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A Review of the Parrotfishes (Family Scaridae) of the Great Barrier Reef of Australia with Description of a New Species

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ABSTRACT. The family Scaridae is represented on the tropical and subtropical coasts of eastern Australia by 25 previously described species. Three species belong in the subfamily Sparisomatinae: *Leptoscarus vaigiensis* (Quoy & Gaimard); *Calotomus carolinus* (Valenciennes); *Calotomus spinidens* (Quoy & Gaimard). The remainder are included in the subfamily Scarinae: *Bolbometopon muricatum* (Valenciennes); *Cetoscarus bicolor* (Rüppell); *Hipposcarus longiceps* (Valenciennes); *Scarus altipinnis* (Steindachner); *Scarus bleekeri* (de Beaufort); *Scarus dimidiatus* Bleeker; *Scarus flavipectoralis* Schultz; *Scarus forsteni* (Bleeker); *Scarus frenatus* Lacepède; *Scarus frontalis* Valenciennes; *Scarus ghobban* Forsskål; *Scarus gibbus* Rüppell; *Scarus globiceps* Valenciennes; *Scarus longipinnis* Randall & Choat; *Scarus niger* Forsskål; *Scarus oviceps* Valenciennes; *Scarus psittacus* Forsskål; *Scarus pyrrhurus* (Jordan & Seale); *Scarus rivulatus* Valenciennes; *Scarus rubroviolaceus* Bleeker; *Scarus schlegeli* (Bleeker); *Scarus sordidus* Forsskål; *Scarus spinus* Kner. The scarid from Australian waters previously misidentified as *Scarus lunula* (a synonym of *Scarus festivus* Valenciennes) represents an undescribed species *Scarus chameleon*, described herein. *Scarus chameleon* has a distribution that includes the western and southern Pacific. It is similar to *S. festivus* but differs in patterns of head and body colouration in the terminal phase, and in the head profile. All but three species listed above are most commonly encountered on the coral reefs of the Great Barrier Reef and the adjacent coral sea. The exceptions are the sparisomatine species *Leptoscarus vaigiensis* and *Calotomus spinidens*, and the scarinine species *Scarus ghobban*. The former two species are often associated with seagrass beds in coastal areas, while *Scarus ghobban* frequents a variety of non-reef habitats. Many of the species listed extend into northern and western Australian waters. Additional collecting is required to establish the limits and identities of the entire Australian scarid fauna. Colour photographs of fresh specimens illustrating the different colour phases of all 27 species are provided. In addition, underwater colour photographs of most species are provided with an emphasis on those which show confusing patterns of short term variation in the initial colour phase. Illustrations of the juvenile phase are provided for some species.

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The Scaridae, a family of labroid fishes, are highly characteristic of coral reef habitats. With few exceptions their geographical distribution is linked to that of tropical reef environments. The number of species of scarids is not great when compared with other families of tropical perciform fishes. However, their relatively large size, complex patterns of colour change, and conspicuous grazing habit have resulted in a continuing interest in this group by ichthyologists and reef biologists generally.

All members of the family Scaridae possess a continuous dorsal fin with 9 flexible spines and 10 soft rays, and an anal fin with 3 flexible spines and 9 soft rays; pectoral fins have 2 unbranched rays (the first always rudimentary) and 11–15 branched rays. Body scales are always large and cycloid with 22–24 in the lateral line. There are 1–4 rows of cheek scales with varying numbers of scales in each row and 2–8 median predorsal scales. Gill rakers of scarids show considerable variation both within and between species. The number of gill rakers within a species will also vary with the size of the individual.

Important structural and ecological characters are the fusion of teeth to form beak-like dental plates, a pharyngeal apparatus in which flattened teeth form a grinding mill, the absence of a true stomach, and a herbivorous habit. A minority of species selectively graze living corals. The scarids form a natural grouping

both taxonomically and ecologically and we prefer to maintain this distinction at the familial level. We do not accept the argument of Kaufman & Liem (1982) that places the Labridae and Scaridae within the same family.

We follow Bruce & Randall (1985) in recognizing two subfamilies of Scaridae, the Sparisomatinae which includes the genera *Leptoscarus* and *Calotomus*, and the Scarinae. The latter subfamily includes all the species characteristic of reef environments and constitutes the main focus of this review. Sparisomatine parrotfishes are more likely to be encountered in non-reef environments such as seagrass beds and are not important members of the Great Barrier Reef fauna. Very few sparisomatine parrotfishes were observed or collected from eastern Australia. For structural details of the three Australian species in this subfamily the reader is referred to the recent revision, Bruce & Randall (1985).

The generic classification of the Scarinae used here follows that of Randall & Bruce (1983). The genus *Bolbometopon* Smith is restricted to a single species, *muricatum*; *Scarus bicolor* Rüppell is placed in *Cetoscarus*. We recognize *Hipposcarus* Smith as a valid genus for *Scarus longiceps* Valenciennes and refer the genus *Scarops* Schultz to the synonymy of *Scarus* Forsskål.

Scarids are important members of reef communities

and have been the focus of a number of questions concerning the importance of herbivorous feeding on reefs and the biology of reef fishes generally, (Choat & Bellwood, 1986; Hatcher & Larkum, 1983; Russ, 1984a,b). Reliable identifications of scarid fishes are a prerequisite for many of these studies. Such identification may be a difficult task. All species are very similar in external morphology and meristic features. They have the same number of lateral line scales, the same number of spines and rays in the medial fins, and very similar body proportions. Some meristic characters, including the number of pectoral rays, the number of scale rows and scales on the cheek, and the number of median predorsal scales vary amongst species. However the diagnostic value of such variation may be limited, as it separates scarids into species groups rather than individual species.

Colour pattern is an important character for distinguishing species of scarids but the use of colour as a diagnostic feature requires caution. Most colour fades rapidly on death and under conditions of preservation may bear little relation to life features, although some distinguishing markings are retained. More importantly the majority of scarids undergo a complex sequence of colour changes during their life. These changes are linked to growth and patterns of sexual ontogeny, most species being protogynous hermaphrodites (Choat & Robertson, 1975).

Previous attempts to review the taxonomy of scarids (Smith, 1956, 1959; Schultz, 1958, 1969) suffered from a lack of information on patterns of colour change, and the poor state of preservation of much of the type material. This has been discussed in detail elsewhere (Randall, 1963; Randall & Choat, 1980; Randall & Bruce, 1983; Bruce & Randall, 1985). These more recent studies with an emphasis on field work have provided two elements essential to a better understanding of scarid taxonomy, good descriptions of the character and sequence of colour change, and a more rigorous analysis of scarid distribution patterns.

The present study provides for the identification of scarids within a single tropical region, the Great Barrier Reef off north-eastern Australia. Although some species have very broad distributions, there are distinct regional groupings of scarids within the western Indian Ocean, the Indo-West and central Pacific (Randall & Bruce, 1983). A study of a major reef area in the southern Pacific provides the material for biogeographic comparisons with other areas such as the northern tropical Pacific (Masuda et al., 1984), the western Indian Ocean and the Red Sea (Randall & Bruce, 1983), and the eastern Pacific (Rosenblatt & Hobson, 1969). In addition the geographic situation of the Great Barrier Reef itself with combined latitudinal (11°S to 22°S) and habitat (coastal mangrove forests to Coral Sea reefs) variation provides a good opportunity for analysing species distributions with reference to these factors (Williams, 1982; Williams & Hatcher, 1983). Other Australian regions, especially the reefs of the northern and north-west coasts, require additional collecting.

Material available to date suggests that these reefs cannot be considered simply as extensions of the Great Barrier Reef.

This study emphasizes life colouration of scarids in the initial and terminal colour phases for each species and deals mainly with the adults. An important aspect of scarid biology, the identification of individuals newly recruited to the reef, will be dealt with in a separate publication. The present work does consider juvenile colouration in species where the phase is particularly striking and likely to be encountered by divers. Our concern is with the upper end of the juvenile size range and adults. Bellwood & Choat (in prep.) will consider very small individuals at the lower end of the juvenile size range.

Introductory aspects of scarid taxonomy and biology are considered under separate headings. These include historical aspects of scarid taxonomy in the Australian region, and distribution patterns of scarid faunas.

Materials and Methods

For species descriptions the emphasis is on the colour of living and fresh material in the initial phase (IP) and terminal phase (TP). Where juveniles are known to have distinct colour phases these are also included; greater detail of colour pattern in small scarids will be provided elsewhere (Bellwood & Choat, in prep.). In this study the term juvenile refers to individuals not sexually mature and usually between 50–120 mm standard length (SL). Where sexual identity is specified this was determined histologically. The majority of species examined are protogynous hermaphrodites; exceptions are identified. The term IP refers to subadult and adult females, primary males and occasionally small secondary males. TP phase refers to secondary males. In colour descriptions, stripes are longitudinal bands, bars are vertical markings.

Meristic data include the number of median predorsal scales, the number of cheek scale rows, the number of scales in each of these rows, and the number of pectoral fin rays. Median predorsal scales are counted from the most anterior scale; small lateral or overlapping scales anterior to the first median predorsal are identified but not included in the counts. Scale rows on the cheek are the horizontal rows between the lower edge of the orbit and the lower margin of the preopercle. The counts of scales in each row start at the most anterior scale (Fig. 1) and do not include the single large postorbital scale characteristic of most species. Counts of the pectoral rays include the upper rudimentary ray which is unbranched. No distinction is made between the upper two unbranched rays and the remaining branched rays. The last dorsal and anal fin rays are split to their base but counted as a single rays. Gill rakers are useful for separating genera of scarids and the species within the subfamily Sparisomatinae (Bruce & Randall, 1983). Gill rakers within the subfamily Scarinae were found to vary both intra- and interspecifically especially in the genus

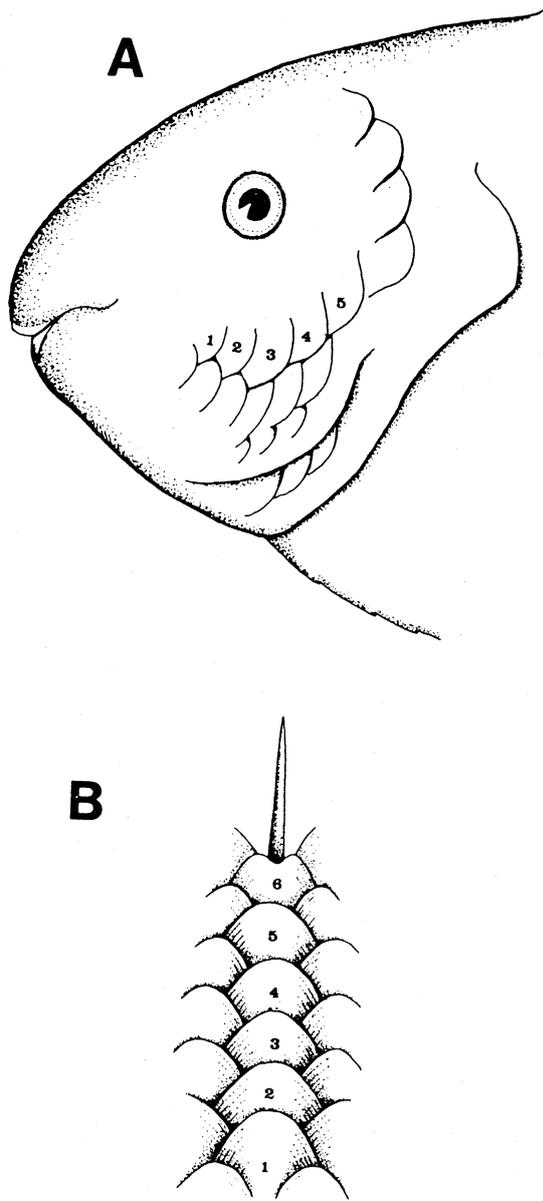


Fig.1. A, format used for counting cheek scales. There are 3 rows of cheek scales with 5 scales in the upper row. Scales are counted with the anterior scale first. The large postorbital scale is not included in the cheek scale counts. **B**, format used for counting median predorsal scales; there are 6 median predorsal scales with the anterior scale counted first. The 2 smaller scales on each side of the first scale are not included in the counts. Scale size is measured as the distance between the posterior tip of one scale and the next. For the first scale the measure is from the base of the scale to its posterior tip.

Scarus. Gill-raker counts were not recorded from members of this genus. The numbers of canine teeth were found to have some diagnostic value and are included. Meristic material in the diagnoses and Tables 1 to 3 refers to Great Barrier Reef material unless specified.

Table 1. Counts of median predorsal scales in Great Barrier Reef scarids.

Species	3	4	5	6	7	8
<i>L. vaigiensis</i>		4				
<i>B. muricatum</i>	1	1	1			
<i>C. bicolor</i>		2	2	3	1	
<i>H. longiceps</i>		13				
<i>S. gibbus</i>		19	1			
<i>S. flavipectoralis</i>	1	14				
<i>S. schlegeli</i>		37				
<i>S. psittacus</i>		50				
<i>S. sordidus</i>		41				
<i>S. spinus</i>	2	20	3			
<i>S. chameleon</i>		39	3			
<i>S. bleekeri</i>		9				
<i>S. longipinnis</i>	2	4				
<i>S. rubroviolaceus</i>				5		
<i>S. dimidiatus</i>			1	2		
<i>S. oviceps</i>			1	13	1	
<i>S. globiceps</i>			34	24	4	
<i>S. rivulatus</i>			10	42	6	
<i>S. ghobban</i>			2	36		
<i>S. altipinnis</i>			2	14		
<i>S. forsteni</i>			2	6	1	
<i>S. frenatus</i>				9	6	
<i>S. niger</i>					5	9

Table 2. Pectoral fin rays (counts from both sides of fish)

Species	13	14	15	16	17
<i>L. vaigiensis</i>	8				
<i>B. muricatum</i>				6	
<i>C. bicolor</i>	1	14	1		
<i>H. longiceps</i>		2	24		
<i>S. gibbus</i>		2	34	2	
<i>S. flavipectoralis</i>			30		
<i>S. schlegeli</i>	2	63	9		
<i>S. psittacus</i>	1	96	3		
<i>S. sordidus</i>		4	76		
<i>S. spinus</i>	5	43			
<i>S. chameleon</i>	3	80	3		
<i>S. bleekeri</i>		1	15		
<i>S. longipinnis</i>		11	1		
<i>S. rubroviolaceus</i>			8	2	
<i>S. dimidiatus</i>		6			
<i>S. oviceps</i>		28	2		
<i>S. globiceps</i>		129	11		
<i>S. rivulatus</i>	3	92	19		
<i>S. ghobban</i>		4	71	3	
<i>S. altipinnis</i>		1	30	1	
<i>S. forsteni</i>	2	16			
<i>S. frenatus</i>		21	9		
<i>S. niger</i>		31	1		

Table 3. Counts of cheek scales in each row (counts from both sides of fish)

Species	Row 1					Row 2					
	4	5	6	7	8	4	5	6	7	8	9
<i>L. vaigiensis</i>	8										
<i>B. muricatum</i>	1	2	3			3	3				
<i>C. bicolor</i>				3	3			1	3	2	
<i>H. longiceps</i>		1	4	4	1			1	4	5	
<i>S. gibbus</i>		3	10	7			4	9	7		
<i>S. flavipectoralis</i>			21	11		1	4	21	6		
<i>S. schlegeli</i>		3	42	20	1		7	42	16	1	
<i>S. psittacus</i>	1	10	79	10			4	19	64	5	
<i>S. sordidus</i>		14	54	10	2		10	38	36		
<i>S. spinus</i>		34	13	1			23	15	9	1	
<i>S. chameleon</i>		7	57	12			2	40	33	1	
<i>S. bleekeri</i>			10	5	1			5	6	5	
<i>S. longipinnis</i>		1	7	4			2	5	5		
<i>S. rubroviolaceus</i>			8	2				4	6		
<i>S. dimidiatus</i>			3	3				2	3	1	
<i>S. oviceps</i>		1	7	2				3	5	1	3
<i>S. globiceps</i>		9	78	48				28	78	31	1
<i>S. rivulatus</i>		19	85	8			6	74	27	1	
<i>S. ghobban</i>		5	64	3			6	61	5		
<i>S. altipinnis</i>		1	9	6				3	9	4	
<i>S. forsteni</i>		1	8	3				1	5	5	1
<i>S. frenatus</i>		1	16	11				2	8	18	
<i>S. niger</i>		2	12	14				5	8	10	3

Table 3. Cheek scales (continued)

Species	Row 3						
	1	2	3	4	5	6	7
<i>B. muricatum</i>	4	2					
<i>C. bicolor</i>			1	1	3	1	
<i>H. longiceps</i>		1	1	2	5	1	
<i>S. gibbus</i>		1	1	7	8	3	
<i>S. flavipectoralis</i>	19	11					
<i>S. spinus</i>	4	39	5				
<i>S. chameleon</i>	11	56	18				
<i>S. longipinnis</i>		12					
<i>S. rubroviolaceus</i>		4	6				
<i>S. dimidiatus</i>	1	3	2				
<i>S. oviceps</i>	1	5	4				
<i>S. globiceps</i>	4	47	81	9			
<i>S. rivulatus</i>	8	102	10				
<i>S. ghobban</i>	14	52	10				
<i>S. altipinnis</i>	2	19	11				
<i>S. forsteni</i>		2	8	3	3		
<i>S. frenatus</i>		10	7	11			
<i>S. niger</i>		15	10	5			

Proportional measurements are used in some instances to separate species but these are not generally diagnostic. Unless specified, length refers to standard length, the straight-line distance from front of snout to base of caudal fin (end of hypurals). Head length is taken from the same anterior point to the posterior fleshy end of the operculum. Depth of the body is the greatest depth. Width of the body is the maximum width immediately posterior to the head. Orbit width is the

greatest fleshy diameter. Interorbital width is the least bony width. Caudal peduncle depth is the least depth. The length of the caudal peduncle is the horizontal distance between the insertion of the last anal ray and the base of the caudal fin. The dorsal and anal spines and rays are usually curved; their lengths are straight-line measurements from extreme base to distal end. Caudal fin length is the greatest horizontal length. Caudal concavity is the horizontal distance between verticals at the tips of the longest and shortest rays of species with emarginate or lunate caudal fins. Pelvic fin length is from the base to the tip of the longest ray. In the description of the new species, data in parentheses refer to paratypes. Additional proportional measurements are provided in the relevant tables.

