark bars remain but fade, except where the orbital and pectoral stripes would pass, thus giving the appearance of two dashed lines. The faded pattern found in preserved specimens is similar to that of some preserved specimens of *S. sp* (*cf. lunula*) and *S. ghobban*.

Scarus niger Forsskål

(Figs 4.11 A, B, C, 4.12 A)

Material examined: 18; 9.5 to 57 mm S.L.

Meristics: Median predorsal scales 7 (occasionally 6), no anterior pair, scales subequal; cheek scale rows 3, 3-4 in ventral row; pectoral rays 14.

Diagnosis: Up to 10 mm S.L., lower half of body dark, upper half translucent, with a series of white pupil-sized dots over body; 10-40 mm S.L., lower portion of body dark with numerous small

pale dots, upper part of body mottled olive green. White patch at base of caudal fin preceded by two dark spots. Caudal peduncle burgundy-red between 30 and 50 mm S.L. Above 40 mm S.L., body dark brown-black, darker ventrally, small pale dots on body fade, caudal peduncle pale brown, white patch at base of caudal diffused and dark dots at base of caudal fade.

Ecological notes: Moderately common; solitary, occasionally in small multispecific schools, site attached, larger specimens aggressive to similarly sized conspecifics. Recorded from reef slope, lagoon and backreef areas of Lizard Island (from 2 to 12 m). Most abundant in deeper water (4-8 m) in relatively sheltered areas, typically over coral rock or rubble near the base of the reef slope. Recorded from backreef areas of outer shelf reefs.

Remarks: *S. niger* has a distinctively marked juvenile phase and is one of the few species that can be accurately identified when recently recruited. Below 9.0 mm S.L., recently recruited *S. niger* have a characteristic row of dark patches along the ventral part of the body. Between 9 and 10 mm S.L., the lower half of the body is dark, the upper half of the body is translucent and a distinctive white dot is present at the base of the caudal fin. A series of white pupil-sized dots on the body correspond to the 'typical' dots found on juvenile scarids (Figs 4.1, 4.11 A).

Above 10 mm S.L., the dorsal part of the body is mottled olive green. In progressively larger specimens, the dark colouration in the ventral part of the body extends dorsally and into the ventral and pelvic fins. The dorsal olive colouration extends

into the dorsal fin and the pale dots on the body decrease in relative size, although they increase in number. These dots may be white or pale blue and may be arranged in horizontal rows, although these rows do not correspond with the pale interspaces of the 'typical' scarid pattern (Figs 4.2, 4.11 B, C). Along the base of the hyaline caudal fin there is a bright white patch, preceeded by two black dots at the bases of the most dorsal and ventral caudal fin rays. The ventral dot is visible at 15 mm S.L. and the dorsal dot at 20 mm S.L. Both dots increase in relative size in progressively larger specimens. The pectoral fin is pale yellow and between approximately 25 and 60 mm S.L. the caudal peduncle often has a deep burgundy colouration (Fig. 4.11 C).

Above 50 mm S.L., the body and fins develop an overall dark hue and the small pale dots on the body are slowly lost. The white patch at the base of the caudal fin diffuses then darkens and the two dark caudal dots fade. The pale yellow pectoral fin is conspicuous at 50 mm S.L. but loses its intensity and darkens in larger specimens. The IP colouration is first displayed at about 90 mm S.L.

In alcohol, *S. niger* retains its distinctive colour pattern. The body is dark brown ventrally and pale brown dorsally. The contrast between the two parts decreases in larger specimens. The pair of dark spots at the base of the caudal fin are distinct but the white caudal patch is indistinct. The pale spots on the body are visible in small specimens but are extremely faint in larger specimens.

Figure 4.3 A

S. bleekeri : 33 mm S.L.

Location : Lizard Island, photographed dead.

Figure 4.3 B

S. bleekeri : 46 mm S.L.

Location : Yonge Reef, photographed dead.

Figure 4.3 C

S. bleekeri : 54 mm S.L.

Location : Lizard Island, photographed dead.



Figure 4.4 A

S. gibbus : 24 mm S.L.

Location : Lizard Island, photographed live.

Figure 4.4 B

S. gibbus : 28.5 mm S.L.

Location : Lizard Island, photographed dead.

Figure 4.4 C

S. gibbus : 40 mm S.L.

Location : Lizard Island, photographed dead.

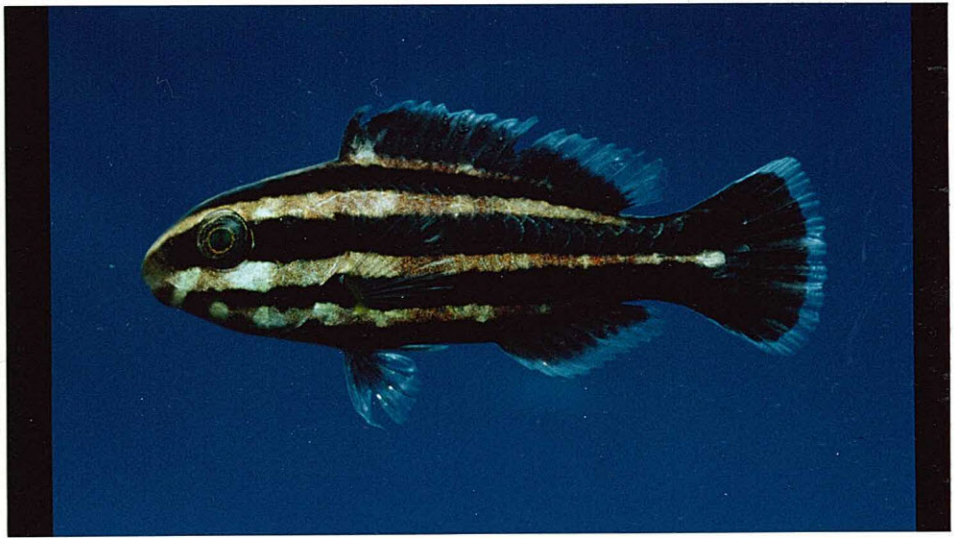
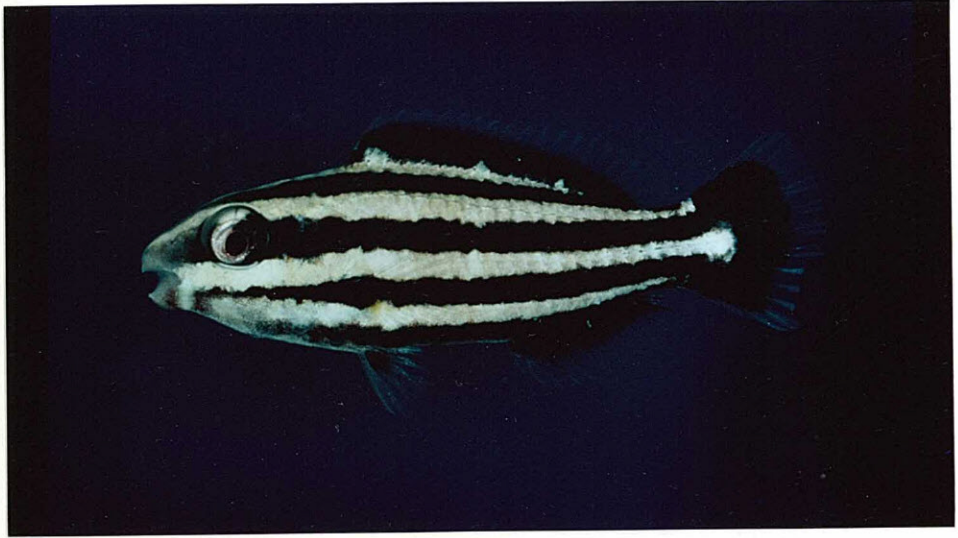


Figure 4.5 A

S. sordidus : 28 mm S.L.

Location : Lizard Island, photographed dead.

Figure 4.5 B

S. sordidus : 40 mm S.L.

Location : Lizard Island, photographed dead.

Figure 4.5 C

S. breviflits : 26 mm S.L.

Location : Lizard Island, photographed live.

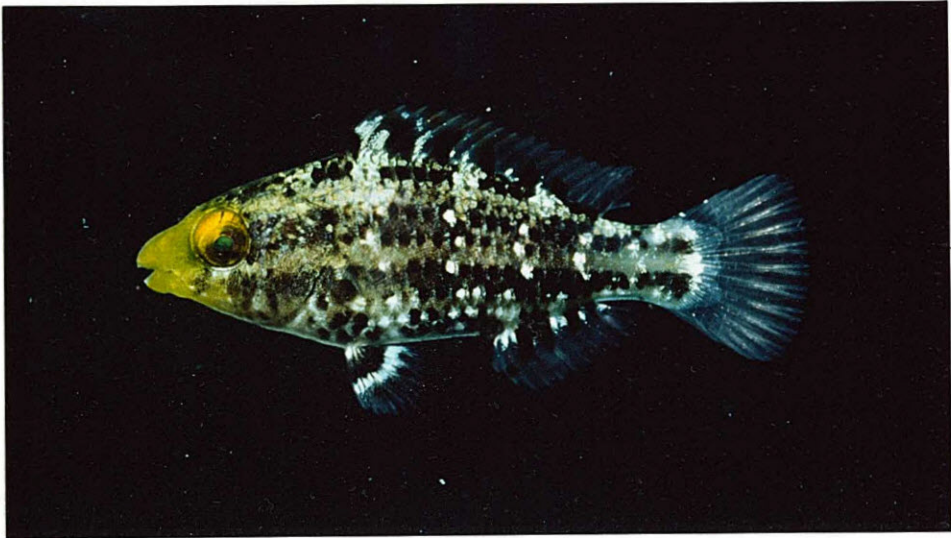


Figure 4.6 A

S. breviflits : 28.5 mm S.L.

Location : Lizard Island, photographed dead.

Figure 4.6 B

S. breviflits : 54 mm S.L.

Location : Lizard Island, photographed dead.

Figure 4.6 C

S. breviflits : approx. 55 mm S.L.

Location : Lizard Island, photographed in the field.
(Photographed by Bill Gladstone)



Figure 4.7 A

S. frenatus : 10.5 mm S.L.

Location : Lizard Island, photographed live.

Figure 4.7 B

S. frenatus : 23 mm S.L.

Location : Yonge Reef, photographed live.