Both authors collected and observed scarids at the northern and southern ends of the Great Barrier Reef. The senior author was able to collect and observe on a series of central reefs from inshore to outer shelf habitats. In addition, a number of workers provided us with information on scarid distribution and abundance patterns from other areas of the Great Barrier Reef and a series of Coral Sea reefs. Unless indicated, the photographs were taken by the junior author. In some instances suitable photographs of Great Barrier Reef material were not available. Under these circumstances, photographs of the species in question from other localities within the species range were used. The locality of each individual illustrated is shown in the figure legends.

In synonymies, the symbol . — separating a scientific name and an author indicates that this reference is not the original description of the species. The identity of scarids from regional lists within the Australian and New Guinea regions are matched as far as possible with current nomenclature. Distributions of each species within the Australian region are indicated, but more collecting in northern and western Australia will undoubtedly result in modifications to these.

Specimens were examined from and deposited in the Australian Museum (AMS); Queensland Museum (QM); West Australian Museum (WAM); Bernice P. Museum (BPBM); British Museum (Natural History) (BM(NH)); Smithsonian Institution, Washington (USNM); Museum National d'Histoire Naturelle (MNHN).

Species accounts are in alphabetical order. The key refers mainly to adult individuals of each species.

Historical Review and Nomenclature of Australian Species

Historically, the taxonomic study of Australian scarids has had two distinct periods. During the latter part of the nineteenth century a number of scarids were collected, mainly from north Queensland coastal waters; ten of these were identified as new species. A smaller number of species were recognized as wider ranging scarids and added to the Australian faunal lists. Very

few additional scarids were recorded until the development of SCUBA diving. Scarids did not feature in the major collecting and descriptive episodes of Ogilby, McCulloch and Whitley during the early and mid-periods of the twentieth century. This suggests difficulties both in collecting in reef environments and the uncertainties of identification of preserved scarid material. The checklists of McCulloch (1930) and Whitley (1964) reflect this. These lists have been augmented by a number of more recent publications. These include the popular text of Marshall (1965) and the illustrated checklist and key of the scarid fauna from the adjacent reefs of New Guinea (Munro, 1967).

The first attempt to compile a record of a Great Barrier Reef scarid fauna was the species list of Heron Island fishes by Woodland & Slack-Smith (1963). Australian Museum-sponsored expeditions by F.H. Talbot to the southern and northern ends of the Great Barrier Reef provided comprehensive species lists culminating in the checklist of fishes recorded from the Capricorn-Bunker reefs (Russell, 1983). This includes 23 species of scarids and differs from the present study only by the absence of recent records from northern waters (*S.pyrrhurus*, *S.frontalis*, *C.spinidens*), and *Bolbometopon muricatum* which is restricted to central and northern areas of the Great Barrier Reef. In addition, the work on scarid reproductive biology by Choat & Robertson (1975) provides a list of scarid species from Heron Island. The checklist of fishes from Lord Howe Island (Allen et al., 1976) provides records of Australian scarids near the southern extremity of their range.

The lists of McCulloch and Whitley provide an entry to the early literature on Australian scarids. They recorded new species described from Australian waters prior to 1964 and early additions to the Australian fauna. Both these categories are considered below.

Twelve species of scarids have been described from Australian waters, most of them from three collections made in the latter half of the nineteenth century. The following species were described as new: *Pseudoscarus viridescens* Castelnau, 1875; *P. obscurus* Castelnau, 1875; *P. modestus* Castelnau, 1875; *P. dumerilii* Castelnau, 1875; *P. richardsonii* Castelnau, 1875; *P. strigipinnis* De Vis, 1885; *P. fuscus* De Vis, 1885; *P. flavipinnis* De Vis, 1885; *P. flavolineatus* Alleyne & Macleay, 1877; *P. nudirostris* Alleyne & Macleay, 1877; *Scarus pyrrostethus australianus* Paradice & Whitley, 1927; and *Scarus toshi* Whitley, 1933. Schultz (1969), in a major review of parrotfishes, considered all of these to be unidentifiable with the exceptions of *S. pyrrostethus australianus* which was placed in the synonymy of *S. ghobban*, and *S. toshi* which he erroneously referred to *S. harid*.

The collections of scarids made by Castelnau resulted in the description of five new species. The type localities of two of these, *P. modestus* and *P. dumerilii*, were Adelaide, and the remaining three were from Cape York. The species from Adelaide are members of the family Odacidae (Gomon & Paxton, 1985) which have

a number of scarid-like features. Those from Cape York were almost certainly scarids but no type material can be located in any Australian museums or in the Paris Museum. The published descriptions are not sufficient to allow identification, and unless type material is located, *P. obscurus*, *P. richardsonii* and *P. viridescens* will remain unidentifiable.

Both De Vis and Alleyne & Macleay described a number of scarids collected in Australian waters. The types are in Australian museums and generally in good condition. De Vis (1885) described three species of scarids collected in north-eastern Australian waters, the types of which were examined in the Queensland Museum. These were found to represent the previously described *S. ghobban* and *S. globiceps* both of which are widely distributed in tropical waters. Alleyne & Macleay (1877) described two species from Cape Grenville, north Queensland. The types in good condition in the Australian Museum represent *S. rivulatus* and *S. ghobban*, previously described and widely distributed species.

Two further species described from Australian waters are *Scarus pyrrostethus australianus* Paradice & Whitley, 1927 and *Scarus toshi* Whitley, 1933. The type of the former is in the Australian Museum and is *S. ghobban*. Although no formally designated type of *S. toshi* exists, it is certain that this species also represents *S. ghobban*.

That most of the identifiable species of scarids described from Australian waters should be referred to *Scarus ghobban* is not surprising. Earlier workers did not have easy access to reef environments and those that did would have found most scarids difficult to collect. Species such as *S. ghobban* and *S. rivulatus* are representatives of the few scarid species which may occur in non-reef environments such as mangroves and rocky shores where they might have been collected by netting and spearing.

In addition to these new species there are a number of earlier records of scarids in the checklists of McCulloch and Whitley which require confirmation. These are *Scarus cyanotaenia* Bleeker, *Scarus axillaris* Steindachner, *Scarus gymnognathus* Bleeker, *Scarus octodon* Bleeker, and *Scarichthys auritus* Bleeker. *Scarus cyanotaenia* was erroneously used by Ogilby (1915) for *S. ghobban*. *Scarus axillaris*, a Caribbean species, is recorded from the 'north coast of Australia' but this is clearly erroneous (Schultz, 1958). Kner (1865) recorded *Pseudoscarus octodon* from Sydney but the description does not allow identification. *Scarus gymnognathus* is a synonym of *S. sordidus*, and *S. auritus* is a synonym of *L. vaigiensis*.

Table 4 lists the nominal species of scarids described from Australian waters and matches these with their present identification. Table 5 lists the nominal species of scarids recorded from Australian waters in a number of important regional studies and species lists. Information concerning the New Guinea scarid fauna is included for comparative purposes.

Table 4. List of nominal species of scarids described from Australian waters. The scientific name as it originally appeared, in alphabetical order according to the trivial name, the author and the date of publication and the present identification. Refer to the text under the senior synonym for the basis of determination.

Species, Author, Publication date	Present Identification
<i>Pseudoscarus dumerilii</i> Castelnau, 1875	<i>Siphonognathus radiatus</i> (Quoy & Gaimard) Family Odacidae
<i>Pseudoscarus flavipinnis</i> De Vis, 1885	<i>Scarus ghobban</i> Forsskål
<i>Pseudoscarus flavolineatus</i> Alleyne & Macleay, 1877	<i>Scarus rivulatus</i> Valenciennes
<i>Pseudoscarus fuscus</i> De Vis, 1885	<i>Scarus globiceps</i> Valenciennes
<i>Pseudoscaurus modestus</i> Castelnau, 1875	<i>Odax acroptilus</i> (Richardson) Family Odacidae
<i>Pseudoscarus nudirostris</i> Alleyne & Macleay, 1877	<i>Scarus ghobban</i> Forsskål
<i>Pseudoscarus obscurus</i> Castelnau, 1875	Type not located
<i>Pseudoscarus richardsonii</i> Castelnau, 1875	Type not located
<i>Scarus pyrrosethus australianus</i> Paradice & Whitley, 1927	<i>Scarus ghobban</i> Forsskål
<i>Pseudoscarus strigipinnis</i> De Vis, 1885	<i>Scarus globiceps</i> Valenciennes
<i>Callyodon toshi</i> Whitley, 1933	<i>Scarus ghobban</i> Forsskål
<i>Pseudoscarus viridescens</i> Castelnau, 1875	Type not located

In addition the types of a number of species of scarids described by Macleay (1883) with a type locality of Port Moresby were examined. These are included below.

<i>Pseudoscarus frontalis</i> Macleay 1883	<i>Scarus rubroviolaceus</i> Bleeker
<i>Pseudoscarus goldei</i> Macleay 1883	<i>Scarus sordidus</i> Forsskål
<i>Pseudoscarus labiosus</i> Macleay 1883	<i>Scarus psittacus</i> Forsskål
<i>Pseudoscarus moresbyensis</i> Macleay 1883	<i>Scarus quoyi</i> Val.
<i>Pseudoscarus papuensis</i> Macleay 1883	Type not located
<i>Pseudoscarus zonatus</i> Macleay 1883	<i>Scarus oviceps</i> Val.

Table 5. A list of the nominal species of scarids recorded from Australian waters in various checklists and from New Guinea by Munro (1967). We have used the checklists of (1) McCulloch (1930), (2) Woodland & Slack-Smith (1963), (3) Whitley (1964), (4) Marshall (1965) and (5) Russell (1983). Choat & Robertson (1975) provided a list (6) of scarids from the Capricorn-Bunker reef as a part of their study on scarid reproductive biology. In addition we have also included the species listed by (7) Munro (1967) from New Guinea waters. Many of these were recorded from southern New Guinea waters and probably have common distributions with the northern Great Barrier Reef fauna. In some instances the true identity of New Guinea material is uncertain. Allen et al. (1976) (8) provide a list of scarids from Lord Howe Island. For discussion refer to the text under the senior synonym.

GBR = Great Barrier Reef; Val. = Valenciennes

Scarid Identity and Checklist Record	Present Identification
<i>Callyodon aeruginosus</i> (Val.) New Guinea (7)	<i>Scarus rivulatus</i> Val.
<i>Scaricthys auritus</i> Valenciennes Moreton Bay, Lord Howe Is.(1)	<i>Leptoscarus vaigiensis</i> (Quoy & Gaimard)
<i>Scarus axillaris</i> Steindachner Northern Australia (1)	<i>Sparisoma rubripinnae</i> (Val.)
<i>Xanophon bataviensis</i> (Bleeker) New Guinea (7)	<i>Scarus psittacus</i> Forsskål
<i>Bolbometopon bicolor</i> (Rüppell) Heron Is. (6)	<i>Cetoscarus bicolor</i> (Rüppell)
<i>Cetoscarus bicolor</i> (Rüppell) Heron Is., GBR (2) (4) (5)	
<i>Chlorurus bicolor</i> (Rüppell) GBR (3)	
<i>Xanophon bleekeri</i> (de Beaufort) New Guinea (7)	<i>Scarus bleekeri</i> (de Beaufort)
<i>Scarus bleekeri</i> (de Beaufort) Southern GBR (5) (6)	

Scarid Identity and Checklist Record	Present Identification
<i>Callyodon blochi</i> (Val.) New Guinea (7)	<i>Scarus quoyi</i> Val.
<i>Scarus brevifilis</i> (Gunther) Southern GBR (5)	<i>Scarus altipinnis</i> (Steindachner)
<i>Calotomus carolinus</i> (Val.) Southern GBR (5)	<i>Calotomus carolinus</i> (Val.)
<i>Callyodon chlorodon</i> (Jenyns) New Guinea (7)	<i>Scarus altipinnis</i> (Steindachner)
<i>Scarus chlorodon</i> Jenyns Heron Is., Lord Howe Is. (6) (8)	
<i>Leptoscarus coeruleopunctatus</i> (Bleeker) Moreton Bay (4)	<i>Leptoscarus vaigiensis</i> (Quoy & Gaimard)
<i>Callyodon cyanognathus</i> (Bleeker) New Guinea (7)	<i>Scarus tricolor</i> Bleeker?
<i>Scarus cyanotaenia</i> Bleeker GBR and Moreton Bay (1) (4)	<i>Scarus ghobban</i> Forsskål
<i>Xanothon cyanotaenia</i> (Bleeker) Moreton Bay (3)	
<i>Scarus dimidiatus</i> Bleeker Southern GBR (5)	<i>Scarus dimidiatus</i> Bleeker
<i>Scarus dubius</i> Bennett Heron Is., GBR (2) (4)	<i>Scarus rivulatus</i> Val.
<i>Callyodon dubius</i> Bennett New Guinea (7)	<i>Scarus rivulatus</i> Val.?
<i>Xanothon erythrodon</i> (Val.) New Guinea (7)	<i>Scarus sordidus</i> Forsskål
<i>Scarus fasciatus</i> Val. Heron Is. (2) (6)	<i>Scarus rivulatus</i> Val.
<i>Callyodon fasciatus</i> Val. GBR, New Guinea (3) (4) (7)	
<i>Callyodon flavipectoralis</i> (Schultz) New Guinea (6)	<i>Scarus flavipectoralis</i> Schultz
<i>Scarus flavipectoralis</i> Schultz Southern GBR (5) (6)	
<i>Callyodon formosus</i> (Val.) GBR, New Guinea (3) (7)	<i>Scarus spinus</i> Kner
<i>Scarus formosus</i> Val. Heron Is. (6)	
<i>Callyodon forsteri</i> (Val.) GBR (3)	<i>Scarus psittacus</i> Forsskål
<i>Scarus forsteri</i> Val. Heron Is., Lord Howe Is. (6) (8)	
<i>Callyodon frenatus</i> (Lacepède) GBR (3)	<i>Scarus frenatus</i> Lacepède
<i>Scarus frenatus</i> Lacepède Southern GBR (5)	
<i>Scarus ghobban</i> Forsskål Heron Is., Lord Howe Is. (2) (5) (6) (8)	<i>Scarus ghobban</i> Forsskål
<i>Callyodon ghobban</i> (Forsskål) GBR, New Guinea (3) (7)	
<i>Scarus gibbus</i> Rüppell Southern GBR, Lord Howe Is. (5) (6) (8)	<i>Scarus gibbus</i> Rüppell
<i>Scarus globiceps</i> Val. Heron Is. (2) (5) (6)	<i>Scarus globiceps</i> Val.
<i>Callyodon globiceps</i> (Val.) GBR (3) (4)	
<i>Scarus gymnognathus</i> Bleeker Western Australia (1)	<i>Scarus sordidus</i> Forsskål
<i>Calotomus japonicus</i> (Val.) New Guinea (7)	<i>Calotomus spinidens</i> (Quoy & Gaimard)?
<i>Scarops jordani</i> (Jenkins) New Guinea (7)	<i>Scarus rubroviolaceus</i> Bleeker
<i>Scarus lepidus</i> Jenyns Heron Is. (6)	<i>Scarus forsteni</i> Bleeker

Scarid Identity and Checklist Record	Present Identification
<i>Hipposcarus longiceps</i> (Val.) Southern GBR, New Guinea (5) (7)	<i>Hipposcarus longiceps</i> (Val.)
<i>Scarus longipinnis</i> Randall & Choat Southern GBR (5)	<i>Scarus longipinnis</i> Randall & Choat
<i>Scarus lunula</i> (Snyder) Heron Is., Lord Howe Is. (6) (8)	<i>Scarus chameleon</i> n.sp.
<i>Scarus microrhinos</i> Bleeker Heron Is. (2)	<i>Scarus gibbus</i> Rüppell
<i>Callyodon microrhinos</i> (Bleeker) GBR (3)	
<i>Chlorurus microrhinos</i> (Bleeker) New Guinea (7)	
<i>Bolbometopon muricatus</i> (Val.) New Guinea (7)	<i>Bolbometopon muricatum</i> (Val.)
<i>Callyodon mutabilis</i> Gray GBR (4)	<i>Scarus schlegeli</i> Bleeker?
<i>Callyodon niger</i> (Forsskål) New Guinea (7)	<i>Scarus niger</i> Forsskål
<i>Scarus niger</i> Forsskål Southern GBR (5) (6)	
<i>Pseudoscarus oktodon</i> Bleeker NSW? (1)	Unidentifiable
<i>Xanothon oktodon</i> (Bleeker) New Guinea (7)	<i>Scarus psittacus</i> Rüppell?
<i>Callyodon oviceps</i> (Val.) New Guinea (7)	<i>Scarus oviceps</i> Val.
<i>Scarus oviceps</i> Val. Southern GBR (5) (6)	
<i>Scarus psittacus</i> Forsskål Southern GBR (5)	<i>Scarus psittacus</i> Forsskål
<i>Callyodon pulchellus</i> (Rüppell) GBR (4)	<i>Cetoscarus bicolor</i> (Rüppell)
<i>Cetoscarus pulchellus</i> (Rüppell) New Guinea (7)	
<i>Scarus rivulatus</i> Val. Southern GBR (5)	<i>Scarus rivulatus</i> Val.
<i>Scarops rubroviolaceus</i> (Bleeker) New Guinea (7)	<i>Scarus rubroviolaceus</i> Bleeker
<i>Scarus rubroviolaceus</i> Bleeker Southern GBR (5) (6)	
<i>Scarus scaber</i> Val. Heron Is. (6)	<i>Scarus dimidiatus</i> Bleeker
<i>Scarus schlegeli</i> Bleeker Southern GBR (5)	<i>Scarus schlegeli</i> Bleeker
<i>Scarus schultzi</i> (Smith) Heron Is. (6)	<i>Hipposcarus longiceps</i> (Val.)
<i>Scarus sexvittatus</i> Rüppell Heron Is., Lord Howe Is. (6) (8)	<i>Scarus frenatus</i> Lacepède
<i>Scarus sordidus</i> Forsskål Heron Is., Lord Howe Is. (2) (5) (6) (8)	<i>Scarus sordidus</i> Forsskål
<i>Callyodon sordidus</i> (Forsskål) GBR (3)	
<i>Xanothon sordidus</i> (Forsskål) New Guinea (7)	
<i>Scarus</i> sp. 1 Southern GBR (5)	<i>Scarus chameleon</i> n.sp.
<i>Scarus</i> sp. Lord Howe Is. (8)	<i>Scarus longipinnis</i> Randall & Choat
<i>Cryptotomus spinidens</i> (Quoy & Gaimard) GBR (3) (4)	<i>Calotomus carolinus</i> (Val.) (Quoy & Gaimard)
<i>Calotomus spinidens</i> Heron Is., New Guinea (6) (7)	
<i>Scarus spinus</i> Kner Southern GBR (5)	<i>Scarus spinus</i> Kner

Scarid Identity and Checklist Record	Present Identification
<i>Chlorurus strongylocephalus</i> (Bleeker) New Guinea (7)	<i>Scarus gibbus</i> Rüppell?
<i>Scarus tricolor</i> Bleeker Southern GBR (5)	<i>Scarus forsteni</i> Bleeker
<i>Scarus venosus</i> Val. Heron Is. (6)	<i>Scarus schlegeli</i> Bleeker
<i>Xanothon venosus</i> (Val.) New Guinea (7)	
<i>Leptoscarus vaigiensis</i> (Quoy & Gaimard) Moreton Bay, New Guinea, Lord Howe Is. (3) (4) (7) (8)	<i>Leptoscarus vaigiensis</i> (Quoy & Gaimard)
<i>Scarus vermiculatus</i> Fowler & Bean Heron Is. (2)	<i>Scarus frenatus</i> Lacepède

Zoogeography and Distribution

The distribution of parrotfishes is linked closely to that of coral reefs. Very few species extend beyond this habitat. Indo-Pacific parrotfish faunas exist in three major groupings; the Red Sea, Indian Ocean, and the western and central Pacific. Numbers of species decline across the central Pacific to its eastern boundary. The tropical eastern Pacific has a very depauperate fauna comprising only six species, three of which are unique to the area. There also appears to be a small southern Pacific element. The greatest number of parrotfishes have been recorded from the Indonesian and Philippine archipelagos and the adjacent western Pacific region.

Each of these faunal areas contain mixtures of both area-specific and wide-ranging species. There are a number of species complexes. These closely related species tend to form a geographical series, replacing each other through the major faunal areas. In many instances there is little spatial overlap amongst the species. The geographic distribution of members of the *Scarus schlegeli* (Fig. 2) complex is a good example. These patterns serve as models for reviewing taxonomic problems involving closely related species. In contrast, the wide-ranging species exemplified by *S. ghobban* may have extensive distributions extending from the Red Sea to the eastern Pacific.

The scarid fauna of the Great Barrier Reef, comprising 27 recorded species, is a mixture of three

faunal elements (Table 6). Of the 27 species, 13 are wide-ranging with many of them extending from the Red Sea to the central Pacific. These include *S. sordidus*, *S. rubroviolaceus* and *S. ghobban*. Twelve are characteristic of the Indo-West Pacific region and include *S. rivulatus*, *H. longiceps* and *S. spinus*. Many of these species extend to the northern tropical Pacific. Recent collecting in the southern Pacific has revealed a small but distinctive fauna with a predominantly southern distribution. We include two species here, the recently described *S. longipinnis* and *S. schlegeli*. *Scarus schlegeli* occurs on the Great Barrier Reef and southern Pacific reefs as a distinctive colour variant (Fig.2).

It is highly probable that with increasing observations on the far northern reefs other species will be added to the Great Barrier Reef list. Species such as *Scarus quoyi*, which occurs in New Guinea, are obvious candidates. Both *S. pyrrhurus* and *S. frontalis* were only sighted very recently on the northern Great Barrier Reef. In addition, there is an unconfirmed sighting of what may be *Scarus oedema*, a species which has previously been recorded from Western Australia but not the Great Barrier Reef.

The Western Australian fauna shares a number of species with the Great Barrier Reef but also contains some distinctive Indian Ocean and western Pacific species. This area requires further collecting, especially on the reefs of the North-West Shelf.

The Australia-wide distribution patterns of the 27 recorded Great Barrier Reef species are shown in Fig.3.

Table 6. Geographic affinities of scarids recorded from the Great Barrier Reef.

A) Widely distributed species. (West Indian and Pacific Oceans)		B) Western and Central Pacific Species	
<i>B. muricatum</i>	<i>S. ghobban</i>	<i>H. longiceps</i>	<i>S. flavipectoralis</i>
<i>C. bicolor</i>	<i>S. sordidus</i>	<i>S. chameleon</i>	<i>S. forsteni</i>
<i>C. carolinus</i>	<i>S. frenatus</i>	<i>S. pyrrhurus</i>	<i>S. altipinnis</i>
<i>C. spinidens</i>	<i>S. niger</i>	<i>S. frontalis</i>	<i>S. dimidiatus</i>
<i>L. vaigiensis</i>	<i>S. globiceps</i>	<i>S. bleekeri</i>	<i>S. oviceps</i>
<i>L. psittacus</i>	<i>S. rubroviolaceus</i>	<i>S. spinus</i>	<i>S. rivulatus</i>
<i>S. gibbus</i>			
C) Southern Pacific species.			
<i>S. longipinnis</i>			
<i>S. schlegeli</i> (southern variant)			

Thirteen of these 27 species extend into northern and western tropical areas. Four of these also extend beyond the limits of reef growth into the edge of temperate areas. These include *S.gobban*, *S.sordidus* and *L.vaigiensis*, all species with wide geographic distributions. In addition, a number of species may recruit some distance to the south of coral reef environments but do not survive. Observations and records from southern New South Wales include newly recruited *S.rubroviolaceus* and *S.chameleon*.

Latitudinal trends within the Great Barrier Reef region. There is little variation in the number and identity of scarid species from the far northern reefs to those of the Capricorn-Bunker group. The only striking latitudinal change is the absence of *B.muricatum* from the southern reefs. Some relatively rare species which

have Indo-Pacific area affinities are more likely to be encountered on the northern reefs. These include *S.dimidiatus*, *S.pyrrhurus* and *S.frontalis*. Some common species also show latitudinal trends in abundance. *Scarus gobban* and *S.rivulatus*, which often penetrate coastal waters, tend to be commoner in the south on outer reefs of the Capricorn Bunker group for example, than on the northern reefs. In a survey of 44 reefs from Townsville to Lizard Island, *S.rivulatus* was found to be present on the outer reefs in the Townsville to Cairns section but absent from the far northern outer reefs of the survey area (A.M. Ayling, unpublished). Species with southern Pacific affinities, such as *S.longipinnis*, are commoner in shallow waters in southern reefs than on northern reefs of the continental shelf.

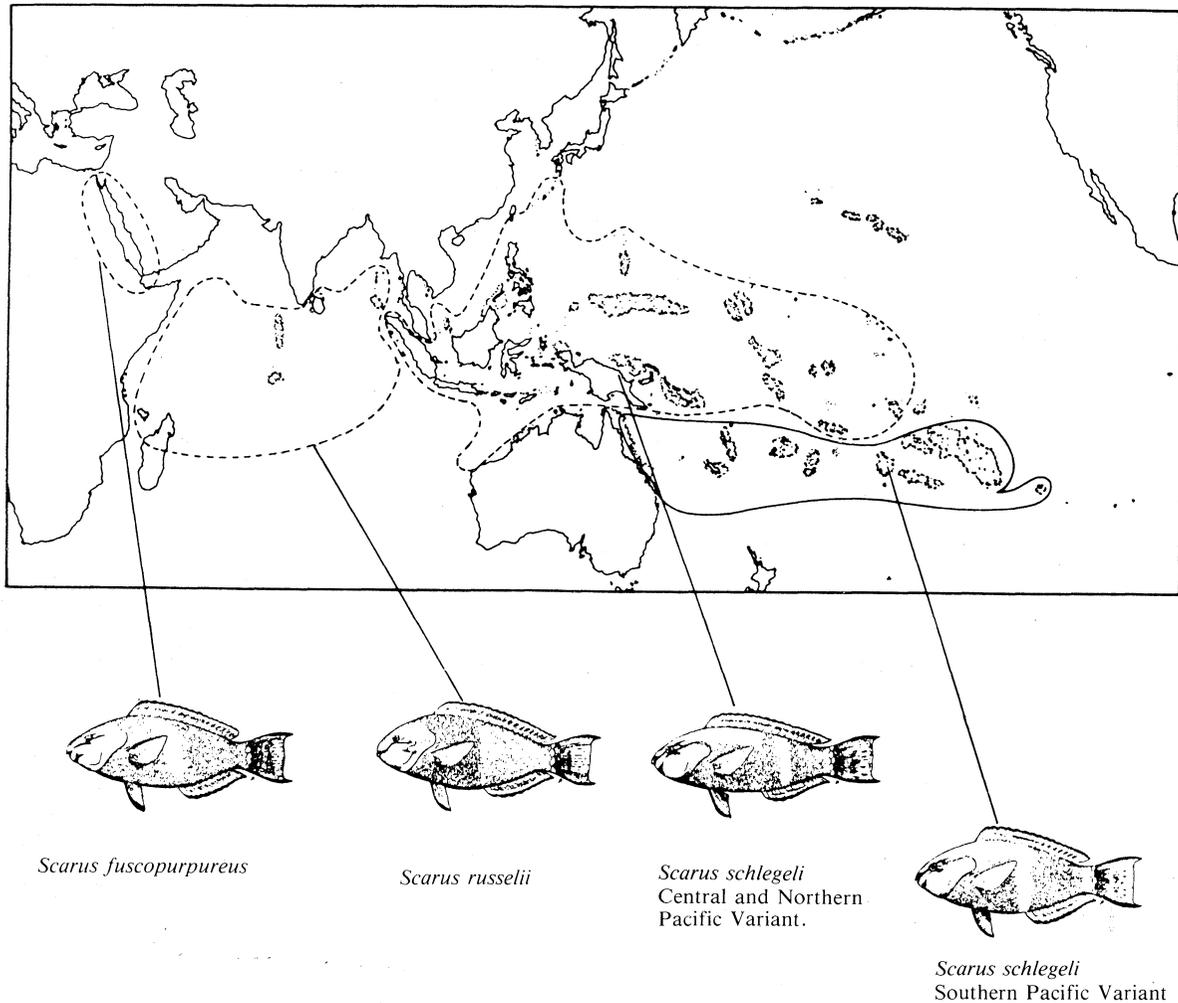


Fig. 2. The distribution of major faunal groupings of scarids within the tropical area extending from the Red Sea to the central Pacific. The faunal areas are exemplified by the geographic distribution of species of the *Scarus schlegeli* complex. *Scarus fuscopurpureus* (Red Sea); *Scarus russelii* (Western Indian Ocean); *Scarus schlegeli* (Central and Northern Pacific variant); *Scarus schlegeli* (Southern Pacific variant). A number of species of scarids have distributions extending over this entire area.

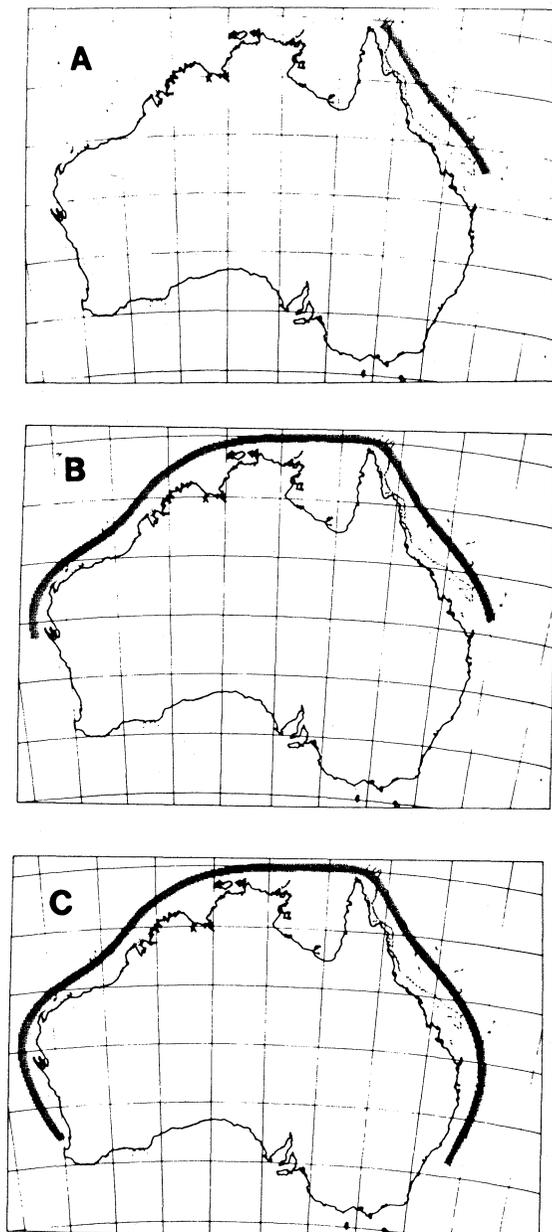


Fig.3. Distribution patterns within Australian waters of the 27 species of scarids recorded from the Great Barrier Reef region.