Figure 4.7 C

S. frenatus : 31 mm S.L.

Location : Yonge Reef, photographed live.

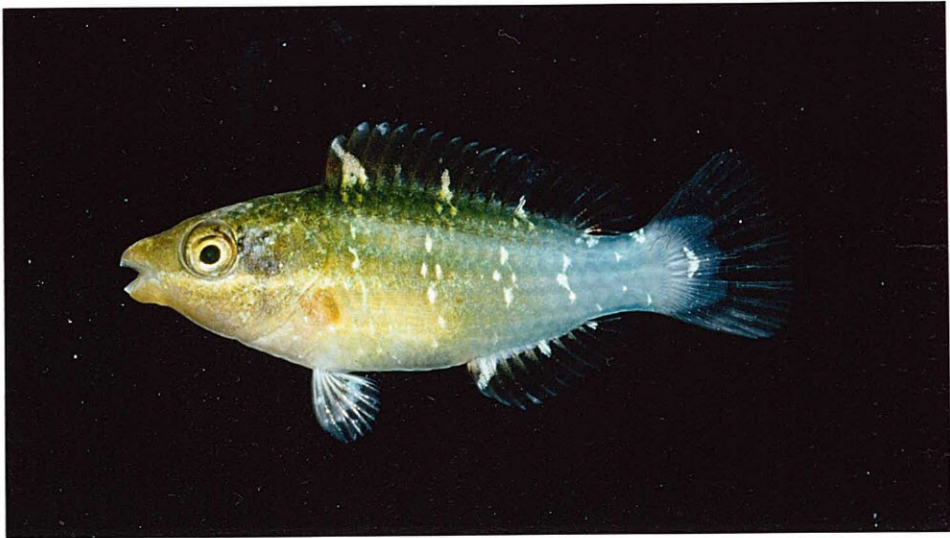


Figure 4.8 A

S. frenatus : approx. 55 mm S.L.

Location : Rib Reef, in 4 m on the reef slope.

Figure 4.8 B

S. flavipectoralis : 33 mm S.L.

Location : Lizard Island, photographed dead.

Figure 4.8 C

S. flavipectoralis : 44 mm S.L.

Location : Lizard Island, photographed dead.

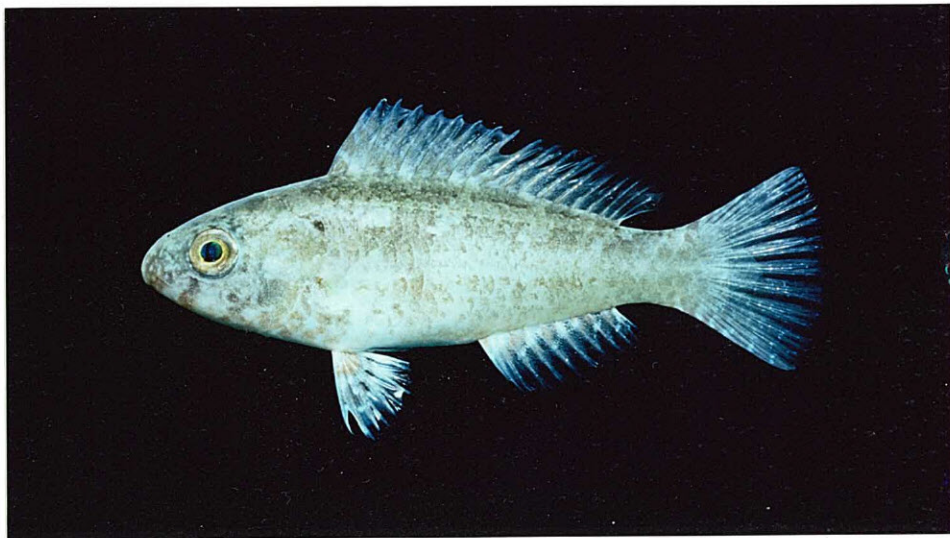
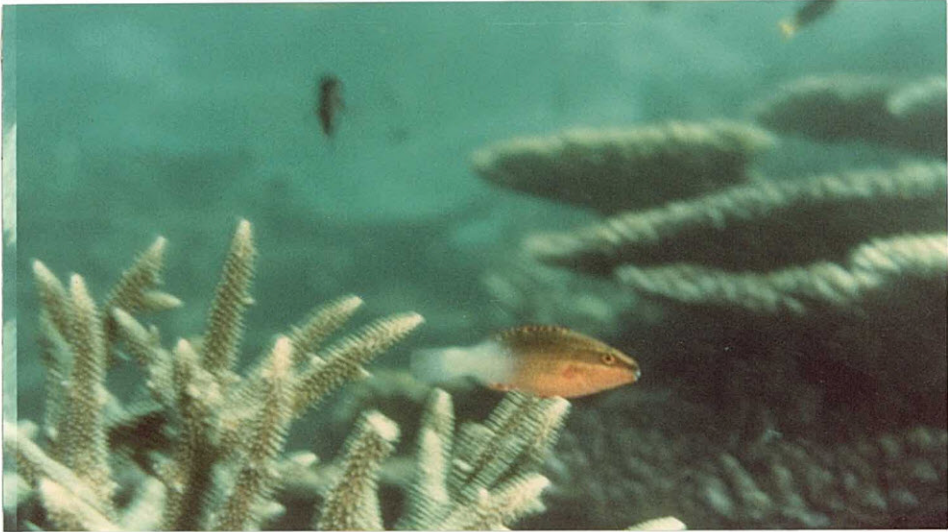


Figure 4.9 A

S. dimidiatus : 30.5 mm S.L.

Location : Yonge Reef, photographed dead.

Figure 4.9 B

S. ovliceps : 32 mm S.L.

Location : Lizard Island, photographed dead.

Figure 4.9 C

S. ovliceps : 73 mm S.L.

Location : Lizard Island, photographed dead.

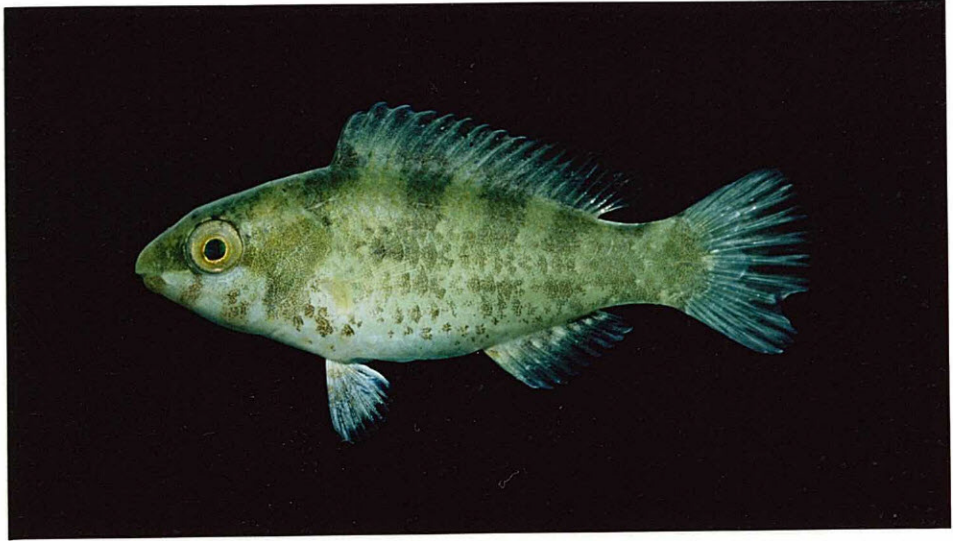


Figure 4.10 A

S. ghobban : 53 mm S.L.

Location : Lizard Island, photographed dead.

Figure 4.10 B

S. longipinnis : 39 mm S.L.

Location : Lizard Island, photographed live.

Figure 4.10 C

S. longipinnis : 75 mm S.L.

Location : Carter Reef, photographed dead.

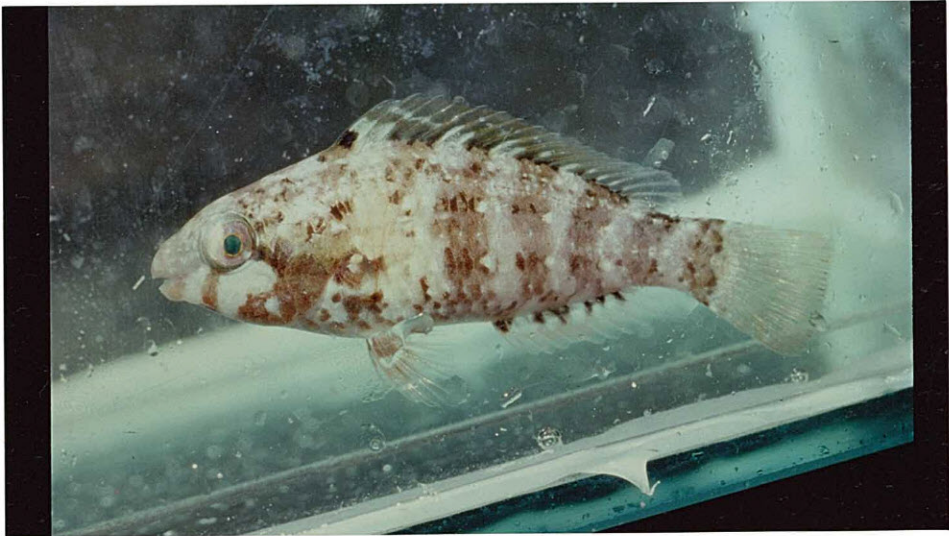


Figure 4.11 A

S. niger : 9.5 mm S.L.

Location : Lizard Island, photographed live.

Figure 4.11 B

S. niger : 24 mm S.L.

Location : Lizard Island, photographed dead.

Figure 4.11 C

S. niger : 34 mm S.L.

Location : Lizard Island, photographed live.



Figure 4.12 A

S. niger : 57 mm S.L.

Location : Yonge Reef, photographed dead.

Figure 4.12 B

S. psittacus : 29.5 mm S.L.

Location : Lizard Island, photographed dead.

Figure 4.12 C

S. tricolor ? (cf. *S. forstent*) : 61 mm S.L.

Location : Yonge Reef, photographed dead.