Category A. Those species recorded from the Great Barrier Reef region only. *C.carolinus*; *C.spinidens*; *B.muricatum*; *C.bicolor*; *H.longiceps*; *S.pyrrhurus*; *S.flavipectoralis*; *S.spinus*; *S.bleekeri*; *S.longipinnis*; *S.frontalis*; *S.altipinnis*; *S.forsteni*; *S.dimidiatus*.

Category B. Those species recorded from northern and western tropical waters. *S.rubroviolaceus*; *S.gibbus*; *S.psittacus*; *S.schlegeli*; *S.chameleon*; *S.globiceps*; *S.oviceps*; *S.frenatus*; *S.niger*. Western Australian waters harbour an additional species *Scarus oedema* which has not been recorded from the Great Barrier Reef.

Category C. Species which are recorded from tropical waters and extend into temperate reefs on the eastern and western coasts: *L.vaigiensis* (not recorded from reef environments of the Great Barrier Reef); *S.sordidus*; *S.rivulatus*; *S.ghobban*.

Longitudinal trends within the Great Barrier Reef region. There are marked cross-shelf trends in scarid abundances and species composition. These trends are associated with the changes in water character, sediment load and reef structure as one follows the environmental gradient from mainland coastal areas to the coral sea (Fig.4).

A number of recent studies (Williams,1982; Williams & Hatcher,1983; Russ,1984a) have provided quantitative information on scarid distribution and abundance. These studies indicate that the number of species, of individuals, and biomass of scarids is significantly lower on inshore reefs when compared to mid- and outer-shelf reefs. Inshore reefs are dominated by *S.rivulatus*, with *S.ghobban* and *S.sordidus* also present but generally rare. The former two species extend to the mid-shelf reefs but are absent or rare on outer reefs. *Scarus sordidus* is a ubiquitous scarid abundant in most areas from which it is recorded. Mid-shelf reefs support slightly greater numbers of species and individuals of scarids than outer-shelf reefs.

A number of surveys by A.M. Ayling and the senior author have provided further data on scarid abundance and distribution patterns which confirm these trends. The information in Table 7 is a compilation of the various recent surveys. The categories indicating abundance are approximations based on a variety of visual survey methods. For details readers are referred to Williams (1982), Russ (1984a) and Choat & Bellwood (1985). An interesting additional point is that the mean size of some species appears to be smaller on outer than on mid-shelf reefs. This trend is apparent on the northern reefs with species such as *S.frenatus* and *C.bicolor*.

Recent information provided by D. Williams and A.M. Ayling identifies an interesting scarid fauna on the reefs of the Coral Sea. Three localities (Flinders Reefs, Herald Cay and Lihou Reef) were examined by various types of visual count techniques. In nearly all localities examined and for all sample techniques used there was an unexpectedly high abundance of the recently described *S.longipinnis*. Other species well represented were *S.sordidus*, *H.longiceps*, *S.altipinnis*, *S.niger*, *C.bicolor* and *S.gibbus*. The Coral Sea scarid fauna has slightly fewer species and for most, a reduced abundance when compared to the shelf reefs. A few species showed a ubiquitous distribution being equally abundant on mid-shelf, outer-shelf and Coral Sea reefs. These include *C.bicolor*, *S.rubroviolaceus*, *S.sordidus*, *S.gibbus* and *S.niger*, species which have broad geographic distributions. Only two species, *S.sordidus* and *S.gibbus*, extended from inshore reefs to the Coral Sea. A summary of longitudinal trends in distribution is provided in Table 7.

Most scarid species also have characteristic habitat associations within reef systems. These are summarised under each species description.

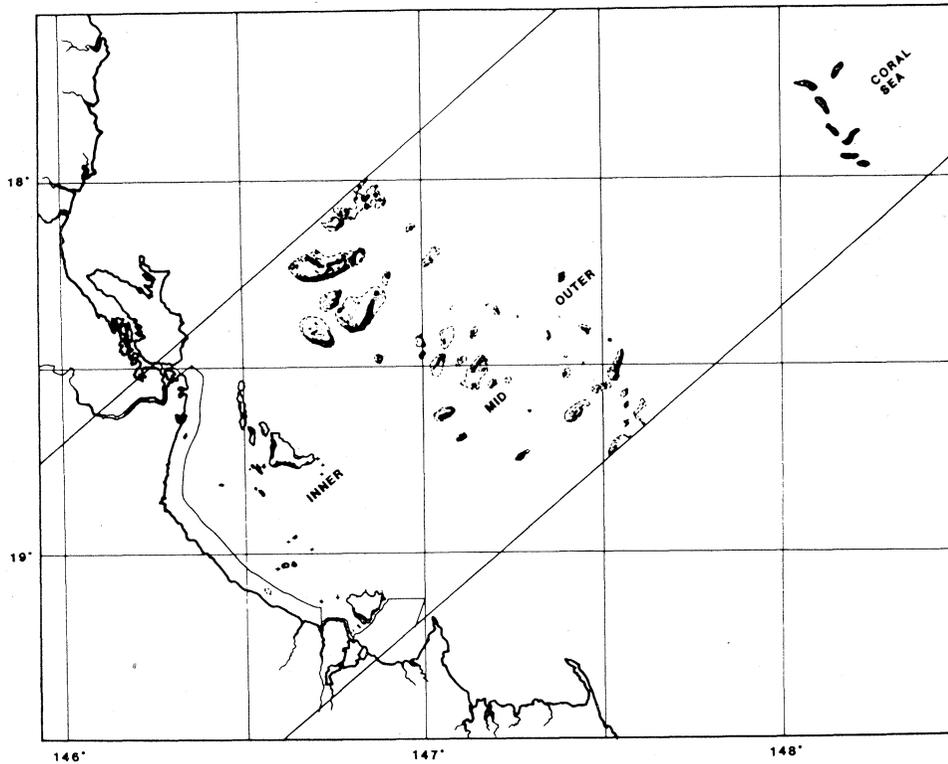


Fig. 4. The geographic distribution of reef sampling areas in the central region of the Great Barrier Reef. Inner, Mid and Outer groups of reefs are located on the continental shelf. The remaining reef group is in the Coral Sea proper. Abundances and species composition of scarid faunas on these reef groupings were used to determine longitudinal trends.

Table 7. The cross-shelf distribution of Great Barrier Reef scarids. Species placed in abundance categories. (See text for details)

Species	Cross Shelf Reef Position			
	Inner	Mid	Outer	Coral Sea
<i>L. vaigiensis</i>	—	—	—	—
<i>C. spinidens</i>	—	—	—	—
<i>S. ghobban</i>	rare	rare	—	—
<i>S. rivulatus</i>	moderate	moderate	rare	—
<i>S. globiceps</i>	rare	moderate	moderate	—
<i>S. gibbus</i>	rare	common	common	rare
<i>S. sordidus</i>	rare	common	common	common
<i>C. carolinus</i>	—	rare	rare	rare
<i>C. bicolor</i>	—	rare	moderate	moderate
<i>H. longiceps</i>	—	rare	moderate	moderate
<i>S. rubroviolaceus</i>	—	rare	rare	rare
<i>S. altipinnis</i>	—	moderate	moderate	moderate
<i>S. spinus</i>	—	moderate	rare	rare
<i>S. chameleon</i>	—	moderate	moderate	moderate
<i>S. schlegeli</i>	—	moderate	moderate	rare
<i>S. psittacus</i>	—	moderate	rare	rare
<i>S. niger</i>	—	common	moderate	moderate
<i>S. frenatus</i>	—	moderate	moderate	rare
<i>S. forsteni</i>	—	rare	rare	rare
<i>S. dimidiatus</i>	—	rare	rare	rare
<i>S. oviceps</i>	—	rare	rare	rare
<i>S. frontalis</i>	—	rare	rare	rare
<i>S. longipinnis</i>	—	rare	rare	common
<i>B. muricatum</i>	—	rare	moderate	rare
<i>S. flavipectoralis</i>	—	moderate	rare	—
<i>S. pyrrhurus</i>	—	rare	rare	—
<i>S. bleekeri</i>	—	rare	rare	—

Colour Phases and Reproductive Biology

There are usually three distinct colour phases in scarids: juvenile phase, initial phase (IP) (subadults, females and some types of male), and terminal phase (TP) (characteristic of large males). These terms were adopted at the International Symposium on Intersexuality in the Animal Kingdom in Mainz, July 1974. Further details of definition are provided by Warner & Robertson, 1978. The abbreviations IP and TP will be used to designate initial and terminal phase throughout this study. The juvenile phase as seen in newly recruited individuals will be dealt with in a forthcoming publication (Bellwood & Choat, in prep.). In general, IP fish display muted colour patterns characterized by brown, grey, reddish or yellow hues. There are usually few distinguishing markings and, to the non-specialist worker, most species of scarids appear to be very similar when in the IP. TP fish are brightly coloured with greens predominating. Most species display highly characteristic markings around the head and snout. Scarids in terminal phase colouration are usually easy to identify. In some areas, however, complexes of closely related species co-occur, so caution is required. The major problem confronting the student of scarid taxonomy is the reliable separation of scarids with IP colouration. Finally, the colour patterns of most scarids both in IP and TP may vary in response to behavioural characteristics. Interactions between species or within species during reproductive behaviour often result in rapid and striking modifications to the basic colour pattern. These are difficult to photograph. Paintings and diagrams recording the variation to colour patterns associated with short term responses in an exemplary species (*S.rivulatus*) are reproduced in Plate 11, F–J. Careful observation of live scarids is required to obtain a comprehensive understanding of the range of variation possible.

Of the 27 species of parrotfishes dealt with here, 23 are dichromatic with distinct IP and TP colours. Three, *Bolbometopon muricatum*, *Scarus frontalis* and *Scarus niger*, appear to be monochromatic in Australian waters. One species, *Scarus gibbus*, does not display the usual size-associated distribution of colour phases.

The sequence of colour changes seen in adult parrotfishes is intimately linked to patterns of sexual ontogeny. Scarids are generally protogynous hermaphrodites (Choat & Robertson, 1975; Robertson & Warner, 1978; Randall & Bruce, 1983) with most females eventually assuming male identity by a process of sexual inversion. This process produces secondary males. In many species there is a varying proportion of primary males which maintain male sexual identity from birth. Females and smaller primary males display the IP colour. Larger males display the TP colour; these may be of either secondary or primary derivation. Females may assume secondary male identity and TP colour by synchronous sex and colour change. Primary males with IP colour may simply undergo colour change to achieve the terminal phase. Species with both primary

and secondary males in their breeding populations are described as diandric; those with secondary males only as monandric.

Although the sequences of colour patterns and sexual ontogeny in scarid fishes are well described, the behavioural and ecological consequences of different patterns of sex and colour change are not. Previous studies (Choat & Robertson, 1975; Randall & Choat, 1980) of Great Barrier Reef scarids have suggested the following general classification of scarid reproductive patterns. Some species are strongly diandric (*S.globiceps*, *S.rivulatus*, *S.psittacus*) with a relatively high proportion of primary males. These usually have high population densities, form schools, and display local spawning migrations to specific sites. Here, both group spawning involving IP males and females, and pair spawning involving a terminal male and a single female occur. Group spawnings appeared to involve large numbers of IP males; TP males at spawning sites were highly antagonistic to IP males.

Weakly diandric and monandric species (*S.niger*, *S.frenatus*) were seen as site-attached scarids in which a single terminal male spawned consistently with a small harem of females in the pair spawning mode. Two species were considered to characterize the different ends of this reproductive spectrum: *Scarus globiceps* as a strongly diandric species with consistent group spawning episodes, and *S.niger* as a strongly site-attached monandric species with a harem, pair spawning mode. However, the small numbers of mature males in the IP found in site-associated species, such as *S.frenatus*, were always a problem for such a classification. As such males were apparently associated with movements of large numbers to particular sites it was difficult to visualize their role in weakly diandric species.

Recent observations on the northern reefs of the Great Barrier Reef indicate that the above generalizations are too simplistic. Most scarids, including members of apparently site-attached species such as *S.niger* and *S.frenatus*, will undergo local spawning migrations to specific sites. Observations at Lizard Island have demonstrated that spawning behaviour is more variable than previously indicated. Group spawning at migratory sites involving very small numbers of IP males (4–5 individuals) was observed to occur in weakly diandric species such as *S.schlegeli*. IP males in such circumstances displayed highly characteristic changes in colour pattern during reproductive behaviour. Pair spawning was observed in *S.niger* and *S.frenatus* involving large males and single females from a waiting pool of females which had apparently migrated to spawning sites. In strongly diandric species, such as *S.rivulatus*, a number of episodes were observed of mixed group spawning involving small numbers of IP males, a single TP male and a single female. There were no aggressive interactions amongst males prior to the spawning run. Such observations indicate highly variable reproductive behaviour in scarids. Details of reproduction and sexual status are included under the individual species headings.

Key to Species of Scaridae from the Great Barrier Reef Region
(Key refers to adult individuals)

1. Horizontal rows of scales on cheek 1; pectoral rays 13 (rarely 12 or 14); gill rakers 8–14; jaws opposing or upper jaw enclosed by lower when mouth closed. 2
 - Horizontal rows of scales on cheek 2–3; pectoral rays 13–17 (rarely 13 or 17); gill rakers 16–81; lower jaw enclosed by upper when mouth closed. 4
2. Teeth in jaws fused to form dental plates; upper jaw enclosed by lower when mouth closed; membranes of spinous portion of dorsal fin incised $\frac{1}{4}$ to $\frac{1}{3}$ length of spines. *Leptoscarus vaigiensis*
 - Teeth in jaws not fused but incisiform, overlying bony ridge of jaws; jaws opposing when mouth closed; membranes of spinous portion of dorsal fin slightly emarginate between spines. 3
3. Incisiform teeth of upper jaw in 3–6 oblique imbricate rows; body depth 2.2–2.75 in SL; gill rakers 10–14; caudal fin rounded in young, becoming truncate to emarginate in adults; a posterior whitish margin on caudal fin. *Calotomus carolinus*
 - Incisiform teeth of upper jaw in a single row; body depth 2.5–3.2 in SL; gill rakers 8–10; caudal fin rounded at all stages; no posterior white margin on caudal fin. *Calotomus spinidens*
4. Outer surface of dental plates granular with individual teeth visible on dental plates; no canine teeth on dental plates; posterior nostril notably larger than anterior (up to 4 times larger), oval or slit-like; gill rakers 16–24; each upper pharyngeal bone with 3 rows of molariform teeth, those of the lateral row rudimentary, inner rows of teeth not interdigitating. 5
 - Outer surface of dental plates relatively smooth; canine teeth often present posteriorly on side of dental plates; posterior nostril not notably larger than anterior (except *S. ghobban*); gill rakers 38–81; each upper pharyngeal bone with 1 row of large molariform teeth, with or without a rudimentary lateral row, inner rows of teeth interdigitating. 6
5. Dorsal profile of head with a hump anterodorsal to eye (evident on specimens at least as small as 200 mm SL); body deep, the depth 2.1–2.5 in SL; profile of snout steep, nearly vertical in large adults; individual teeth with small raised tubercles; median predorsal scales 2–5 (usually 4); one row of scales on interopercle; pectoral rays 15 or 16; gill rakers 16–18; adults dull green to blue-green (not sexually dichromatic). *Bolbometopon muricatum*
 - Dorsal profile of head slightly and evenly convex; body depth 2.5–2.8 in SL; profile of snout sloping; median predorsal scales 5–7; two rows of scales on interopercle; pectoral rays 14 or 15 (usually 14); gill rakers 20–24; IP reddish, yellow on back, the scales on side of body edged and spotted with black; terminal male green, head and anterior body with orange spots, scales edged with orange. *Cetoscarus bicolor*
6. Dental plates narrow, their height about 1.5–2.0 in orbit diameter; head pointed, with a distinctly angular snout; eye near dorsal profile, the interorbital space slightly convex; cheek scales small, in a nearly isolated patch; caudal fin double emarginate. *Hipposcarus longiceps*
 - Dental plates not narrow, their height usually greater than orbit diameter; head not pointed; eye not near dorsal profile, the interorbital space strongly convex; cheek scales not small and not in an isolated patch; caudal fin rounded to lunate. 7
7. Dorsal profile of head rising steeply from mouth to level of eye, then curving abruptly to nearly straight for remaining profile of head; rudimentary lateral row of teeth on upper pharyngeal bones may be present in small juveniles

- but lost in larger individuals; median predorsal scales 6-7; IP reddish except yellowish grey side of body; body scales with narrow blackish edges and short blackish markings, fins red; terminal male green dorsally, shading to yellowish on sides and light blue-green ventrally; upper lip narrowly salmon with a broad blue-green band above; lower lip broadly blue-green at margin; chin salmon crossed by a blue-green band which joins that of lip and passes to below orbit. *Scarus rubroviolaceus*
- Snout not shaped as above (large *S.gibbus*) and *S.frontalis* have steep snout profiles but the angular break in contour is above eye level); a row of rudimentary teeth laterally on each upper pharyngeal bone nearly always present; colour not as above. 8
8. Pectoral rays usually 16 (rarely 15 or 17); cheek scales in 3 rows, usually with 5-7 scales in third (lower) row; dorsal profile of small individuals strongly convex, of large individuals very steep from mouth to above level of eye, then curving to slightly convex for remainder of profile; 2 colour phases: one green to blue-green with a narrow salmon pink bar on each scale of body (except ventrally); ventral part of head pale with an irregular bright blue-green band from corner of mouth across cheek to operculum; a red phase with body uniform reddish becoming yellowish ventrally. *Scarus gibbus*
- Pectoral rays 13-16 (rarely 16); cheek scales in 2 or 3 rows, (when 3, the third row with no more than 4 scales, except for *S.forsteni* and *S.niger*); dorsal profile of head not as above; colour not as above. 9
9. Median predorsal scales usually 4; scale rows on cheek 2 or 3. 10
- Median predorsal scales usually 5-7; scale rows cheek 3. 19
10. Pectoral rays usually 14; lips cover half or more of dental plates; scale rows on cheek 2 or 3. 11
- Pectoral rays usually 15; lips cover less than half of dental plates; scale rows on cheek 2. 16
11. Scale rows on cheek 2. 12
- Scale rows on cheek 3, the lowermost row with 1-3 scales. 13
12. Caudal fin of IP slightly emarginate; IP brown to reddish brown with a large dark brown spot anterobasally on first interspinous membrane of dorsal fin and a narrow whitish posterior margin on caudal fin; terminal male with 3 blue-green bands extending posteriorly from eye, the lowermost passing forward submarginally onto upper lip; head above this band lavender grey. *Scarus psittacus*
- Caudal fin of IP slightly rounded; IP purplish to olivaceous brown, edges of scales orangish, with 5 curved pale bars on body; terminal male dark green, sometimes suffused with purple, edges of scales orange-red to salmon; a squarish spot of bright yellow on back at level of eleventh to thirteenth vertical scale rows of body and below first dorsal ray. *Scarus schlegeli*
13. Dorsal spines and rays long, the longest spine 1.7-2.1 in head; pelvic fins long, 1.15-1.5 in head; a broad blue-green bar from in front of eye to chin, another across interorbital space, and a third prominent bar across cheek from lower edge of eye to pectoral base. *Scarus longipinnis*
- Dorsal spines and rays not long, the longest spine 2.2-3.2 in head; pelvic fins not long, 1.6-2.1 in head; colour not as above. 14
14. No overlapping lateral pair of small scales anterior to median predorsal scales; IP grey, caudal fin dark purplish, pectoral fins with large yellow spot at base; terminal male with head and anterior third of body brown with a broad green band from front of snout through lower part of eye to end of opercle, posterior $\frac{2}{3}$ of body abruptly blue-green with narrow orange bar on each scale. *Scarus flavipectoralis*

- Transverse overlapping pair of scales directly anterior to first median predorsal scale; colour not as above. 15
- 15. Body depth 2.3–2.6 in SL; head bluntly rounded anteriorly, dorsal and ventral profiles almost identical; IP dark brown with four or five indistinct pale bars on body (from pale centers of scales) or may be uniform blackish brown; terminal male with head blue–green to green, shading to yellow on operculum, with two broad curved transverse salmon bands on chin. *Scarus spinus*
- Body depth 2.5–2.8 in SL; head somewhat pointed anteriorly; dorsal profile of head smoothly convex (or with only a slight angularity above eye in large males); IP pale greyish to brown with yellowish caudal fin; TP with single green band across interorbital space. *Scarus chameleon* n.sp.
- 16. IP uniform dark brown, caudal fin red with a narrow black posterior margin; terminal male with body purplish anteriorly, greenish yellow angular patch in middle, and blue–green posteriorly, each scale with an orange mark (narrow vertical bar anteriorly and round spot posteriorly). *Scarus pyrrhurus*
- Colour not as above. 17
- 17. Snout of terminal males with very steep profile to above level of eye where there is an abrupt angle, rest of profile to origin of dorsal fin nearly straight; both initial and terminal phases green with pink or purplish bar on each scale of body, head with irregular reddish to pink markings around eye (except ventrally), on chin and corner of mouth. *Scarus frontalis*
- Dorsal profile of head of terminal males smoothly convex; colour not as above (IP brown); head of terminal male phase without irregular reddish to pink markings. 18
- 18. Initial phase dark brown, edges of scales orangish, body with five faint yellowish bars, shading ventrally to dull orange–red and posteriorly to yellowish, caudal fin and peduncle yellowish; terminal male with large whitish area on cheek bordered with blue–green; dental plates of both phases white. *Scarus bleekeri*
- IP brown, sometimes with two rows of small whitish spots on side, becoming red around mouth (a transient colour phase displays broad whitish bar on caudal peduncle containing a large dark brown spot at caudal fin base); terminal male green, the broad central region of body mainly yellow, becoming green ventrally, caudal peduncle distinctly lighter green; dental plates of IP reddish white, of terminal male green. *Scarus sordidus*
- 19. Pectoral rays usually 15. 20
- Pectoral rays usually 14. 21
- 20. Spinous portion of dorsal fin and elongate first soft ray distinctly higher than rest of soft portion of fin; caudal fin of adults double emarginate (broadly rounded in center, the lobes produced); IP brownish red, often with series of small whitish spots along side of body; head of terminal male orange, shading posteriorly to green, with broad blue–green transverse bands on snout and chin, and dark blue–green spots and irregular markings around eye and postorbitally; dental plates of both phases dark blue–green. *Scarus altipinnis*
- Spinous portion of dorsal fin not higher than soft portion; lobes of caudal fin of TP male extended but not double emarginate; IP phase yellow, centers of scales blue, often with five blue bars on body; terminal male light green, scales edged with salmon pink; light blue–green horizontal bands through upper and lower edges of eye and one extending posteriorly from middle of orbit, intervening bands pale salmon; posterior nostril 2–5 times larger than anterior. *Scarus ghobban*
- 21. Caudal fin of IP slightly rounded, of terminal male truncate; IP yellowish, shading to white ventrally, with 5 slightly diagonal grey–brown bars on upper

half of body which are broader than yellow interspaces; terminal male solid blue-green on upper head posterior to mid-interorbital space and anterodorsal body, rest of body blue-green with orange edges on scales; diagonal purplish brown band runs from eye to end of opercular membrane with, below and adjacent, pale salmon band edged in blue-green, continuing below eye as blue-green band which expands broadly onto chin and front of snout (except narrow edge of upper lip which is salmon pink).

- *Scarus dimidiatus*
- Caudal fin of IP truncate to emarginate, of terminal male emarginate to double emarginate or lunate; colour not as above. 22
22. No canine teeth on dental plates; IP with upper half of head and body dark grey, lower half pale yellowish to pinkish (though scales may be edged in grey), with diagonal yellow bar on back beginning above pectoral fin tip (second fainter yellow bar may be present posterior and parallel to first); terminal male with head above level of lower edge of eye and anterodorsal part of body to base of eighth dorsal spine dark purplish, rest of head and body abruptly blue-green, scales of body edged in salmon pink to orange; dental plates of IP white, of terminal male dark blue-green. *Scarus oviceps*
- Canine teeth usually present posteriorly on side of dental plates, at least on upper plate of large males; colour not as above. 23
23. Median predorsal scales usually 7. 24
- Median predorsal scales usually 5 or 6. 25
24. Penultimate anal ray prolonged in large males, its length 1.5–1.6 in head; small individuals greenish brown on body with small black spots; head orangish brown, becoming orange-red anteriorly, with green markings (notable are two bands on chin and one at base of upper lip and small black-edged green spot behind upper end of gill opening); large individuals similar in colour but dark spots on body faint or absent and overall colour more purplish; dental plates blue-green. *Scarus niger*
- Penultimate anal ray of terminal male not prolonged; IP reddish brown, becoming grey over side of body with 5–7 dark brown stripes, fins red; terminal male green on lower half of head and body, posterior to a vertical at base of fifth dorsal soft ray; rest of head and body green with numerous small orange spots and short irregular lines; dental plates of IP white, of terminal male blue-green. *Scarus frenatus*
25. Caudal fin of IP emarginate, of terminal male lunate; 3 rows of cheek scales with 4–5 in ventral row; IP olivaceous to light reddish brown with broad longitudinal blue band along side of body, a white spot frequently present in life on side near tip of pectoral fin, and caudal fin orange-red; terminal male green, scales of body edged in salmon (green pale on lower side, hence salmon predominating); lips edged in salmon pink (the upper more broadly), both with wide submarginal blue-green band; pectoral fins blue-green with median streak of purplish orange; dental plates of IP white, of terminal male blue-green. *Scarus forsteni*
- Caudal fin not lunate; colour not as above. 26
26. Caudal fin of IP truncate, of terminal male slightly to moderately emarginate; 3 rows of cheek scales with 2–3 in ventral row; IP brown to brownish grey with 2 or 3 whitish stripes on abdomen; terminal male green with an orange bar on each scale except abdomen where green is arranged in 3 stripes, and anterodorsally where green is broken into small spots; salmon pink stripe edged in blue-green passing from front of snout through eye, and blue-green lines radiating dorsally from orbit; blackish spot at or near base of fourth dorsal spine. *Scarus globiceps*
- Caudal fin rounded in IP, truncate in TP; 3 rows cheek scales with 1–2 scales

in ventral row; IP grey to reddish brown with 2 to 3 whitish stripes on abdomen (in life light greyish with a distinct yellowish caste); lower head of terminal male orange with irregular blue-green lines and small spots on snout, chin, cheek and radiating from eye. *Scarus rivulatus*

Calotomus carolinus (Valenciennes)

Plate 1D, E

- Callyodon Carolinus* Valenciennes in Cuvier & Valenciennes, 1840: 291 (type locality, Caroline Islands).
Callyodon genistriatus Valenciennes in Cuvier & Valenciennes, 1840: 293 (type locality unknown).
Callyodon sandwicensis Valenciennes in Cuvier & Valenciennes, 1840: 295 (type locality, Hawaiian Islands).
Callyodon brachysoma Bleeker, 1861: 244 (type localities, Ambon and Ternate).
Calotomus xenodon Gilbert, 1890: 70 (type locality, Socorro Island, Revillagigedo Islands).
Calotomus irradians Jenkins, 1900: 58, fig. 15 (type locality, Hawaiian Islands).
Calotomus snyderi Jenkins, 1903: 467, fig. 25 (type locality, Honolulu).
Scarichthys rarotongae Seale, 1906: 59, fig. 8 (type locality, Rarotonga, Cook Islands).
Cryptotomus albimarginatus Fourmanoir & Guézé, 1961: 19, fig. 6 (type locality, Réunion).

Material examined. Two specimens, Heron Island AMS I.15502-001, USNM 235594; one specimen (juvenile), Lizard Island, AMS I.25905-002.

Diagnosis. Teeth not fused to form dental plates; upper jaw with slightly curved, bluntly pointed, incisiform, imbricate teeth in 3-6 oblique rows (number of teeth increasing with size), lower jaw with 4-7 rows; 1 or 2 strongly curved canine teeth on side of upper jaw which flare laterally and posteriorly; pectoral rays 13; single row of 4 or 5 scales on cheek below eye; median predorsal scales 3 or 4 (usually 4); gill rakers 10-14; body depth 2.2-2.75 in SL; head 2.9-3.25 in SL; snout 2.3-3.1 in head; interorbital space slightly convex; dorsal spines flexible; caudal fin slightly rounded in small individuals, truncate to slightly emarginate in large IP fish, and slightly emarginate to deeply emarginate or double emarginate in terminal males, upper caudal lobe usually longer than lower.

Colour pattern. IP: Body greyish to yellowish brown, often faintly blotched with darker brown and flecked with whitish, shading ventrally to reddish or orangish brown; an orangish line often present from orbit to corner of mouth; three reddish lines may extend posteriorly from orbit; fins similar in colour to body but with more pale flecks; dark spot often present centrally on first interspinous membrane of dorsal fin, large dark spot basally on posterior part of fin; a similar but smaller spot posterobasally on anal fin; caudal fin with whitish posterior margin; pectoral fins broadly dark brown basally, shading to pale on about distal two thirds.

TP: Body brownish red, strongly suffused with green or blue-green (green dominating in most individuals), scale edges with narrow vertically elongate bars or spots of salmon pink; head blue-green with narrow salmon pink to orange bands radiating from orbit; one or more short bands of the same colour on front of snout and chin; dorsal and anal fins blue-green with irregular longitudinal bands of salmon pink or orange, the dorsal with a blackish spot on first membrane and sometimes on second; unscaled part of caudal fin blue-green with irregular salmon pink to orange markings and narrow whitish posterior margin; pectoral fins greenish on about basal two thirds with some orangish streaks, becoming pale on outer third.

Remarks. The synonymy and species description follows Bruce & Randall (1985). Most recent authors have erroneously used the name *Calotomus spinidens* for this parrotfish. Gosline & Brock (1960) applied the name *C. sandwicensis* (sic) to the species in the Hawaiian Islands.

Calotomus carolinus ranges from the coast of East Africa (at least as far south as 21°) throughout most of the tropical Indo-Pacific region to Mexico (Bruce & Randall, 1985). It appears to be absent from the Red Sea, Persian Gulf and Easter Island. In the western Pacific it ranges from the Ryukyu Islands to the southern Great Barrier Reef.

Calotomus carolinus is a protogynous hermaphrodite. Robertson et al. (1982) reported on the collection of 22 IP fish (to 253 mm SL) at Aldabra, all of which were females (maturing at a SL of about 160-180 mm) and six TP fish, 240-270 mm SL, all of which were secondary males.

In Australia this species has been consistently misidentified as *C. spinidens* (Table 5). On the Great Barrier Reef *C. carolinus* is usually rare and may be observed in reef crest and reef base habitats on mid- and outer-shelf reefs, occurring in pairs or as individuals. Small IP individuals were observed at Lizard Island and were readily recognizable underwater by the high body profile and the prominent light-coloured eyes. Small numbers were observed at Herald Cay and Lihou Reefs in the Coral Sea by A.M. Ayling. This species has not been recorded from Western Australia. Pair spawning was observed once at Lizard Island. The terminal phase male was approximately 300 mm SL and displayed a prominent white blotch on the side during spawning. Two specimens collected at Heron Island were 397 and 273 mm SL. The largest specimen examined by Bruce & Randall (1985) was 398 mm SL (BPBM 16658), from Pitcairn.

Calotomus spinidens (Quoy & Gaimard)

Plate 1C

Scarus spinidens Quoy & Gaimard, 1824: 289 (type locality, Vaigiou = Waigeo).

Callyodon Waigiensis Valenciennes in Cuvier & Valenciennes, 1840: 296 (new name for *Scarus spinidens* Quoy & Gaimard).

Callyodon hypselosoma Bleeker, 1855b: 425 (type locality, Ambon).

Callyodon moluccensis Bleeker, 1861: 243 (type localities, Celebes, Ternate, Batjan, Timor, Ambon, Ceram and Banda).

Material examined. One specimen, 5 miles northwest of Lizard Island, AMS I.20752-027.