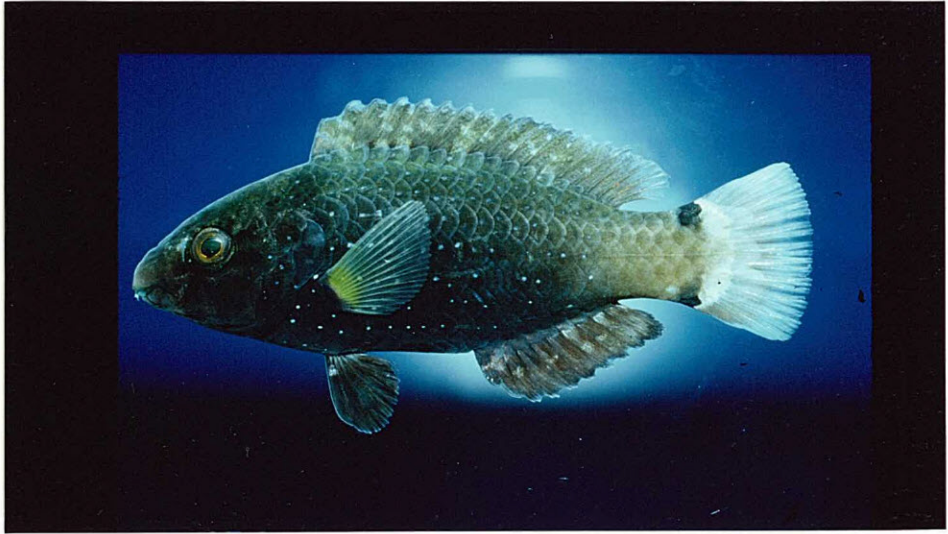


Figure 4.13 A

S. rivulatus : 49 mm S.L.

Location : Lizard Island, photographed dead.

Figure 4.13 B

S. schlegelii : 37 mm S.L.

Location : Lizard Island, photographed live.

Figure 4.13 C

S. schlegelii : 38 mm S.L.

Location : Lizard Island, photographed dead.

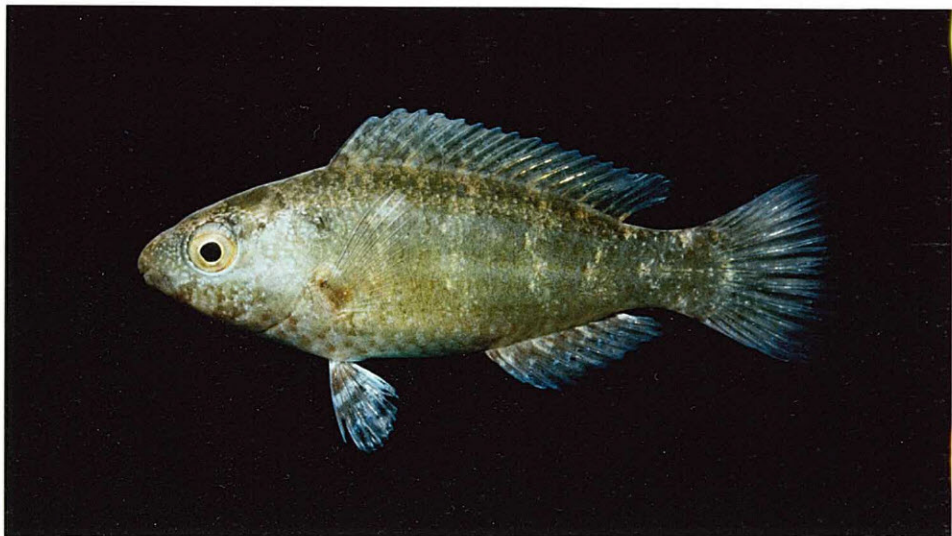
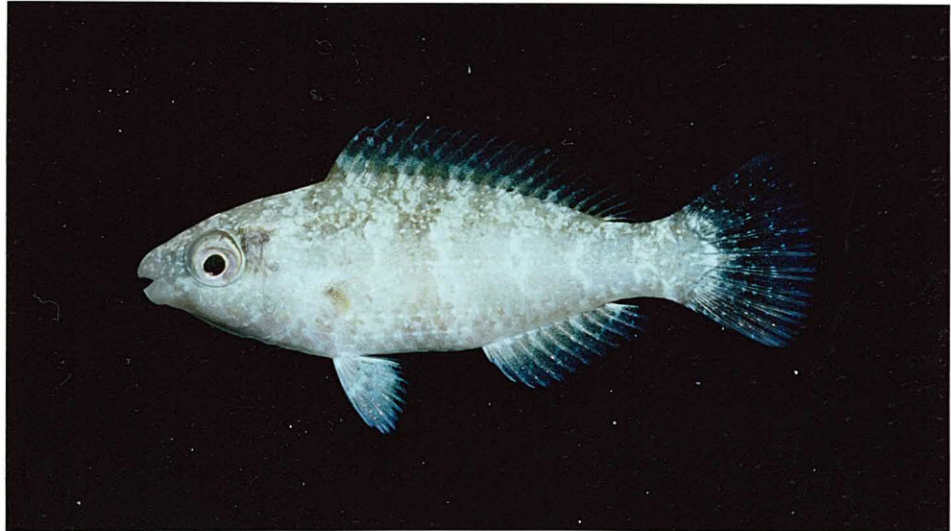
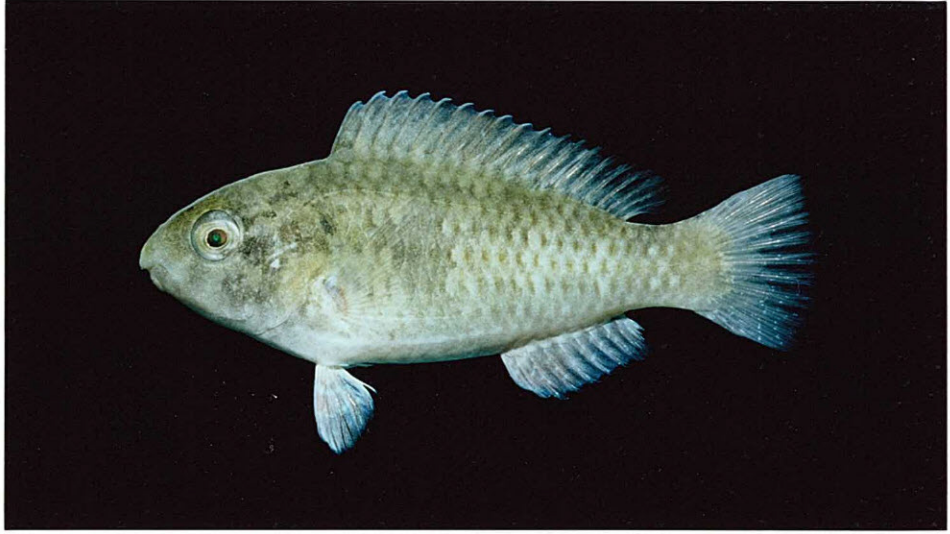


Figure 4.14 A

S. sptnus : 20 mm S.L.

Location : Lizard Island, photographed dead

Figure 4.14 B

S. sptnus : 22 mm S.L.

Location : Lizard Island, photographed dead

Figure 4.14 C

S. sptnus : 27 mm S.L.

Location : Yonge Reef, photographed dead.

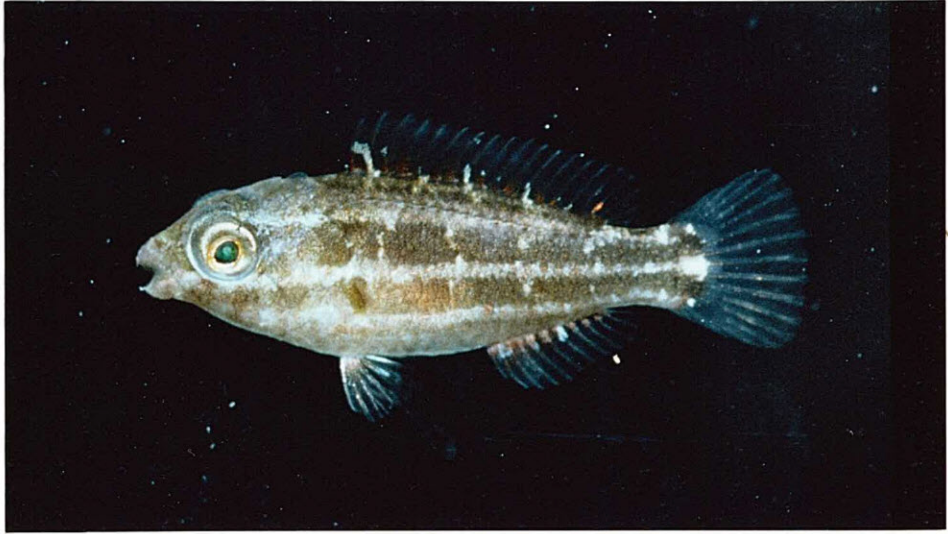


Figure 4.15 A

S. rubroviolaceus : 18 mm S.L.

Location : Lizard Island, photographed dead.

Figure 4.15 B

S. rubroviolaceus : 22.5 mm S.L.

Location : Lizard Island, photographed dead.

Figure 4.15 C

S. rubroviolaceus : 38 mm S.L.

Location : Lizard Island, photographed dead.

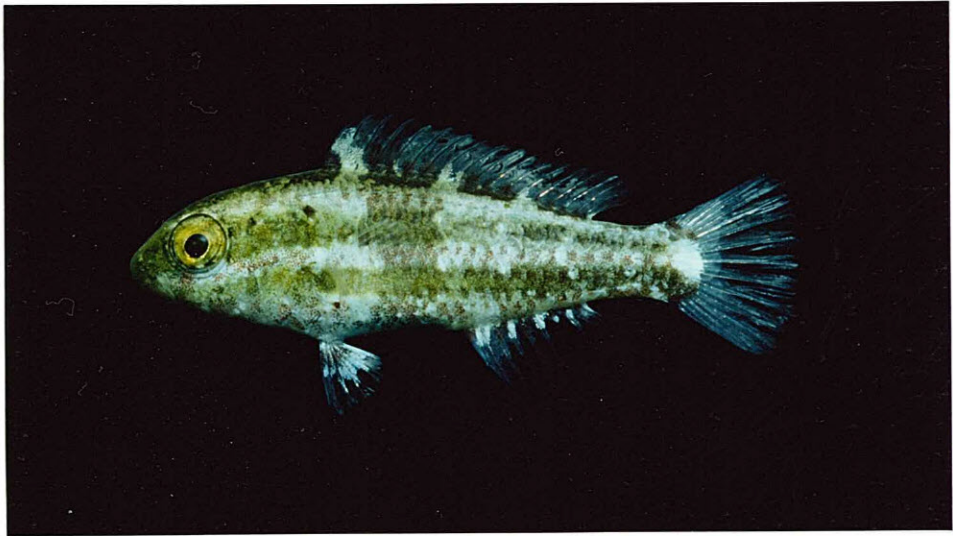


Figure 4.16 A

Scarus. sp. (cf. *lunula*) ? : 10.3 mm S.L.