Diagnosis. Upper jaw with outer row of prominent, protruding, slightly flattened, conical teeth (well spaced on large individuals), last 1 or 2 recurved, this series buttressed behind by a bony ridge which has 1 row of small close-set incisiform teeth (with rounded, not truncate tips) posteriorly; medial to bony ridge one row of well spaced, short, conical teeth, medial to these, two more short conical teeth; lower jaw with about 3 oblique rows of bluntly pointed, incisiform, imbricate teeth anteriorly on external face of bony ridge, series of small, close-set incisiform teeth (with rounded tips) posteriorly; pectoral rays 13 (rarely 12); single row of 4 or 5 scales on cheek below eye; median predorsal scales 4; gill rakers 8-10; body depth 2.5-3.2 in SL; head 2.8-3.2 in SL; snout 2.75-3.5 in head; interorbital space slightly convex; dorsal spines flexible; caudal fin rounded at all sizes.

Colour pattern. IP: body greenish brown, finely and densely flecked with whitish, shading to whitish ventrally, with 3-4 longitudinal rows of whitish spots (often only upper 2 rows visible); faint lateral pale stripe often present on body; median and pelvic fins whitish to yellowish, stippled and blotched with white; anal fin with pink spot basally on each ray; pectoral fins uniformly pale.

TP: males similar in ground colour but have rows of small orange spots on body and basally on dorsal fin, small orange spots or short lines on head, 2 diagonal orange lines from eye to corner of mouth; blackish spot near base of second interspinous membrane of dorsal fin; 2 irregular orange bands in anal fin; blackish bar across pectoral fin base.

Remarks. The synonymy and description follows Bruce & Randall (1985). Schultz (1958) and others have erred in using the name *C. spinidens* for the species identified herein as *C. carolinus*. Schultz placed *Callyodon moluccensis* Bleeker and *C. spinidens* Bleeker in the synonymy of *Calotomus japonicus* (of Bleeker's *C. spinidens*, Schultz wrote, 'not of Quoy & Gaimard', but Bleeker's material is the true *spinidens*). Examination of Schultz' specimens of *C. japonicus* at the USNM revealed that only those from Japan are *C. japonicus*. Most of the rest are the true *C. spinidens*; one lot from the Palau Islands is *Leptoscarus vaigiensis*.

Calotomus spinidens occurs from the coast of Africa

(at least as far south as Delagoa Bay, Mozambique) eastwards to the Marshall Islands in the northern Pacific, and Tonga in the southern Pacific. It is absent from the Persian Gulf, and records from the Red Sea appear to be misidentifications of *C. viridescens* (Ruppell). In the western Pacific it ranges from the Ryukyu Islands and Taiwan south to the Great Barrier Reef (AMS I.20752-027 is a 125 mm male taken 5 miles WNW of Lizard Island). This species appears to be rare in Australian waters.

Robertson et al. (1982) observed 10% functional primary males among the IP fish at Aldabra, and both primary and second males in the terminal phase (but predominately secondary males). Four intersex individuals were found among IP fish. The smallest mature IP males and females were both 67 mm SL. The smallest TP male was 81 mm SL.

This species was not observed underwater on the Great Barrier Reef. It appears to inhabit seagrass beds in deeper water between reefs on the northern and central GBR. The largest specimen examined by Bruce & Randall (1985) was 148 mm SL (USNM 201503), from the Amirante Group of the Seychelles.

Leptoscarus vaigiensis (Quoy & Gaimard)

Plate 1A,B

Scarus vaigiensis Quoy & Gaimard, 1824: 288 (type locality, Vaigiou = Waigeo).

Scarus (Calliodon) caeruleo-punctatus Ruppell, 1835: 24, pl. 7, fig. 2 (type locality, Red Sea).

Scarus rubro-notatus Ehrenberg in Cuvier & Valenciennes, 1840: 212 (type localities, Gulf of Arabia and Red Sea).

Scarus auritus Kuhl and Van Hasselt in Cuvier and Valenciennes, 1840: 218 (type locality, Java).

Scarus naevius Valenciennes in Cuvier & Valenciennes, 1840: 253 (type locality, Seychelles).

Scarus Bottae Valenciennes in Cuvier & Valenciennes, 1840: 262 (type locality, Jeddah, Red Sea).

Calliodon chlorolepis Richardson, 1840: 137, pl. 64, figs 4-7 (type locality, Hong Kong).

Material examined. One specimen, Rottneest Island, WAM P.26842-001; one specimen, Caloundra, Qld, QM I.5973; two specimens, Moreton Bay, QM I.4705, I.12044; one specimen, Lord Howe Island, AMS I.2789; one specimen, Sydney, AMS IB.4519; one specimen, New Caledonia, AMS IB.2403.

Diagnosis. Teeth fused to form dental plates, upper enclosed by lower when mouth closed; males with 2-7 canine teeth anteriorly near base of upper dental plate; lips covering dental plates; pectoral rays 13 (rarely 12 or 14); single horizontal row of scales on cheek; median predorsal scales usually 4; gill rakers 10-14; body elongate, depth 2.85-3.8 in SL; head length 2.95-3.35 in SL; snout 2.55-2.9 in head; interorbital nearly flat; dorsal spines flexible; membranes of spinous portion of dorsal fin incised $\frac{1}{4}$ - $\frac{1}{3}$ length of spines; caudal fin rounded.

Colour pattern. IP: body olivaceous, spotted and mottled with whitish and dark brown, shading to whitish

or pale yellow ventrally; two irregular transverse whitish bands on chin extending upward to cheek; large brown blotches on dorsal fin, first covering most of first interspinous membrane and part of second; anal fin with alternating diagonal dark brown and whitish bands; dark brown bar on pectoral base; large reddish blotch basally on pelvic fins.

TP: greenish brown, mottled with darker brown and whitish, shading to light brownish or greenish yellow ventrally, with numerous small blue spots on head and body, some short blue lines radiating from eye; irregular whitish stripe from above pectoral base along side of body to slightly below mid-base of caudal fin; opercular membrane often orange-red; fins similar in colour to initial phase but not as strongly marked.

Remarks. The synonymy and species description follows Bruce & Randall (1985). *Leptoscarus vaigiensis* is a wide-ranging species, occurring from the Red Sea and coast of East Africa to Oceania. In the South Pacific it extends to Easter Island, but north of the equator it is known only to the Palau Islands and Mariana Islands. It has not been found in the Caroline Islands, Marshall Islands, Gilbert Islands, Line Islands or the Hawaiian Islands. In the western Pacific it ranges from southern Japan to Queensland; there is one valid record from northern New Zealand (Russell & Ayling, 1976). In Australia the species has an extensive distribution from Sydney Harbour in the east (R. Kuiter, pers. comm.) to Rottneest Island in the west. The preferred habitat appears to be algal and seagrass beds. In Australia, *L. vaigiensis* has been recorded from a number of localities (Table 5). It was not observed by the authors in any coral reef environments although it may occur on northern inshore reefs (A.M. Ayling, pers. comm.). The largest specimen examined by Bruce & Randall (1985), 327 mm SL (WAM P.26842-001) was from Rottneest Island. The species does not approach this size in warmer waters.

Robertson et al. (1982) reported that *L. vaigiensis* appears to be gonochoristic, i.e., exhibits no change in sex. No other scarid fish is known in which there is no female to male sex reversal. Mature IP females of *L. vaigiensis* were found as small as 69 mm SL, and IP males as small as 72 mm SL. Males are capable of changing from the initial phase to the terminal phase at a small size (as small as 85 mm SL), but there is a broad overlap in the size of IP and TP males. Females appear to reach about the same maximum length as males. Both pair spawning and group spawning were observed at Aldabra in the western Indian Ocean.

Cetoscarus bicolor (Rüppell)

Plates 1G,H; 6I

Scarus bicolor Rüppell, 1829: 82, pl. 21, fig. 3 (type locality, Jeddah).

Scarus pulchellus Rüppell, 1835: 25, pl. 8, fig. 3 (type locality, Jeddah).

Scarus ocellatus Valenciennes in Cuvier & Valenciennes, 1840: 278 (type locality, Caroline Islands).

Scarus rosiceps Valenciennes in Cuvier & Valenciennes, 1840: 279 (type locality, Caroline Islands).

Callyodon scriptus Gronow in Gray, 1854: 85 (type locality, Indian Ocean).

Pseudoscarus nigripinnis Playfair & Gunther, 1867: 105, pl. 15, fig. 2 (type locality, Zanzibar).

Scarus ophthalmistius Herre, 1933: 21 (type locality Jolo, Philippine Islands).

Material examined. One specimen, One Tree Island, AMS I.15685-039; one specimen, Ayr, QM I.12731; three specimens, Heron Island, and one specimen, One Tree Island, not retained; two specimens, Lizard Island, to be deposited AMS.

Diagnosis. Median predorsal scales 4-7, subequal, anterior scales often partly embedded; 3 rows of scales on cheek, upper with 7-8 scales, not extending above lower edge of eye, middle row with 6-8, lower row with 3-6; interopercle with 2 longitudinal rows of scales (1 row on other Scarinae); pectoral rays 14-15; lips largely covering dental plates, rows of fused teeth on dental plates clearly visible, no canine teeth on dental plates; each upper pharyngeal bone with three longitudinal rows of molariform teeth, outer row rudimentary, inner rows of teeth not interdigitating; posterior nostrils of adults large.

Colour pattern. Juvenile: body white with broad, dark-edged orange bar on head enclosing eye and most of postorbital head, snout pale brownish; dorsal and anal fins white, large orange-margined black spot on anterior dorsal fin; pectorals and ventrals pale orange to yellow; caudal white with upper and lower margins light orange.

IP: body above level of eye yellow, below abruptly dark brownish, scales edged with black, centres with small black dots and short irregular lines (body colour may vary to light grey so dark scale markings stand out in sharp relief); head light brown with series of small dark dots on lower opercular membrane and throat; fins reddish to purplish brown; caudal with medial posterior region pale yellowish; pectorals brownish, central regions paler; pelvics darker brown; iris orange, dental plates white.

TP: body green, edges of scales orange; scales on anterior half of body with small orange spots; ventral part of head, thorax and abdomen yellow to orange; an area of lower cheek, side of thorax below pectoral fin base, and abdomen darker green; snout, occiput and cheek green with numerous small orange dots; lower lip narrowly green with orange bar on chin, upper lip orange, then green bounded above by an additional orange bar, an orange line from edge of upper lip to pectoral base and continuing ventrally across side of abdomen to level of vent; eye with 1-2 orange postorbital lines; iris orange, dental plates white; dorsal fin green becoming yellowish toward distal margin with orange blotch on each interradiial membrane, distal margin darker green; anal fin yellowish orange with broad blue-green distal margin; caudal fin orange with

crescentic green area, distal margin with thin green line, upper and lower lobes orange with green outer margins; pectoral fins with dark bluish rays and clear membranes, axilla of fin bright yellow; pelvic fins yellow with blue lateral margin. This colour description refers to freshly collected specimens. In life, orange areas of colour pattern are bright pink.

Remarks. This species was placed in the genus *Bolbometopon* by some authors (Rosenblatt & Hobson, 1969; Schultz, 1969). The status of the genus *Cetoscarus* and the synonymy of *C. bicolor* is discussed by Randall & Bruce (1983).

Cetoscarus bicolor is a widely distributed scarid ranging from the Red Sea to the central Pacific. It is distributed along the entire length of the Great Barrier Reef on mid and outer reefs where it generally occurs in pairs on reef crest areas, but larger groups (up to 15) may be encountered on outer barrier reefs. It has not been recorded from Western Australia. *Cetoscarus bicolor* is a large scarid with terminal males reaching 460 mm SL on the southern Great Barrier Reef.

In December 1982 the senior author observed a group of 15–20 IP individuals assembling at an exposed point on Yonge Reef in apparent preparation for spawning. During reproduction, terminal males swim rapidly with the jaws open.

Hipposcarus longiceps (Valenciennes)

Plates 11, J; 6B.

Scarus longiceps Valenciennes in Cuvier & Valenciennes, 1840: 241 (type locality, Waigeu).

Scarus macrocheilos Bleeker, 1854a: 60 (type locality, Halmahera).

Scarus harid (not Forsskål).—Schultz, 1958: 50, pl. 9B.

Hipposcarus schultzi Smith, 1959: 277, fig. 8 (type locality, Philippines).

Material examined. Two specimens, One Tree island, AMS I.15637–044, I.20578–005; one specimen, Lizard Island, AMS I.15637; two specimens (juveniles), Lizard Island, AMS I.25783–001, I.25798–001; one specimen, Half Mile Pass, Great Barrier Reef, BPBM 30886; one specimen, Port Moresby, BPBM 15893; one specimen, Fanning Island, BPBM 7597; seven specimens, One Tree Island, not retained.

Diagnosis. Median predorsal scales 4, scales subequal; 3 rows of cheek scales, upper row 6–8 scales, middle row 5–7 scales, lower row 3–6 scales, these in small triangular patch on cheek; pectoral rays 15; dental plates narrow, their height about 1.5–2.0 in orbit diameter, outer surface smooth, lips covering dental plates, terminal phase with 1–2 canines on upper dental plate; each upper pharyngeal bone with about 8 ridged molariform teeth and an outer row of rudimentary teeth; nostrils exceedingly small; head with sharply pointed profile; caudal fin strongly double emarginate with very short lobes.

Colour pattern. Juvenile: body yellowish grey, scales with darker dots and small lines, these more pronounced

dorsally; abdomen pale yellowish; head and snout brownish; longitudinal pink to red band from tip of snout, through lower portion of eye, extending down side of body to caudal peduncle; posterior region of caudal peduncle yellowish with prominent black spot at termination of longitudinal red band; dorsal and caudal fins brownish, anal fin yellowish brown, pectorals hyaline, pelvics whitish; iris yellow. Outline of longitudinal band present in alcohol preserved specimens.

IP: body pale uniform grey; dorsal scales with faint dark vertical lines; abdominal scales with faint bluish markings; caudal peduncle yellowish; snout and head brownish, upper lip yellowish orange with fine blue border, extending backward as yellow-orange line to point just anterior to orbit; lower lip light bluish; chin and isthmus faintly reddish, cheeks paler; upper margin of orbit light blue; iris yellow; posterior margin of operculum adjacent to pectoral base light orange-yellow; dorsal and anal fins yellow with faint medial blue longitudinal line, distal margin of fins blue; remainder of dorsal fin hyaline; caudal fin yellow, base and upper and lower margins pale blue; upper rays of pectoral light blue, then yellowish orange bar; pelvics pale yellowish, anterior and posterior margins faintly blue. Underwater observations of IP individuals gives the impression of a uniform grey fish with distinct yellow caudal fin and peduncle, with the yellow of the caudal peduncle extending on to dorsum below last 5–6 dorsal rays.

TP: body bluish dorsally, becoming yellowish on sides; scales of dorsum with light orange vertical bars; thorax and lower abdomen bluish; three most ventral scale rows of abdomen with rows of blue blotches, these being restricted to an area posterior to pectoral fin; caudal peduncle yellowish; snout and occiput bluish green, cheek paler; upper lip orange, lower lip bluish, 1–2 small blue postorbital lines; dorsal and anal fins orange-yellow with vertical blue blotch on each fin membrane, these becoming fainter posteriorly, distal margins of these fins blue; caudal membranes orange-yellow with thin blue basal line; upper and lower caudal rays faintly bluish, remaining rays bluish, posterior margin of caudal fin light blue; upper pectoral rays bluish, followed by an orange bar, remainder of fin hyaline; pelvics light bluish, posterior margin darker blue. Viewed underwater, TP individuals have greenish cast with pinkish colouration on head. Blue markings on vertical and pectoral fins appear purple.