Location : Lizard Island, photographed live.

Figure 4.16 B

Scarus. sp. (cf. *lunula*) : 33 mm S.L.

Location : Lizard Island, photographed dead.

Figure 4.16 C

Cetoscarus bicolor : 11 mm S.L.

Location : Lizard Island, photographed live.

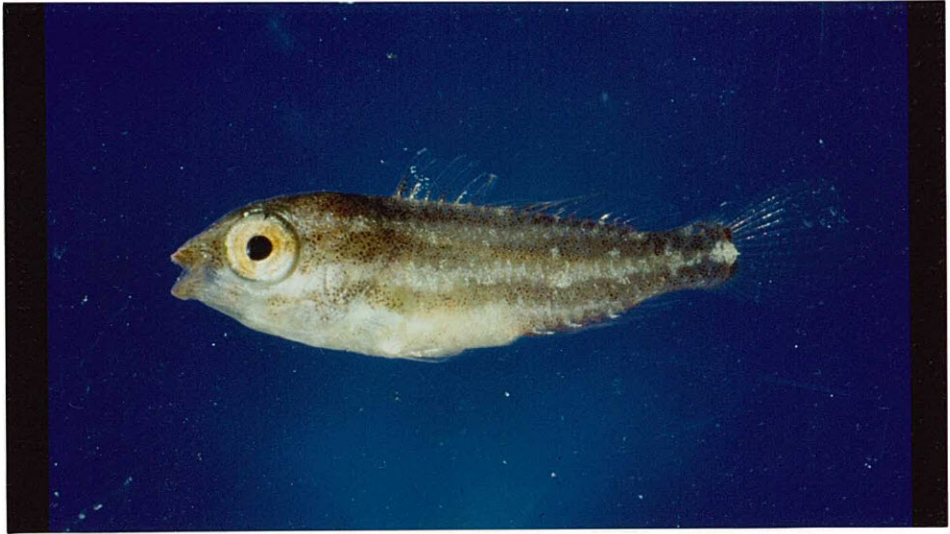


Figure 4.17 A

Hipposcarus longiceps : 48 mm S.L.

Location : Lizard Island, photographed dead.

Figure 4.17 B

Calotomus carolinus : 43 mm S.L.

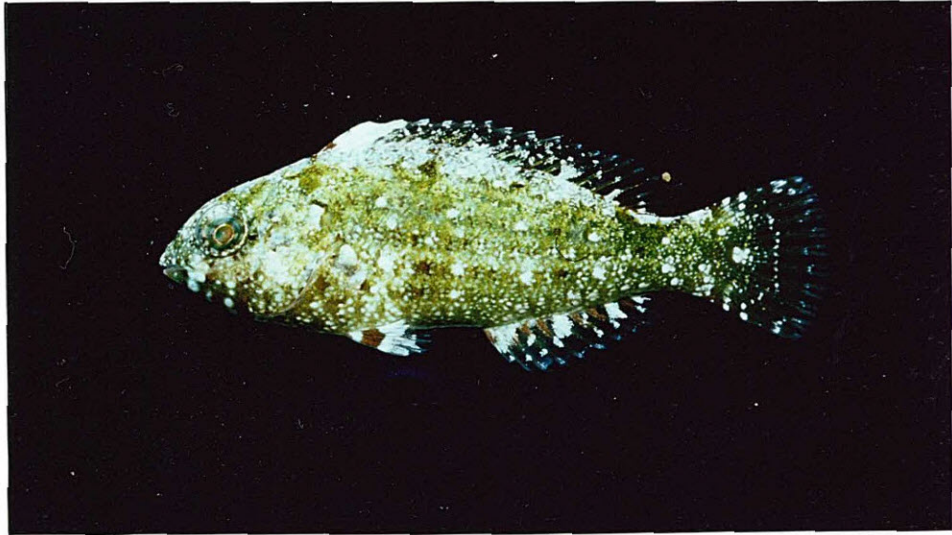
Location : Lizard Island, photographed live.

Figure 4.17 C

Calotomus carolinus : 43 mm S.L.

Location : Lizard Island, photographed dead,

(same individual as in 4.17 B above).



Scarus rivulatus Valenciennes

(Fig. 4.13 A)

Material examined: 11; 46 to 59 mm S.L.

Meristics: Median predorsal scales 6, no anterior pair, scale size reduced anteriorly; cheek scale rows 3, 2 (occasionally 3) in ventral row; pectoral rays 14.

Diagnosis: On northern G.B.R. reefs, caudal fin has a yellow hue, sometimes extending onto the caudal peduncle and mid-body, body pale tan or olive. A variable species.

Ecological notes: Common; some specimens below 45 mm S.L., site attached, solitary or in small (5) to large (25+) multispecific schools. At Lizard Island, recorded from the reef flat, lagoon and other sheltered areas, in shallow water (1-6 m) over all substratum types except open sand. On inshore reefs, abundant on the reef flat, reef slope and in sargassum beds.

Remarks: *S. rivulatus* is a variable species (Table 4.1) capable of rapid changes of its colour pattern. It shares several colour patterns with other species, including *S. globiceps*, *S. psittacus* and *Scarus* sp. (*cf. lunula*). At Lizard Island, *S. rivulatus* has two predominant colour patterns: a) a pale olive/tan body with dark scale edges (as in Fig. 4.13 A) and a pale blue hue round the pupil, and b) a pale olive/tan body with a pale yellow caudal fin and caudal peduncle. The former pattern distinguishes *S. rivulatus* from all other G.B.R. species with the exception of *S. globiceps*. *S. rivulatus* can only be separated from *S. globiceps* when displaying the latter, unique colour pattern. This pattern is retained in the IP at Lizard Island and assists in the identification of IP *S. rivulatus*. However, this pattern

does not appear to be displayed by *S. rivulatus* at other G.B.R. localities (Randall & Choat, 1980). *S. rivulatus* is the most numerous scarid species on inshore reefs. In some localities it is the only species present and forms large monospecific schools.

In alcohol, *S. rivulatus* has a grey body, darker dorsally. In some specimens, faint dashes are present at the bases of the dorsal and anal fins, and on the body (where the 'typical' scarid bands and stripes intersect [Fig. 4.2]). In other specimens, there is a dark patch on the middle of each scale.

See Remarks under *S. globiceps* for notes on the similarity between *S. rivulatus* and *S. globiceps*, and a possible means of separating the two species.

Scarus globiceps Valenciennes

Material examined: 3 (provisionally); 24 to 59 mm S.L.

Meristics: Median predorsal scales 6, no anterior pair, scale size reduced anteriorly; cheek scale rows 3, 3 in ventral row; pectoral rays 14.

Diagnosis: A variable species, extremely similar to *S. rivulatus*.

S. globiceps has no discernable unique or diagnostic colour patterns.

Ecological notes: Individuals tentatively identified as *S. globiceps* were observed in reef flat, back reef and lagoonal areas at Lizard Island, in shallow water (1-4 m) over sand and coral rubble, in small multispecific schools.

Remarks: *S. globiceps* is extremely difficult to identify both in the field and in preserved collections, because of its similarity to *S. rivulatus*. Mature IP specimens of these species often have identical colour patterns but can be separated when collected, by

their meristics and caudal fin shape. The validity of these factors has been confirmed by analyses of the sexual status of individuals in mixed collections, as *S. globiceps* matures at a smaller size than *S. rivulatus* (Randall & Choat, 1980). There is, however, some degree of overlap between the two species in their scale counts and the shape of the caudal fin is not a useful character below 130 mm S.L. (Randall & Choat, 1980).

In this study, therefore, specimens were provisionally identified as *S. globiceps*, if they: a) consistently maintained *S. rivulatus*-like colour patterns, especially the striped and uniformly pale phases, but did not show any signs of a yellow caudal fin or caudal peduncle and, b) had six or less median predorsal scales and three or more scales in the ventral row of cheek scales (following Randall & Choat, 1980).

In alcohol, specimens tentatively identified as *S. globiceps* were uniformly grey-brown, darker dorsally. One specimen had faint body stripes and dashes at the base of the dorsal and anal fin.

An analysis of the form of the upper pharyngeal tooth plates of mature *S. rivulatus* and *S. globiceps* revealed a relatively consistent difference in their form, especially that of the innermost tooth rows. In *S. globiceps*, the dental plate is relatively small and elongate, with strongly interdigitating medial (*i.e.* innermost) tooth rows which form a rhabdom-like central region (Fig. 4.18 A). In contrast, *S. rivulatus* has a more robust dental plate, larger, rounded teeth and less strongly interdigitating medial tooth rows (Fig. 4.18 B). These differences were consistent in specimens above 114 mm S.L. and

Figure 4.18 A

A ventral view of the upper pharyngeal tooth rows
of a 128 mm S.L. *S. globiceps*.

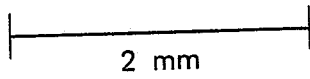
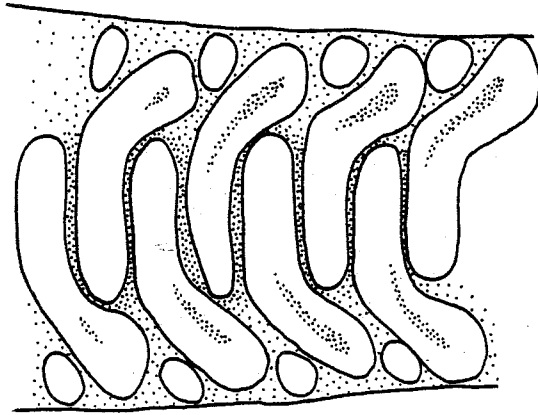
Figure 4.18 B

A ventral view of the upper pharyngeal tooth rows
of a 128 mm S.L. *S. rivulatus*.

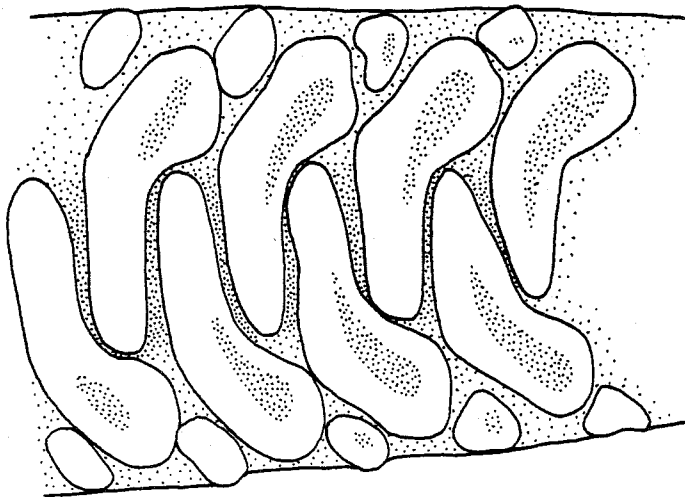
Both figures are of the mid region of the upper pharyngeal
bones from the first tooth showing signs of wear.

The anterior teeth are to the left.

A



B



may assist in the identification of *S. rivulatus* and *S. globiceps* as juveniles.

Scarus rubroviolaceus Bleeker

(Figs. 4.15 A, B, C)

Material examined: 10; 10 to 38 mm S.L.

Meristics: Median predorsal scales 6 (rarely 7), two antermost scales smallest, rest subequal; cheek scale rows 3, 2 scales in ventral row; pectoral rays 15.

Diagnosis: Small specimens (< 25 mm S.L.), body off white, three brown stripes, orbital and dorsal stripes faint, pectoral stripe broad and dark especially caudally. In larger specimens, (> 25 mm S.L.) stripes are olive-green and dorsal and orbital stripes become increasingly visible. Pale dots clearly visible in orbital and pectoral stripes. A broad dark vertical band extending from dorsal spines 3 to 8 is distinct in small individuals but fades in progressively larger specimens. Above 40 mm S.L., body pale brown, each scale possessing a dark edge. The pale spots and interspaces become increasingly faint.

Ecological notes: Uncommon; solitary, occasionally joining small multispecific schools, site attached. Recorded at Lizard Island from moderately exposed reef slope sites, from the crest (1-2 m) to the reef base (8-10 m), over open rock or rubble.

Remarks: *S. rubroviolaceus* is a distinctive species and is easily identified, even when recently recruited. Recently recruited specimens (< 10 mm S.L.) have three dashed lines. The pectoral line is notably wider than the dorsal and orbital lines, and fuses first. At 10 mm S.L., it appears as a broad band with pale dots interspersed along its length. The orbital and dorsal lines

(stripes) fuse at about 25 mm S.L. The dorsal stripe lies close to the base of the dorsal fin, but leaves a short, pale interspace along the midline anterior to the dorsal fin. The snout may have a pale green hue. The dark vertical band corresponding to band 2 of the 'typical' scarid pattern (Fig. 4.2) appears at about 14 mm S.L. It extends from dorsal spines 3 to 8 and is darker dorsally. This band fades in progressively larger specimens and is lost at about 40 mm S.L. The band may be faint in small specimens and if so, the dashes or part of the stripes in the region of the band are darker than the remaining dashes or striped regions. At 25 mm S.L., all three stripes are clearly visible, but become increasingly faint above this size. The edges of the scales start to darken at about 38 mm S.L. The dark pectoral base visible in Figure 4.15 C was not apparent in life. Above 40 mm S.L., the stripes fade (initially the pectoral stripe anterior to the pectoral fin base). At 80 mm S.L., the body is pale brown-grey with dark scale edges, although the pale interspaces and pale dots may be faintly visible. The typical IP colour phase, with a pale anterior half was not displayed by specimens below 200 mm S.L. at Lizard Island or on the nearby outer shelf reefs.

In alcohol, the live pattern is retained. The body is pale grey with distinct dark grey-brown dashes and/or stripes. The pale dots in the pectoral and orbital stripes are retained. In smaller specimens, the dark vertical bar is retained, although it is faint. The pectoral fin base is dark but not as intense as in the specimen provisionally identified as *S. tricolor* (Fig. 4.12 C).

Scarus psittacus Forsskål

(Fig. 4.12 B)

Material examined: 34; 11 to 31 mm S.L.

Meristics: Median predorsal scales 4, no anterior pair, anteromost scale largest; cheek scale rows 2; pectoral rays 14.

Diagnosis: Extremely variable; if pale, uniformly pale tan and notably paler than other species. Often has dark dots (parasitic scars or cysts) on body and fins. When striped (Fig. 4.12 B), 3 stripes, orbital and pectoral stripes relatively broad, often fusing on the caudal peduncle. Small specimens (< 25 mm S.L.), often with dark grey-brown stripes, metallic bronze interspaces and a series of small bronze dots. Larger specimens, occasionally brown body, red pelvic fins and pale snout.

Ecological notes: Common; usually in small (5) to large (25) schools often monospecific; site attached (up to 40 mm S.L.). At Lizard Island, abundant in shallow (1-5 m) sheltered areas, over sand and coral rubble or coral rock.

Remarks: See Remarks under *S. schlegeli*.

Scarus schlegeli (Bleeker)

(Figs 4.13 B, C)

Material examined: 7, 20 to 38 mm S.L.

Meristics: Median predorsal scales 4, no anterior pair, anteromost scale largest; cheek scale rows 2; pectoral rays 14.

Diagnosis: Small specimens typically uniformly black or dark grey-brown with pale snout, rarely striped, if striped, overall dark with 3 indistinct stripes. Displays 4-5 thin pale vertical lines, most frequently in specimens above 50 mm S.L.

Ecological notes: Common; occasionally solitary, usually in small (5) to large (25+) schools, often monospecific. In deeper water (5-12 m), over sand and coral rubble, in both exposed and sheltered sites at Lizard Island and some outer reefs.

Remarks: *S. psittacus* and *S. schlegelii* are difficult to separate. *S. psittacus* is an extremely variable species (Table 4.1), capable of rapid changes of its colour patterns. *S. schlegelii* is less variable, with fewer possible colour patterns (Table 4.1) and less frequent changes. *S. psittacus* can be distinguished from other species, including *S. schlegelii*, when in the pale or striped phases (described in the diagnosis) but may require extended observations before these patterns are displayed. *S. schlegelii* can only be separated from other species when displaying pale vertical lines (they are distinctly narrower than in *S. bleekeri*). A small elongate, consistently black juvenile scarid in deep water is probably *S. schlegelii* but it must be collected in order to separate it from other species exhibiting this colour pattern (Table 4.1). Likewise, consistently uniformly pale juveniles in shallow water are likely to be *S. psittacus* but require meristic analysis. The two species may be distinguished as follows:

S. psittacus - often pale or striped (see diagnosis), does not display vertical bands nor a uniformly black colouration. If the overall colour is brown (as in some larger specimens) the pelvic fins and to a lesser extent, the anal fin have a red hue. Abundant in shallow water.

S. schlegelii - usually has a uniformly dark brown or black body and fins, rarely displays stripes and if so, they are indistinct. Occasionally displays pale narrow vertical lines (=pale interspaces). If the overall colour is brown, the anal fin remains brown and the red hue in the pelvic fins, if present, is relatively indistinct.

Despite these differences, some specimens can not be accurately identified in the field, especially those which are consistently brown with a pale snout, even if observed for extended periods. These specimens must therefore, be collected for further analysis.

In alcohol, *S. psittacus* and *S. schlegelii* can be readily separated from other species displaying the same colour phases (e.g. *Scarus* sp., *S. sordidus* and *S. rivulatus*) by scale counts. The two species can not, however, be accurately separated from each other as both share the same basic meristic counts. Despite this, some identification is possible as the colour patterns of the two species in alcohol differ.

In alcohol, *S. psittacus* is typically uniformly pale brown with an occasional trace of body stripes (especially where the 'typical' scarid bands and stripes intersect; Fig. 4.2). The fins are pale brown to off-white with occasional exceedingly faint dashes at the base of the dorsal and anal fin. In comparison, in *S. schlegelii*, the body and fins are dark brown (with occasional indistinct body stripes). Smaller specimens, in particular, have dark dashes at the base of the dorsal and anal fins and occasionally at the base of the most dorsal and ventral

caudal fin rays. As in live specimens, however, there is some overlap, in which case specimens can be identified no further than to *S. psittacus/schlegelii*.

In this study, positive identifications were restricted to specimens exhibiting diagnostic colour patterns in the field. Diagnostic patterns were linked to the respective species by observations on individuals displaying juvenile and IP patterns or juvenile-IP intermediate patterns. The range of patterns in *S. psittacus* was based on field observations of scarred and tagged specimens as well as collections.

Scarus spinus (Kner)

(Figs 4.14 A, B, C)

Material examined: 12; 17 to 35 mm S.L.

Meristics: Median predorsal scales 4, antermost scale relatively small, preceded by a pair of laterally overlapping scales; cheek scale rows 3, 1-2 (usually 2) in ventral row; pectoral rays 14 (rarely 15).

Diagnosis: Five dark stripes; dorsal division of dorsal stripe remains dashed up to 27 mm S.L. Posterior extremities of orbital and pelvic stripes form intense dark round dots in a white patch at the base of the caudal fin rays.

Ecological notes: Uncommon; solitary or in small multispecific schools, site attached. On outer reefs, over coral and coral rubble off backreef bommies (3-8 m), on Lizard Island, occasionally in shallow semi-exposed locations, most often found near live coral in the lagoon.