Remarks. This species is a member of a distinctive genus of scarids characterised by a pointed head, narrow dental plates and the cheek scales reduced to a small subtriangular patch. The cheek scales themselves are small, often irregularly arranged in rows and some difficulty may be experienced in obtaining accurate counts in small specimens. Members of the genus occur in the Red Sea and Indian Ocean, through to the western and central Pacific. Details of the Red Sea and Indian Ocean species are provided in Smith (1959), Schultz (1969) and Randall & Bruce (1983). Smith (1959)

subdivided members of this genus into a Red Sea (*H.harid harid*) and Indian Ocean (*H.harid vexillus*) subspecies and an Indo-West Pacific species, *H.longiceps*. *Hipposcarus harid* and *H.longiceps* are clearly distinct (Randall & Bruce, 1983). The status of the subspecies of *harid* is more problematical. They are distinct in a number of features of colour pattern (Randall & Bruce, 1983) and different total numbers and disposition of cheek scales. Schultz (1969, table 3) made counts of the cheek scales of 21 individuals from the Red Sea and 18 from the Indian Ocean. Mean total cheek scales in the Red Sea populations was 18.5 ± 0.4 and Indian Ocean populations 26.0 ± 0.6 . The geographical pattern of species distribution described above is consistent with that seen in a number of other scarid species complexes. Further investigation of the *H.harid* complex is needed.

Hipposcarus longiceps is widespread in the northern tropical Pacific and extends southwards to New Guinea and Australia, and eastwards to the central Pacific. It occurs along the entire Great Barrier Reef and is characteristic of the lagoons and outer slopes of reefs both on the outer shelf and in the Coral Sea. The presence of this species in Western Australia remains to be confirmed. It consistently forms large schools as adults. Juveniles tend to be solitary. A moderately large species, terminal males reaching 400 mm SL on the Great Barrier Reef.

Bolbometopon muricatum (Valenciennes)

Plates 1F; 6A.

Scarus muricatus Valenciennes in Cuvier & Valenciennes, 1840: 208, pl. 402 (type locality, Java)

Material examined. One specimen, Lizard island, AMS I.18755-077; two specimens, 775 and 613 mm Yonge Reef, collected by senior author, both retained by D. Bellwood.

Diagnosis. Median predorsal scales 3–5, scales subequal; 3 rows of cheek scales, upper with 4–6 scales, middle with 5–6 scales, and lower with 1–2 scales; cheek and predorsal scales partly embedded with age; 1 row of scales on interopercle; pectoral rays 16–17; dental plates exposed; rows of fused teeth on dental plates easily discernable, each tooth bearing a small tubercle at proximal apex, surface of each tooth slightly convex, giving a nodular texture to the plates, no canine teeth on dental plates; each upper pharyngeal bone with 3 rows of teeth, outer row rudimentary, inner rows not interdigitating; nostrils of young small, posterior nostril oval, increasing in relative size with age, becoming 3 or 4 times longer than anterior nostril; prominent convexity developing on the head, increasing greatly with size until nearly in vertical alignment with mouth in large individuals; caudal fin rounded in juveniles, double emarginate in adults, lobes only slightly produced.

Colour pattern. This species does not display the usual sex-associated patterns of colour change; it maintains a uniform colouration in adult females and males. There

is a distinct juvenile colour pattern.

Juvenile: body uniform greenish with 5 rows of white spots on body, first at level of third dorsal spine, fifth on caudal peduncle, each row with 2–3 spots; vertical fins slightly darker green, pectorals hyaline yellowish, pelvics greenish; iris yellow, dental plates white; white spots still apparent on individuals up to 300 mm SL at which size head profile is becoming convex.

In alcohol, body colouration is brownish green with numerous small dark spots on body; chin with two dark bars.

Adults: uniform dull green on body and fins, head green with anterior part of hump, snout and chin pink; dental plates white; in life body colouration may be lighter green with darker longitudinal bands running along body; in very large individuals sides of head and occipital regions may display temporary light green colouration.

A.M. Ayling provided notes on colour patterns of individuals engaged in courtship activities. Larger individuals within a group (presumably males) dull green on body, with head and posterior ventral region of body pale greenish white. Vertical and caudal fins also greenish white.

Remarks. This is the largest of all the scarids reaching a size of 1000 mm SL. There appears to be a single species although a thorough examination of material from over the full geographic range should be undertaken. This species is poorly represented in museum collections as it is usually difficult to approach and collect. It occurs in small schools; it is most commonly observed on reef fronts but also ranges over reef crests and flats. It feeds on live coral colonies and on algae. No spawning was observed by the authors, although what appeared to be a group spawning assemblage of 40–50 fish was observed on the outer face of Yonge Reef by the senior author during December 1983. *Bolbometopon muricatum* has a wide distribution extending from the Red Sea to the central Pacific. It reaches Okinawa in the northern Pacific and the Great Barrier Reef in the south.

Bolbometopon muricatum is present on mid- and outer-shelf reefs of the Great Barrier Reef but does not extend into the Swain or Capricorn-Bunker reefs at the southern end (Russell, 1983). A.M. Ayling has provided information on the longitudinal distribution on the Great Barrier Reef gathered during his extensive *Plectropomus* surveys. The farthest south this species was observed was in the Swain Reef Group. Five adults were observed on Reef 21-072 (21°08'S) and the species was moderately common on Elusive Reef (21°06'S). None were observed during surveys of Creal, Little Bugatti, Whitetip and Little Stevens Reefs off MacKay (21°36'S). Small numbers were observed during surveys in the Flinders Reefs, Herald and Lihou Cays in the Coral Sea. *Bolbometopon muricatum* has not been recorded from Western Australia.

Scarus altipinnis (Steindachner)

Plates 5I,J; 6F; 10A,B,C

Pseudoscarus altipinnis Steindachner, 1879: 18 (type locality, Kingsmill Islands).*Callyodon waitei* Seale, 1906: 60, fig. 16 (type locality, Tahiti).*Pseudoscarus altipinnis*.—Gunther, 1909: 326, pl.160.*Pseudoscarus brevifilis* Gunther, 1909: 327, pl.161 (type locality, Tahiti).*Scarus chlorodon*.—Schultz, 1969: 26 (In part).

Material examined. HOLOTYPE of *Callyodon waitei* Seale BPBM 1408 320 mm SL; three specimens, Cape Cleveland, QM I.15998, I.16003, I.6894; one specimen, Heron Island, AMS I.15679-049; five specimens (juveniles), Lizard Island, I.25791-001, I.25795-001, I.25403-001, I.25909-001, I.25911-001; one specimen (juvenile), Younge Reef, AMS I.25912-007; ten specimens, Heron Island, not retained.

Diagnosis. Median predorsal scales 5-6; 3 rows of cheek scales, upper row with 6-7 scales, middle row with 6-8 scales, ventral row with 1-3 scales; pectoral rays 15; dental plates exposed, dark green in both colour phases; 1-2 canines on upper dental plates of adults; spinous portion of dorsal fin distinctly higher than soft dorsal, fin membrane covering last few spinous dorsal rays and first soft ray as an extended filament; caudal fin of adults double emarginate, lobes produced as filaments in adults.

Colour pattern. Juvenile: body greyish brown, caudal peduncle abruptly paler, 3-4 vertical series of white dots on sides of body; snout and iris yellow, dental plates pale; dorsal and anal fins with distinctive black and white mottling, pectorals hyaline light yellowish, caudal hyaline whitish, pelvic light grey.

IP: body reddish brown, sides of body posterior to pectoral fin tip with series of small distinctive white dots, these arranged roughly in 3-4 vertical series of 2-3 dots, this pattern becoming more diffuse in adults; dorsal, anal and pelvic fins light reddish brown with bluish distal margins, pectoral light brownish, caudal reddish brown; iris yellow, dental plates dark green.

TP: body dark greenish, distal margins of body scales with darker green bars, these more pronounced on posterior ventral regions of body, abdomen and thorax; isthmus lighter greenish brown, scales on abdomen, base of anal fin and ventral portion of caudal peduncle with scattered greenish spots; occiput and upper snout dark green, a dark green suborbital line, cheeks paler becoming light orange ventrally marked with greenish flecks and dots, operculum with scattering of green dots, snout becoming orange, upper lip orange with a dark green bar, lower lip orange, chin with two dark green bars; dorsal fin greenish brown, the membranes investing each spine and ray dark green, base and distal margin of fin dark green; anal fin greenish brown with extensive and irregular green outer margin, medial region of fin with series of dark green blotches, these becoming more pronounced posteriorly; caudal fin brownish green, dorsal and anal lobes paler, dorsal and ventral margins dark green, posterior margin paler, medial area of caudal fin with dark greenish blotches;

pectoral fins brownish green, upper margin dark green; pelvics pale greenish, spine and anterior ray dark green; iris orange, dental plates dark green. In life, often a broad vertical dusky band in centre of body (Plate 10 C), with colouration anterior to this slightly paler. This dusky band intensified during reproductive behaviour.

Remarks. *Scarus altipinnis* is a member of a complex of three large scarids characterised by a relatively large body depth, strongly lunate caudal fins and an acute snout. The complex includes *S.falcipectus* which is confined to the Indian Ocean from the Seychelles to the west; *S.prasiognathus*, Indian Ocean eastwards from the Maldives, Indonesia, Philippines to the Ryukyu Islands and Palau; and *S.altipinnis* through the west, central, and southern Pacific. Large *S.altipinnis* may be readily separated from other members of this complex by the characteristic extension of the dorsal fin membrane at the last spine and first soft ray.

Scarus altipinnis has been identified most recently as *S.brevifilis* and prior to this *S.chlorodon*. *Scarus chlorodon* is in fact a synonym of *S.prasiognathus* (see Randall & Choat, 1980). Since 1980 almost all identifications of *S.altipinnis* from Pacific and Australian waters have referred this species to *S.brevifilis*. Schultz (1969) included both *S.altipinnis* and *S.waitei* (Seale) within the synonymy of *S.chlorodon*. However both these species have central and southern Pacific type localities and were considered unlikely to be *S.prasiognathus*. The description of *S.altipinnis* by Steindachner (1879) clearly refers to the Pacific scarid previously identified as *S.brevifilis* (Gunther). The original description suggests that Steindachner may have been uncertain about the distinction between *S.altipinnis* and *S.janthochir* (a synonym of *S.prasiognathus*) but the name has been recognized and used by other workers. Gunther (1909) recognized both *S.altipinnis* and *S.brevifilis*. It is clear from his illustrations that he had identified the terminal (*S.altipinnis*) and initial (*S.brevifilis*) phases of this species although he was unaware of the sexual dichromatism. *Scarus altipinnis* is a valid earlier name for the west and central Pacific scarid previously identified as *S.brevifilis*. The holotype of *Callyodon waitei* Seale was examined by the junior author and was also found to be *S.altipinnis*.

There are a number of informal records of *S.janthochir* (a synonym of *S.prasiognathus*) from Australia. As far as we can determine, these all refer to *S.altipinnis*, although it is possible that *S.prasiognathus* does occur in north-western Australia. Munro (1967) recorded *S.chlorodon* from New Guinea. We are unable to determine from the description whether this refers to *S.altipinnis* or *S.prasiognathus*.

Scarus altipinnis is generally a schooling scarid, common on the outer-shelf reefs of the Great Barrier Reef and the reefs of the Coral Sea, feeding in large groups on reef crests. On mid-shelf reefs smaller groups occur, often associated with very large TP individuals. A small proportion of IP fish were found to be primary

males. Pair spawning involving a very large (approximately 500 mm SL) TP male was briefly observed at Lizard Island. Prior to spawning, the male swam in a highly characteristic fashion with the posterior region of the body arched downward and the filament on the dorsal fin projecting backward. This species shows a wide size range for the terminal colour phase (200–450 mm SL at Heron Island). It is one of the larger scarids on the Great Barrier Reef.

Scarus bleekeri (de Beaufort)

Plates 4A,B; 8I,J

Scarus Quoyi (not Valenciennes).—Bleeker, 1853b: 607 (Ternate).

Pseudoscarus Quoyi (not Valenciennes).—Bleeker, 1862: 29, pl. 6, fig. 3.

Callyodon bleekeri de Beaufort, 1940: 318 (new name for *Scarus quoyi* Bleeker, 1853, not Valenciennes).

Scarus troscheli.—Schultz, 1969: 21 (in part).

Material examined. Four specimens, Madang, AMS I.17090–023, I.18090–023, I.17088–044; one specimen, Fiji, BPBM 11404; one specimen, Heron Island, USNM; one specimen (juvenile), Yonge Reef, AMS I.25792–001; two specimens Lizard Island (juveniles), AMS I.25903–002, I.25916–001.

Diagnosis. Median predorsal scales 4; scale rows on cheek 2, both with 6–8 scales; pectoral rays 15; caudal fin truncate in both colour phases; dental plates not covered by lips; 1–2 canines posteriorly on side of upper dental plates of adults.

Colour pattern. IP: body dark brown, edges of scales narrowly orangish, shading to dull orange-red on abdomen and thorax; body with faint greenish yellow bars, these numbering 3–4 with anterior one predorsal, bars extending only to body mid-line; posterior caudal peduncle and base of caudal fin greenish yellow, in small IP individuals caudal peduncle pale yellow to white, fading to orangish brown on death (also fading, a yellowish wash on upper half of head); upper lip with narrow margin of salmon pink and submarginal band of dull blue-green; lower lip and chin salmon pink with three transverse dull blue-green bands that join to median dull blue-green band ventrally; fins orangish to reddish brown, dorsal and anal with faint median longitudinal dark band and narrow dark margin; pectoral membranes pale; pelvics with dark lateral margin; dental plates white; eye orange-yellow. Viewed underwater, IP individuals characteristically show irregular lighter bars against dark body colouration, the bars fading rapidly on death. Preserved specimens uniform brownish with lighter caudal peduncle; bands on chin usually still visible. Care must be taken to differentiate these from IP *S.sordidus* in preserved collections.

TP: scales of body green with vertically elongate rosy salmon bar, except abdomen and thorax green, and anterodorsally body and nape yellowish; large whitish area on cheek bordered by blue-green; lips faintly

salmon, band of this colour continuing from rictus to lower edge of eye and along upper edge of large pale area on cheek; transverse turquoise band on upper lip and 2 on chin; green band extending anteroventrally and 2 posterodorsally from eye; dorsal fin salmon with blue margin, green at base, with median longitudinal green band; anal fin blue-green basally, turquoise distally, the 2 regions separated by band of salmon; caudal fin turquoise with salmon band in each lobe and short streaks of this colour centrobasally; pectoral fins largely turquoise with streak of salmon in upper part and whitish at base; pelvic fins pale salmon with blue lateral margin; dental plates greenish. In preserved specimens, characteristic cheek marking highly visible and there are no difficulties associated with identification in museum collections.

Remarks. This species is similar to *Scarus troscheli* Bleeker and was regarded by Schultz (1969) as a junior synonym of that species. The taxonomic history of *S.bleekeri* and *S.troscheli* plus details of their distribution patterns are discussed in Randall & Choat (1980). *Scarus bleekeri* is relatively rare on the Great Barrier Reef. It was not included in any of the major surveys of shelf and Coral Sea reefs carried out by A.M. Ayling and D. Williams but was observed occasionally on the slopes of mid- and outer-shelf reefs. It was observed most frequently in more sheltered reef habitats with abundant coral growth, typically in deeper water. The authors have observed both colour phases as solitary individuals and small groups over much of the Great Barrier Reef. Very small IP individuals may be confused with small *S.sordidus*. This species has not been recorded from northern or western Australia.

Scarus chameleon n.sp.

Plates 3C,D; 9D,E,F,G,H

Scarus lunula (not *Callyodon lunula* Snyder).—Choat & Robertson, 1975: 264–267 (Heron Island, Great Barrier Reef)

Material examined. HOLOTYPE: BPBM 22177, 204 mm SL, TP male, Philippines, Sumilon Island (off southeast Cebu), east side, 20 m, spear J.E. Randall, 26 August 1977.