Remarks: This species closely resembles *S. sordidus*. In the field, *S. spinus* can be easily mistaken for *S. sordidus*, although it can

be distinguished as it typically has a more angular snout (below 40 mm S.L.), a more elongate body, darker, narrower stripes, a more distinctly dashed dorsal division of the dorsal stripe (especially when viewed from above) and rarely takes on an overall dark hue below 30 mm S.L. Below this size, the most easily observed diagnostic feature of *S. spinus* is the form of the posterior ends of the orbital and pectoral stripes. They appear black (more intensely in the field than in Fig. 4.14 A), and are distinctly visible as a result of the hemispherical white patch at the base of the caudal fin. (This patch is shown in Fig. 4.14 B, but in life it is more intense, comparable to that of *S. niger* in Figs 4.11 B and C). There is no convergence of the posterior ends of the orbital and pectoral stripes and these stripes do not fade on the caudal peduncle as in *S. sordidus* (Fig. 4.5 B). *S. spinus* is, however, able to vary the intensity of its stripes, especially between 15-30 mm S.L. Above 30 mm S.L., both species may be uniformly dark. At this stage, they can most easily be separated by their shapes (*S. sordidus* being deeper in the body) and the distinctive, unique patterns of *S. sordidus* which are usually displayed when this species is followed or chased. *S. spinus* retains the dark colouration throughout the remaining part of the juvenile phase and into the initial phase.

In alcohol, the striped pattern, the dark dots on the posterior ends of the orbital and pectoral stripes and the dashed dorsal division of the dorsal stripe remain distinct. In specimens above 30 mm S.L., however, these markings become increasingly faint and the body darkens.

Scarus tricolor Bleeker

(Fig. 4.12 C [provisionally])

Material examined: 1 (provisionally); 61 mm S.L.

Meristics: Median predorsal scales 5, scale size increases posteriorly, the fourth being largest, preceded by a small pair of laterally overlapping scales; cheek scale rows 3, 2-5 in ventral row; pectoral rays 14.

Diagnosis: Small individuals bear a series of pale dots on a pale-brown to brown body, which may be striped. The largest pale dot near to the tip of the pectoral fin is retained in larger specimens.

Ecological notes: Rare; solitary specimens were observed in deep water (9-25 m) on the reef slope of outer barrier reefs (*i.e.* Yonge Reef and Carter Reef).

Remarks: *S. tricolor* is a variable species (Table 4.1), capable of some rapid colour changes. Specimens 25-40 mm S.L. have a brown body and often display pale interspaces delineating the orbital and pectoral stripes. Two rows of pale dots in the orbital and pectoral stripes slowly fade, the lower row first, with only one dot near the tip of the pectoral fin remaining in large specimens. The intensity of this pale dot can vary rapidly, but above 40 mm S.L., it becomes increasingly prominent and increases in relative size. In larger specimens, the mid-body takes on a darker hue, although the intensity varies considerably. In addition, the pale dot may have a dark patch of variable intensity on its upper border.

The Great Barrier Reef species presently identified as *S. tricolor* (Randall & Choat, 1980) may prove to be *S. forstent*

(Bleeker) (pers. comm. J.E. Randall). Adult *S. tricolor* (*forstent*) were not observed around Lizard Island, but were recorded from the adjacent MacGillivray Reef.

The single specimen examined in this study was collected at 5 m over coral rock on Yonge Reef, near to the channel between Yonge and Carter reefs. When first sighted this specimen had a pale brown body. The pale interspaces delineating the orbital stripe and the pale patch near the tip of the pectorals (both faintly visible in Fig. 4.12 C) were only displayed when the fish was disturbed and intensified upon capture. The dark patch at the base of the pectoral fin was not noted before capture. The basic colour and meristic data comply with that of *S. tricolor* (and *S. forstent*). This specimen is therefore, tentatively identified as *S. tricolor* (*forstent*). However, the blue-green dental plates and dark pectoral base are problematical as IP *S. tricolor* (and *S. forstent*) are reported to have white dental plates (Randall & Choat, 1980 and Randall & Bruce, 1983). The dark pectoral base is not mentioned. These characteristics may be juvenile features, which are lost in mature specimens. Similar transitions occur in other species (e.g. *S. rubroviolaceus*).

In alcohol, the above specimen is grey, darker dorsally. The distinct dark pectoral base and faint pale interspaces remain.

Further analysis of juvenile *S. tricolor* (*forstent*) is required.

Scarus sp. (cf. *lunula*)

(Figs 4.16 A, B)

Material examined: 32; 12 to 54 mm S.L.

Meristics: Median predorsal scales 4, antermost scale moderately large, preceded by a pair of laterally overlapping scales; cheek scale rows 3, 1-3 in ventral row; pectoral rays 14.

Diagnosis: Snout and/or head section of orbital stripe golden. Pectoral stripe when present, terminates near pectoral base, cheek region pale. Often golden hued and distinctly pale ventrally. Extremely variable colour patterns.

Ecological notes: Common; solitary or in small or large (25+) multi- or monospecific schools, some individuals site attached when small. Found in all reef habitats at Lizard Island, from 1-10 m, most abundant on sheltered reef slopes. Recorded from reef flat, lagoon and backreef of outer reefs.

Remarks: *Scarus* sp. is one of the most variable and ubiquitous of juvenile scarids. It has a wide range of colour patterns (Table 4.1) which it can change rapidly. It is therefore, one of the most difficult juvenile scarids to identify. If striped, the golden anterior orbital stripe (faintly visible in Fig. 4.16 B) and truncated pectoral stripe make identification possible, although individuals may need to be followed for several minutes, or hours, before they display this pattern. *Scarus* sp. is most difficult to identify when in deep water, as it often displays an overall dark hue and is easily mistaken for *S. schlegelii*. It is often necessary to collect these individuals for meristic analyses. In freshly caught specimens, the golden snout and orbital stripe are quickly lost, although the pale cheek remains

distinctive, as in Figure 4.16 B. A series of pale dots is often visible in freshly caught specimens at the base of the dorsal fin and following the orbital and pectoral stripes (Fig. 4.16 B). The latter dots are occasionally visible in the field. Large juveniles occasionally display the initial phase colouration (*i.e.* a pale yellow caudal fin and a brown body), but when schooling, they frequently display a distinctive pattern, with a pale brown body and an abruptly pale belly below the level of the pectoral stripe.

In alcohol, *Scarus* sp. may be uniformly pale or dark, banded, striped or patchy with a pattern of indistinct patches corresponding to the basic scarid bands and stripes (Fig. 4.2). The orbital and pectoral stripes may be dark posteriorly, but not as intensely as *S. spinus* or *S. sordidus*. *Scarus* sp. retains no characteristic colour pattern.

Scarus sp. (*cf.* *lunula*) is presently being described by J.H. Choat and J.E. Randall (*pers. comm.*).

Hipposcarus longiceps (Valenciennes)

(Fig. 4.17 A)

Material examined: 2; 48 to 48.5 mm S.L.

Meristics: Median predorsal scales 4, no anterior pair, antermost scale largest; cheek scale rows 3, 2-6 scales in ventral row; pectoral rays 15.

Diagnosis: Deep body and angular snout. Body silvery-grey to pale tan, whitish ventrally. Caudal fin and caudal peduncle pale yellow. A thin, beige-orange stripe extends from snout, along flank to base of caudal fin, terminating in a black spot.

Ecological notes: Rare; solitary, possibly site attached. At Lizard Island, one specimen from Mermaid Cove, over coral rock and rubble (5 m) and one specimen from a semi-exposed site at the base of the reef slope (9 m) over coral rock and boulders.

Remarks: *H. longiceps* is an unusual species. The body shape and colour pattern more closely resembles those of a *Lethrinus* species rather than those of a *Scarus* species. The behaviour likewise resembles that of *Lethrinus* species. *H. longiceps* remains motionless above the substratum for extended periods of time and swims in short bursts. It periodically feeds on turf algae. *H. longiceps* does not school with other scarids and is occasionally aggressive towards them.

In aquaria, four narrow pale vertical bands are occasionally displayed (faintly visible in Fig. 4.17 A). The colour pattern during the transition to the IP are not known, although the beige stripe and dark spot at the caudal base are lost by 120 mm S.L.

In alcohol, the body is pale brown, paler ventrally and caudally. A pale off-yellow to tan stripe is visible extending from the orbit to the base of the caudal fin where it terminates at a distinct black dot. The dorsal fin is pale brown. The distal part of the ventral and caudal fins are hyaline.

Cetoscarus bicolor (Ruppell)

(Fig. 4.16 C)

Material examined: 1; 11 mm S.L. (specimen destroyed)

Meristics: From Randall and Bruce (1983); median predorsal scales 5-7, the posterior 3 being largest, cheek scale rows 3, 3-7 in ventral row; pectoral rays 14-15 (usually 14 [Schultz, 1958]).

Diagnosis: Body white, a bright orange vertical band with black margins extends from the anterior edge of the orbit to the base of dorsal and pectoral fins. Black ocellus with orange margin in anterior part of dorsal fin.

Ecological notes: Rare; solitary, site attached. At Lizard Island, sighted over coral rubble/boulders in gullies and at the base of reef slopes (n=6), and twice around backreef bommies. All sightings between 3 and 11 m. A shy species, remaining close to shelter.

Remarks: *C. bicolor* is the most distinctive and easily identified juvenile scarid. At 11-12 mm S.L., the head is brick-red, the body white and fins hyaline, with the exception of the first few spines of the dorsal fin which are white. These spines are exceptionally long and are usually held erect (Fig. 4.16 C). At this size, the dorsal ocellus is absent. At 40 mm S.L., a broad vertical orange bar with black anterior and posterior margins is present. This bar extends from the anterior margin of the orbit to the bases of the first dorsal spine and pectoral fin. The mouth, snout, body, anterior part of the dorsal fin and caudal fin are white, and the caudal fin has orange markings on the posterior edge. The spines in the anterior part of the dorsal fin are still relatively long and bear a large black ocellus with an orange margin. In larger specimens (up to about 60 mm S.L.), the orange margins on the caudal fin extend along the dorsal and ventral edges of the fin, the white markings in the dorsal and anal fins extend posteriorly, and a yellow colouration extends from the pectoral base into the pelvic fins and across the belly to the base of the anal fin. (Colour plates of such specimens

can be found in Axelrod & Emmes, 1969 pages 247-248, Axelrod & Burgess, 1979 and Masuda *et al.*, 1975). Above this size, the orange band diffuses, the body darkens and the relative size of the ocellus decreases (as in the 123 mm S.L. specimen figured by Randall & Bruce [1983]).

At 11 mm S.L., *C. bicolor* swims with an undulating motion, strikingly similar to similarly sized *Amphiprion* species. It also remains close to shelter and rapidly dives for cover if disturbed. With increasing size, this cover seeking behaviour decreases and the undulating swimming patterns is slowly lost.

Calotomus carolinus (Valenciennes)

(Figs 4.17 B, C)

Material examined: 2; 31 to 43 mm S.L.

Meristics: Median predorsal scales 4, no anterior pair, scales increase in size anteriorly; one cheek scale row (4 scales); pectoral rays 13; upper jaw incisiform teeth in 3 oblique imbricate rows.

Diagnosis: Body elongate, green to green-brown, body and fins with white and brown dots and flecks. Mouth pointed and first two dorsal spines white.

Ecological notes: Uncommon, solitary, occasionally in small multispecific schools, site attached when small. On Lizard Island, recorded over rubble or macroalgae near the base of the reef slope (5-9 m), in exposed and moderately exposed locations.

Remarks: *C. carolinus* is an unusual species. As a member of the Sparisomatinae, it is closely related to the labrids (Chapter 3). It can be distinguished easily from other scarids but may, when recently recruited, be difficult to distinguish from some

labrids. *C. carollinus* settles at a relatively large size. The smallest specimen observed was approximately 12 mm S.L. (cf. 7.5 to 8 mm S.L. in *Scarus* species). In recently recruited specimens (approx. 14.5 mm T.L.), the body is translucent, with a few brown and white dots in an apparently random pattern. A white patch on the anterior part of the dorsal fin is visible at this size, extending from the anterior dorsal spine to, but not including, the third dorsal spine. The remaining part of the dorsal fin and the other fins are hyaline. Above 15 mm T.L., the body darkens to grey/green or green/brown. The dots are retained, with the larger pale dots forming a double row along the side of the body (visible in Figs 4.17 B and C). These dots correspond with the two medial rows of pale dots present in small *Scarus* species (Fig. 4.1 B, C, D). The white patch on the anterior part of the dorsal fin is present at 43 mm S.L. (Figs 4.17 B, C) but is lost by 80 mm S.L. At this size, the body is slightly deeper and the head is more rounded. The eyes protrude and are distinctly visible when viewed from the rear. The body colour darkens in some specimens and the pale dots decrease in intensity.

C. carollinus has an unusual swimming motion when compared to other scarids. Between 14 and 16 mm S.L., it only occasionally moves with the characteristic 'C'-shaped body, as found in other scarids (Section 4.3.2) and often swims in a labrid-like manner. Between 16 and 25 mm S.L., *C. carollinus* retains its labrid-like swimming manner. When disturbed, it usually glides away with the dorsal and anal fins extended and exposes its flank to the onlooker by laying on one side. This swimming behaviour is

similar to that of the labrid *Novaculichthys taenurus* (Lacepède). Above 25 mm S.L., *C. carolinus* swims in a more 'typical' scarid-like manner.

In alcohol, the body is pale green/grey, the head is shaded with brown and a series of brown dots are present on the body and along the base of the dorsal fin. The pale dots on the body and the white patch on the dorsal fin are lost. The fins are hyaline.

Other Species

Juveniles of the following scarid species recorded from the Great Barrier Reef were not observed during this study:

- S. japonensis* (Bloch)
- S. frontalis* Valenciennes
- S. (Ypsiscarus) oedema* (Snyder)
- B. muricatum* (Valenciennes)
- Leptoscarus vaigiensis* (Quoy and Gaimard)

4.4 Discussion

The scarid species found on the Great Barrier Reef exhibit a wide range of colour patterns during the juvenile phase. The striking dissimilarity between the colour patterns of some species and the close similarity between the colour patterns of other species suggests that the various patterns arose in response to strong selective forces, the combinations of which differ markedly between species. The nature of these selective forces are not known, but it is proposed that in the majority of species the colour patterns are for concealment, probably in response to diurnally active visual predators including serranids, carangids and synodontids. The latter family in particular, includes species that are active predators on small fishes (Sweatman, 1984). (Of the seven predation events observed involving juvenile scarids in this study, four attacks were by a *Synodontus* species, one of which was successful).

The concealment of most juvenile scarid species is interpreted in terms of crypticism (*i.e.* by closely resembling the background) and/or camouflage (*i.e.* by breaking up the fish's outline). In some species, however, the fish appear to be concealing their identity rather than their presence, by mimicking non-scarid species. Concealment colouration, however, cannot account for all the observed colour patterns, and other factors including inter- and intraspecific recognition features and predator confusion mechanisms may be important. The various concealment strategies and other factors considered to be important in determining the colour patterns of juvenile scarids will be outlined below, with notes on

some of the environmental and behavioural factors which may be responsible for maintaining these colour patterns.

It is difficult to distinguish between cryptic and camouflaged colour patterns as these two terms refer to the extremes of a spectrum of concealment patterns. Most juvenile scarid colour patterns are both cryptic and camouflaged although the extent of each may vary between species.

The most notable examples of predominantly cryptic colour patterns are found in solitary species. *Calotomus carolinus*, small *S. frenatus* (11-15 mm T.L.) and recently recruited *Scarus* species closely resemble the algae or algal covered rubble which is their typical habitat. The colour patterns of *S. oviceps* and *S. dimidiatus* blend well with the colours of the live *Acropora* and the shadows cast by the long arborescent branches of the corals amongst which they live. In *S. niger*, the mottled olive dorsal patch and the dark body make it difficult to locate this species against a background of algal covered rubble. The mottled olive dorsal patch blends with the turf algae (especially when viewed dorsally) and the pale spotted dark body blends with the numerous dark interstices and shadows in the background. Some colour patterns of *S. bleekeri* and *S. gibbus* also blend with these dark interstices and shadows which are common in the deep rubble-strewn areas commonly occupied by these species. In *S. brevitlittis* and *S. frenatus*, the relatively pale colour patterns with dark and white flecks do not closely resemble any specific background type. Their patterns are, however, interpreted as generalized patterns which are able to blend with, and break up the fish's outline against the

variable and often structurally complex areas commonly occupied by these species.

All of the above species or stages are solitary, site attached, relatively habitat-specific, and typically live in structurally complex areas. Although these species undergo marked changes in their colour patterns during ontogeny, rapid transformations in the colour patterns are rare. Ontogenetic changes in the colour patterns of these species probably help to maintain maximal concealment throughout development by ensuring that the colour patterns of the fish match with comparable features in the background.

In schooling species, concealment is achieved by a markedly different series of colour patterns from those of the solitary species described above. *S. globiceps*, *S. psittacus*, *S. rivulatus*, *S. schlegelii*, *S. sptnus* and *Scarus* sp. (cf. *lunula*) are mobile, relatively less site attached or habitat specific than the solitary species, and often feed in both open and structurally complex areas. In these schooling species, changes in the colour patterns throughout ontogeny are limited. However, all schooling species are capable of rapid changes in their colour patterns. Each species may have up to six different colour patterns (as in *Scarus* sp., Table 4.2) although in all the schooling species examined two colour patterns predominated: one being uniformly pale or dark and the other, striped or banded.

The two primary colour patterns in schooling species (*i.e.* plain or striped) are interpreted as adaptations to the extensive and variable habitats utilized by these species. The plain colours

are cryptic and blend with the background in areas of open rock or low rubble. The striped phases are also cryptic in open areas but may also camouflage the fish in structurally complex areas by disrupting the fish's outline. The striped phases were displayed most frequently by solitary individuals or individuals in small schools in structurally complex areas. The ability of schooling species to rapidly change their colour patterns would enable them to maintain an effective concealment colouration when moving between open and structurally complex areas. The speed of the change may also confuse potential predators.

In schooling species, the range of colour patterns probably represent a compromise which gives the best possible concealment over a wide range of background types. This probably accounts for the lack of ontogenetic changes in the colour patterns of these species as a more generalized concealment pattern may be effective throughout ontogeny, unlike those of solitary species where a more specific colour pattern is necessary to match a relatively restricted range of background types. It is notable that at night, when juvenile scarids are solitary and closely associated with the substratum, all species examined displayed a cryptic mottled nocturnal pattern.

One of the most striking features of schooling species is the extent of overlap and the degree of similarity between the colour patterns of these species. This suggests that there are strong selective forces acting upon schooling species. The colour patterns of schooling species are interpreted as a response to predation by diurnally active visual predators including synodontids, serranids

and carangids. Schooling behaviour in open areas decreases the susceptibility of an individual fish to predation (Neill & Cullen, 1974, Shaw, 1978 and Partridge, 1982). In *Scarus* species, schooling may therefore, enable some species to utilize areas with little cover, such as open expanses of rock or rubble.

The wide range of colour patterns exhibited by each species and the speed of transformation between patterns enables many species to join a school of scarids and rapidly blend with the school, irrespective of its species composition. The similarity between the various schooling species will enhance the efficiency of schooling as a means of avoiding predation by decreasing the probability of predators being able to recognize individuals within a school (Hobson, 1963 and W.A. Stark quoted in Neill & Cullen, 1974). This behaviour may be classified as 'arithmetic mimicry' (Dafni & Diamant, 1984) or 'synergic inviting mimicry' (Vane-Wright, 1976). A striped pattern, in particular, may be associated with schooling behaviour. Striped patterns are widespread in schooling apogonids (Dafni & Daimant, 1984) and juvenile scarids (Table 4.1), which both form a large proportion of the reef fish population that remains in schools near to the substratum during the day (pers. obs.; this does not include pomacentrids or caesionids which spend most of their time in the water column). Barlow (1972) has suggested that a longitudinally striped pattern may make it difficult for a predator to fix on a particular reference point, especially if the fish are schooling. In scarids therefore, avoidance of predation is seen as the major benefit of schooling, although other functions, including the swamping of territorial herbivores, may be important (Robertson *et al.*, 1976).

In the above discussion, two species have been omitted, *S. rubroviolaceus* and *S. flaviptectoralis*. These are typically solitary species, although they have colour patterns similar to those of schooling species. This is seen as a response by these two species to environmental pressures that are similar to those of schooling species, as both *S. rubroviolaceus* and *S. flaviptectoralis* typically live over open expanses of rock or in areas of limited structural complexity. It is notable that these two species do not undergo rapid colour pattern changes and that they exhibit relatively few colour patterns. The ability to change colour patterns rapidly and the possession of a large range of colour patterns appear to be specific characteristics of schooling species.

In all of the species considered above, concealment has been interpreted in terms of concealing the fishes' presence. Some species, however, appear to be concealing their identity rather than their presence by mimicking non-scarid species. This strategy is most clearly demonstrated in *Cetoscarus bicolor* and *Hypposcarus longiceps*.

It is proposed that *C. bicolor* mimics *Amphiprion* species. Recently recruited *C. bicolor* and *Amphiprion* species both remain close to the complex rubble substratum near which they live and have a strongly undulating swimming motion. The colour pattern of *C. bicolor* also resembles that of recently recruited *Amphiprion* species, particularly *A. melanopus* Bleeker. On Lizard Island, this species and other *Amphiprion* species were present in the regions occupied by *C. bicolor* (pers.obs.).

It is proposed that *H. longiceps* mimics a *Lethrinus* species. Juvenile *H. longiceps* have a gross morphology, swimming pattern and feeding behaviour extremely similar to that of juvenile *Lethrinus* species. *H. longiceps* also has a colour pattern which is virtually identical to that of a juvenile *Lethrinus* species, possibly *L. mahsena* (Forsskål) or *L. ramak* (Forsskål), which differs from *H. longiceps* only in the absence of the dark dot at the base of the caudal fin (and the distinct longitudinal stripe in larger specimens). *H. longiceps* and the *Lethrinus* species were both present in the same areas at Lizard Island, with the *Lethrinus* species being most numerous.

The mimicry of *Amphiprion* species by *C. bicolor* and a *Lethrinus* species by *H. longiceps* appears to be examples of a type of Batesian mimicry. In Batesian mimicry, a harmless palatable mimic adopts the typical colouration and pattern of an unpalatable model (Wickler, 1978). The unpalatable species is avoided by predators as a result of various repugnant effects (e.g. noxious taste, poison, spines etc.). In the above examples, however, the models, *Amphiprion* and *Lethrinus*, do not have any markedly repugnant properties. Although they may not be unpalatable, they are likely to be undesirable targets for predators when compared with *Scarus* species. *Scarus* species have few predator defence mechanisms (in terms of toxins, spines etc., with the exception of the mucous cocoon [Casimir, 1971]) and are major food items for a range of piscivorous reef fish species (Randall & Bishop, 1967, Choat, 1968, Popova & S'erra, 1983 and Stevens, 1984). *Amphiprion* and *Lethrinus* species appear to be less vulnerable. *Amphiprion* species remain close to cover and have a close relationship with an anemone which confers some protection

against predation (Mariscal, 1970 and Allen, 1972), whilst *Lethrinus* species are relatively fast swimmers and have more robust spines than *H. longiceps* (pers. obs.). In addition, as search images may play an important role in prey selection (Mueller, 1971), a scarid which resembles a rare non-scarid species may decrease its susceptibility to predation by predators with a scarid-orientated search image. The above examples may both be classified as cases of antergic defensive mimicry as defined by Vane-Wright (1976). However, in these examples, it appears that a vulnerable species mimics a moderately acceptable prey species, rather than an acceptable prey species mimicing an unpalatable species, as in the 'typical' Batesian classification.

The only other example of mimicry in this study was by *S. frenatus*, which appeared to mimic labrids at sizes between 20 and 70 mm S.L. At these sizes, *S. frenatus* swims and feeds in a labrid-like manner, with a relatively low bite rate and few bites per feeding foray (Chapter 6). The colour pattern is relatively gaudy and the pale stripes on the head give the snout an angular labrid-like appearance. The function of this mimicry is apparently to prevent aggression by territorial herbivores thus giving *S. frenatus* access to algal resources which are unavailable to other scarid species, as territorial pomacentrids and acanthurids are less aggressive to labrids than to scarids (Low, 1971 and pers. obs.). *S. frenatus* was the only juvenile scarid species observed feeding regularly in the territories of territorial pomacentrids and acanthurids at Lizard Island, without eliciting aggression by the territory holders (Chapter 6). This mimicry may be classified as antergic aggressive mimicry as defined by Vane-Wright (1976).

The various forms of concealment colouration described above refer to concealment of the fish as a whole. However, many species have, in addition, colour patterns or aspects of their colour patterns which conceal only the eye. These patterns can again be divided into three forms: crypticism, camouflage and mimicry. Crypticism, where the colour of the eye blends with the body colouration may be seen in larger specimens of *S. niger*, *S. schlegelii* and some colour phases of *S. bleekeri*, *S. gibbus* and *S. sordidus*. The commonest form of concealment of the eye is by camouflage, where bands, stripes or patches conceal the eye's outline, as in *S. bleekeri*, *S. dimidiatus*, *S. flavipectoralis*, *S. frenatus*, *S. ghobban*, *S. gibbus*, *S. globiceps*, *S. longipinnis*, *S. oviceps*, *S. psittacus*, *S. rivulatus*, *S. rubrovittatus*, *S. sordidus*, *S. spinus*, *S. tricolor* (forstent), *Scarus* sp., *Cetoscarus bicolor* and *H. longiceps*. The third form of concealment is mimicry, where the eye is apparently mimicked by dark spots or ocelli on the body. Dark spots, highlighted by a pale surrounding area are present in some phases of *S. niger*, *S. sordidus*, *S. spinus* and *H. longiceps*. The most distinctive example of eye mimicry is in *C. bicolor*, which has a large ocellus with a black centre and an orange margin on the dorsal fin. The function of these patterns is apparently to confuse or mislead visual predators (Barlow, 1972 and Wickler, 1978).

High mortality rates have been recorded in the first year after settlement of some coral reef fish species (Williams 1980, Doherty, 1983 and Sale *et al.*, 1984 a). In juvenile scarids, most losses, presumably due to predation, were recorded during the first few weeks after settlement (Chapter 6). This period is a key interval

in determining the life history of a species (Paine, 1984) as even small reductions in the mortality rates of juveniles can have significant effects on population numbers of animals with high mortality rates (Meats, 1971). Adaptations which may reduce predation or enhance the survival rates of juvenile fishes therefore, will be strongly selected for (Paine, 1984). In this study, it is suggested that the colour patterns of juvenile parrotfishes function as a means of decreasing predation by diurnally active visual predators. This function has been alluded to in several other studies of colour patterns in coral reef fishes (Barlow, 1972, Ehrlich *et al.*, 1977, Randall & Choat, 1980 and Dafni & Diamant, 1984). In this context, it is interesting to note that mimicry was only noted in two relatively 'unspecialized' genera, both of which contain few species (one in *Cetoscarus*, three in *Hipposcarus*). The mimetic behaviour of the juveniles of species in these genera may be instrumental in ensuring the survival of these species by decreasing mortality rates during the vulnerable juvenile phase.

So far, the function of the colour patterns of juvenile scarids has been interpreted in terms of concealment in response to predation by diurnally active predators. However, other selective factors may be important in determining the colour patterns. The close similarity between species may be partially a result of the limited range of colour patterns available when based on the 'typical' scarid pattern described in Section 4.3.3 (Fig. 4.2). There also appears to be a degree of similarity between the colour patterns of closely related species, for example *S. dimidiatus* and *S. oviceps* (Figs 4.9 A, B), and members of the 'sordidus' group:

S. sordidus, *S. gibbus* and *S. bleekeri* (Table 4.1). Colour patterns may therefore, be partially dependent on the phylogeny of the species considered.

Finally, social factors may have some influence on juvenile colour patterns. In other families, the recognition of juveniles by adults has been suggested as an important factor which influences the colour patterns of juveniles (Fricke, 1980 and Thresher, 1984;378). These studies have suggested that the distinctive juvenile colour patterns reduce adult-juvenile aggression. In this study, however, no adult-juvenile aggression was observed and in many species, the two stages occupy different areas of the reef (Chapter 6). Adult-juvenile aggression is therefore, likely to be of minor importance in influencing the colour patterns of juvenile scarids.

The only observation in this study that suggests that social factors may be important in influencing the colour patterns of juvenile scarids is the apparent correlation between levels of interspecific aggression and the colour of the caudal fin and the caudal peduncle. In the species observed, most aggressive interspecific interactions were from solitary species which possessed a pale caudal fin and caudal peduncle, these are: *S. frenatus*, *S. brevipilis* and *S. bleekeri*. The pale caudal region may therefore act as an 'aggressive' display, in a manner similar to that outlined in the 'poster colour' hypothesis of Lorenz (1962). The high levels of aggression by solitary species are consistent with the observations of Lorenz (1962), Zumpe (1965) and Brown *et al.* (1973).

In conclusion, the diverse range of colour patterns displayed by juvenile scarids appears to be adapted to the particular habitat and lifestyle of each species, with concealment from diurnally active visual predators being the primary selective factor. The proposed functions of the colour patterns are tentative and in many cases, speculative, but they will hopefully form a basis for testable hypotheses. With the aid of the descriptions in this chapter, most juvenile scarids on the Great Barrier Reef can be identified in the field. Studies of the early post-recruitment life histories of scarids are therefore possible (Chapter 6).

Summary

1) Recently recruited *Scarus* species share a common colour pattern.

Changes in this pattern during ontogeny result in a wide range of colour patterns but most are variations of a basic pattern of four horizontal stripes and/or six vertical bands. The four stripes are designated here as the dorsal, orbital, pectoral and ventral stripes, with a possible sub-division of the dorsal stripe. The bands are numbered 1 to 6, with band 2 occasionally being subdivided dorsally.

2) The colour patterns of juvenile scarids are interpreted as concealment colouration in response to diurnally active visual predators. Three concealment strategies are described: crypticism, camouflage and mimicry.

Crypticism is most often displayed by solitary species. Those species typically have a limited mobility and occupy specific habitat types. They may undergo several changes of colour pattern throughout ontogeny, but they are unable to change

colour patterns rapidly. The patterns are often complex, with a series of flecks, dots or dashes.

Camouflage is often utilized by schooling species, although many patterns are also cryptic. Schooling species have a moderate mobility and often transverse several habitat types, many of which lack structural complexity. These species often have extremely similar colour patterns and are able to change colour patterns within a few seconds. This ability appears to be specifically associated with schooling species. The patterns are typically uniform, striped or banded.

Mimicry was observed in two species. Recently recruited *Cetoscarus bicolor* appear to mimic *Amphiprion* species, whilst *Hipposcarus longiceps* mimics a *Lethrinus* species (possibly *L. nebulosus*).

- 3) Similar strategies of crypticism, camouflage and mimicry were utilized to conceal the location of the eye.
- 4) The phylogeny of a species and social factors appear to play only minor roles in determining the colour patterns of juvenile scarids.