PARATYPES: AMS I.15470–001, 211 mm SL, TP (eviscerated), Australia, Queensland, Great Barrier Reef, Capricorn Group, Heron Island, 23°27'S, 151°57'E, spear, J.H. Choat, 2 February 1967; BPBM 7425, 136 mm SL, IP female, Belau, outside barrier reef east of Eil Malk, 6 m, spear, J.E. Randall, 10 June 1968; BPBM 9466, 149.5 mm SL, TP male, Belau, Augulpelu Reef, west side, 3.5 m, spear, J.E. Randall, 10 April 1970; BPBM 11649, 159.5 mm SL, TP male, Fiji, Viti Levu, Nukulau Pass off south-east side of Makuluvā Island, 15 m, spear, J.E. Randall, 2 September 1971; BPBM 14517, 2: 151–187 mm SL, IP female and TP male, Great Barrier Reef, Capricorn Group, Heron Island, outer reef flat and reef front, 1–4 m, spear, J.E. Randall, J.H. Choat & D.R. Robertson, 21 January 1973; BM(NH) 1984.4.17.41, 169.5 mm SL, IP female; CAS 54884, 166 mm SL, IP female; USNM 266381, 2: 136–186 mm SL, IP female and TP male—all with same data as BPBM 14517; BPBM 14621, 176 mm

SL, TP male, Fiji, Yanutha Island in Mbengga Lagoon, 4 m, spear, J.E. Randall, 11 March 1973; NTM S11158-001, 189 mm SL, TP male, Great Barrier Reef, Carter Reef, outside reef, 6 m, spear, J.E. Randall, 25 June 1973; AMS I.20572-014, 193 mm SL, TP male, Great Barrier Reef, Capricorn Group, One Tree Island, 6 m, explosives, B.C. Russell and party, 23 November 1973; NSMT-P 23034, 205 mm SL, TP male, Ryukyu Islands, Okinawa, Sesoko Island, west side, 10 m, spear, J.E. Randall, 1 June 1975; AMS I.21997-001, 137.5 mm SL, IP female, Great Barrier Reef, Yonge Reef, 27 m, explosives, B.C. Russell and party, 1 November 1975; BPBM 29403, 161 mm SL, IP female, same data as holotype; MNHN 1984-418, 149.5 mm SL, TP male, Philippines, Cebu City market, J.E. Randall, G.W. Tribble, R. Rutherford & K.E. Carpenter, 31 July 1978; QM I.14902, 248 mm SL, TP male, Queensland, Flinder's Reef (off Cape Moreton), spear, M. McDade, 24 September 1978; QM 16006, 210 mm SL, TP male, Great Barrier Reef, Capricorn Group, North West Island, spear, M. McDade, May 1979; BPBM 27840, 90.4 mm SL, Great Barrier Reef, Lizard Island, off Granite Bluff, 13 m, spear, J.E. Randall, 20 September 1981; BPBM 29401, 2: 165.5-175.5 mm SL, IP females, Great Barrier Reef, Lizard Island, point at north end of Coconut Beach, outer edge of fringing reef, 4-12 m, spear, J.E. Randall, 8 December 1982; WAM P.28275-001, 168 mm SL, IP female, same data as preceding; BPBM 29402, 134 mm SL, IP female, Great Barrier Reef, MacGillivray Reef (near Lizard Island), 4 m, spear, J.H. Choat, 11 December 1982 (see Table 8).

Additional material examined. One specimen, Sydney Harbour, AMS I.17740-003; one specimen, Heron Island, QM I.6841; five specimens, Lizard Island, AMS I.18767-032, I.19445-014,

I.19455-016, I.19461-004; eight specimens (juveniles), Lizard Island, AMS I.25799-001, I.25793-001, I.25782-002, I.25904-001; one specimen, Yonge Reef, QM I.14867; one specimen, Kenn Reef, AMS IB.4892; one specimen, Kendrew Island, Western Australia, WAM P.24636-001; one specimen, Abrolhos Island, WAM unregistered; one specimen, Madang, AMS I.17088-066; 21 specimens, Lizard Island, not retained.

Diagnosis. Median predorsal scales 4, preceded by pair of moderately large, laterally overlapping scales; rows of scales on cheek 3, upper two of 6-7 (rarely 8) scales, and lower of 1-3 scales; pectoral rays 14; gill rakers 39-46; lips covering $\frac{3}{4}$ to all of upper dental plate and $\frac{1}{2}$ - $\frac{3}{4}$ of lower dental plate; terminal males with 1-2 canine teeth posteriorly on dental plates, and IP fish with 0-1 canines on dental plates; nostrils small; dorsal profile of head of large terminal males with slight convexity in interorbital space; body depth 2.5-2.8 in SL; head length 2.75-2.9 in SL; snout 2.5-2.95 in head; orbit diameter 5.3-7.35 in head; caudal fin of IP slightly rounded to slightly emarginate, of TP males emarginate to lunate, the maximum caudal concavity 3.5 in head; pectoral fins 1.35-1.55 in head; pelvic fins 1.85-2.2 in head.

Colour of IP when fresh: brown, lower third of body often abruptly lighter brown; dorsal fin orangish brown with violet-grey margin; unscaled part of caudal fin brownish yellow.

Colour of TP when fresh: broad zone of salmon pink on lower side of body extending posteriorly from behind

Table 8. Proportional measurements of type specimens of *Scarus chameleon* expressed as a percentage of the Standard Length

	Holotype			Paratypes							
	BPBM 22177 TP♂	BPBM 27840 juv	AMS I.21997-001 IP♀	BPBM 9466 TP♂	BPBM 29403 IP♂	BPBM 29401 IP♀	BPBM 29401 IP♀	BPBM 14517 IP♀	AMS I.20572-014 TP♂	NSMT-P 23034 TP♂	AMS I.15470-001 TP♂
Standard length (mm)	204	90.4	137.5	149.5	161	165.5	175.5	187	193	205	211
Body depth	39.9	36.4	35.5	39.4	39.4	36.4	37.2	36.8	37.0	38.3	36.0
Body width	17.2	17.6	17.3	18.3	16.8	18.0	18.5	17.0	16.5	17.6	16.6
Head length	36.7	35.9	35.7	36.3	36.0	34.5	36.5	36.1	34.7	36.1	36.2
Snout length	14.5	12.6	12.2	13.7	13.5	13.7	13.6	14.2	13.3	13.7	14.1
Orbit diameter	5.1	6.8	5.8	5.7	5.5	5.4	5.7	5.2	4.9	4.9	5.0
Interorbital width	12.1	11.9	10.8	11.1	11.2	12.2	11.1	11.7	11.4	12.1	11.1
Caudal peduncle depth	15.6	aberrant	15.1	16.1	15.5	15.1	15.6	14.9	14.9	15.6	14.8
Caudal peduncle length	13.3	13.5	13.2	12.7	12.5	13.0	13.4	13.1	12.4	12.2	12.0
Predorsal length	35.8	35.0	34.8	36.1	34.1	34.9	34.8	34.8	34.0	34.5	35.2
Preanal length	66.9	64.5	67.2	68.1	65.8	63.8	63.5	67.0	67.5	68.7	68.8
Prepelvic length	36.8	36.5	36.8	37.4	36.7	35.5	37.0	37.8	36.4	37.0	37.5
Dorsal fin base	58.2	57.2	56.1	57.7	59.4	58.8	59.3	58.8	57.0	58.8	58.1
Length first dorsal spine	9.8	12.2	12.2	11.2	10.8	9.3	10.2	11.4	11.4	11.6	11.7
Length 9th dorsal spine	11.2	13.3	13.6	12.7	11.6	10.8	11.1	11.6	12.3	12.6	12.5
Length longest dorsal ray	12.3	14.3	14.1	13.4	12.4	13.0	12.0	13.7	12.4	12.7	12.7
Anal fin base	26.1	26.6	23.0	24.6	26.0	26.9	27.0	26.5	25.7	25.4	25.1
Length 3rd anal spine	9.8	11.9	11.5	10.7	10.1	9.8	9.4	10.6	10.1	10.5	9.5
Length longest anal ray	11.8	13.9	13.0	11.5	11.8	12.1	11.8	11.6	10.2	12.1	12.3
Caudal fin length	27.2	22.7	23.4	24.0	23.0	20.4	21.6	25.0	27.0	24.5	26.0
Caudal concavity	10.3	0	3.7	4.2	2.6	0	2.6	6.3	4.9	5.7	5.1
Pectoral fin length	24.6	24.8	25.3	25.0	23.6	25.2	23.4	23.5	23.8	24.0	24.4
Pelvic spine length	12.5	14.7	14.7	13.7	12.4	13.3	13.7	14.3	12.2	13.9	11.3
Pelvic fin length	16.5	18.0	19.2	18.1	16.7	16.0	17.2	18.1	17.2	18.5	17.6

head; scales of body above and posterior to this zone about half blue-green and half salmon pink, below largely pale blue-green; head with green band crossing upper interorbital space; caudal fin orange with blue upper and lower margins, and large D-shaped mark of green and blue-green centroposteriorly in fin; pectoral fin pale orange with blue band at base connected to blue upper margin of fin.

Description (based on holotype and ten paratypes). Dorsal rays IX,10; anal rays III,9; pectoral rays 14 (uppermost ray rudimentary, second ray unbranched); pelvic rays I,5; principal caudal rays 13, uppermost and lowermost unbranched; upper procurrent caudal rays 7; lower procurrent caudal rays 7; lateral line interrupted, dorsoanterior portion with 18 (17–19) tubed scales (tubules mostly branched) and peduncular part with 6 (4–6) (plus 2 tubed scales on caudal fin base, last greatly enlarged); scales above lateral line to origin of dorsal fin $1\frac{1}{2}$; scales below lateral line to origin of anal fin $5\frac{1}{2}$; median predorsal scales 4, these preceded by pair of laterally overlapping scales about $\frac{3}{4}$ width of predorsal scales; median predorsal scales slightly larger posterior to anterior, the most posterior deeply indented for first dorsal spine; scale rows on cheek 3, upper row with 7 (6–8, rarely 8) scales, middle row with 7 (6–8, rarely 8) scales, and lower row with 2 (1–3, usually 2, rarely 1) scales; circumpeduncular scales 12; gill rakers 41 (39–46 in 10 paratypes); branchiostegal rays 15; vertebrae 11 + 14 (holotype and one paratype).

Body moderately deep, depth 2.5 (2.55–2.8) in SL, and compressed, width 2.3 (2.0–2.35) in depth; head length 2.75–2.9 in SL; head moderately pointed, dorsal and ventral profiles of IP and small TP fish about equally convex, but large terminal males, such as the holotype, have slight protuberance in dorsal profile over interorbital space; snout 2.55 (2.5–2.95) in SL; orbit diameter 7.2 (5.3–7.35) in head; interorbital space very convex, least width 3.05 (2.85–3.3) in head; caudal peduncle deeper than long, least depth 2.35 (2.25–2.45) in head.

Mouth slightly inferior, gape slightly oblique; teeth fully fused to form relatively thin, beak-like, dental plates, surfaces of which are smooth; median suture in each dental plate; margin of plates slightly irregular; 2 canine teeth projecting laterally (slightly ventroposteriorly) posteriorly from side of upper dental plate near free margin (1–2 on TP paratypes; 0–1 on IP paratypes); 1 lateral canine posteriorly on lower dental plate (1–2 on TP paratypes; 0–1 on IP paratypes); upper lip covering $\frac{3}{4}$ to all of upper dental plate, and lower lip covering $\frac{1}{2}$ – $\frac{3}{4}$ of lower dental plate.

Upper pharyngeal bones each with row of 10 ridged molariform teeth (cusps of posterior teeth flattened by wear) which interlock medially and lateral row of small rudimentary molariform teeth which alternate with ridged molars; lower pharyngeal bone with concave elliptical surface of interdigitating molariform teeth in 5 transverse rows of 15, first three transverse rows distinctly ridged, the rest worn nearly flat (pharyngeal mill dissected from 176 mm paratype).

Nostrils very small, anterior in short membranous tube, in front of upper edge of pupil about $\frac{1}{3}$ horizontal distance to front of snout; nostrils close together, internarial space about $\frac{2}{3}$ pupil diameter.

Scales large, cycloid, extending dorsally on head to mid-interorbital space; fins naked except for upper row of scales on body which extend broadly onto base of dorsal fin (except posteriorly) and 2 vertical rows of scales basally on caudal fin; scaly process of 2 scales (more posterior one pointed) mid-ventrally at base of pelvic fins; slender pointed axillary scale at lateral edge of pelvic fin base about $\frac{3}{4}$ length of pelvic spine.

Origin of dorsal fin directly above upper end of gill opening; dorsal fin continuous with no notch between spinous and soft portions; dorsal and anal spines slender and flexible, tips curving posteriorly; first dorsal spine 3.7 (2.95–3.7) in head; second to ninth dorsal spines subequal, ninth 3.3 (2.65–3.3) in head; seventh to ninth dorsal soft rays longest, 3.0 (2.5–3.05) in head; first anal spine very slender, about $\frac{1}{2}$ length of second spine; second anal spine about $\frac{3}{4}$ length of third spine; third anal spine 3.75 (3.0–3.9) in head; third to seventh anal soft rays longest, 3.1 (2.6–3.4) in head; caudal fin slightly rounded to slightly emarginate in IP fish, emarginate to lunate in TP males, its length 1.35 (1.3–1.7) in head; caudal concavity of holotype 3.55 in head; third or fourth pectoral ray longest, 1.5 (1.35–1.55) in head; pelvic fins 2.2 (1.85–2.2) in head.

Colour of holotype in alcohol: brown, becoming light brown on side of body in a broad zone from behind head to beyond a vertical at origin of anal fin; each lip edged in a narrow pale band, the upper one extending to lower edge of orbit; a transverse narrow pale band at base of upper lip joined to marginal band by a narrow median pale band; median fins light brown, the dorsal with a submarginal translucent band which is wavy on its lower margin (progressively more undulating posteriorly); anal fin with a similar translucent band, but broader and nearer middle of fin; paired fins light brown, the pectorals with a slightly darker upper margin; a crescentic area posteriorly in caudal fin slightly lighter than rest of fin.

Colour of adult IP fish in alcohol: dark brown, slightly paler ventrally; a narrow dark margin on dorsal fin; centroposterior part of caudal fin a little paler than rest of fin; paired fins light brown. A 90.4 mm paratype is brown with the lower half of the head and about the lower third of the body abruptly pale.

Colour of holotype when fresh: scales of back and posterior body orangish with broad vertically elongate blue-green band on each; broad zone of salmon anteriorly on lower side of body between level of eye and lower pectoral base, narrowing and becoming diffuse posteriorly above middle of anal fin; ventral part of head and body largely pale blue-green; lips narrowly edged in bright blue, the band of the upper lip extending to lower edge of eye and continuing as an irregular green band to end of opercle; head above this band light green with lavender cast; transverse dark green band across posterior interorbital space; irregular dark green

markings on nape; irregular horizontal green band extending posteriorly from eye; short transverse narrow blue line on snout at base of upper lip joined by median narrow blue band to blue band on upper lip, the two bands separated by a zone of salmon pink; chin salmon pink with narrow transverse blue band which is joined at right angles to midventral blue band; lower half of head light blue-green suffused with orange; posterior margin of opercle with lower part of opercular flap to level of ventral edge of pectoral fin base with blue-green band; iris brownish orange, becoming blue-green outwardly; dorsal fin green basally with broad blue margin and broad submarginal orange band, the lower edge of which becomes progressively more wavy posteriorly, such that the last few membranes have a tongue of orange extending downward into the green zone nearly to the base; anal fin divided almost equally into basal band of blue-green, middle band of orange (lower edge somewhat wavy) and outer band of blue; basal scaled part of caudal fin coloured like caudal peduncle; unscaled part orange, suffused basally with green, upper and lower borders blue; large D-shaped mark centroposteriorly caudal fin, curved anterior part of 'D' green and vertical posterior part blue (center of 'D' and narrow margin posterior to it orange); pectoral fins with salmon pink rays, pale membranes, and blue-green band across base linked to blue-green upper margin; pelvic fins pale yellowish with blue lateral margin.

Colour of a 170 mm IP female when fresh: dark brown, lighter brown ventrally with reddish caste; lower lip and front of chin pinkish; iris brownish orange-red; unscaled part of dorsal fin light brownish orange with violet-grey margin; anal fin light reddish brown; unscaled part of caudal fin brownish yellow, lobes darker than centre of fin; pectoral fins with orangish brown rays, pale membranes; dark bluish grey band across base joining band of same colour along upper edge of fin about $\frac{2}{3}$ distance to tip; pelvic fins light pinkish with 3 indistinct small purplish spots along lateral edge.

Colour of a 90.4 mm paratype when fresh: upper $\frac{2}{3}$ of body brown, lower $\frac{1}{3}$ abruptly light reddish grey; caudal fin brownish yellow; dorsal fin orangish brown; anal fin reddish brown; two reddish brown transverse bands on chin.

Colour of a 23 mm juvenile when fresh: head brown; body grey, shading to brown posteriorly, with 5 longitudinal rows of white spots, those in upper row (level of upper end of gill opening) and third row (level of upper edge of pectoral base) as 4 or 5 close-set pairs; 2 transverse brown bands on chin; base of pectoral fins yellow; iris brownish yellow.

Remarks. This species is named *chameleon* in reference to its ability to rapidly change colour. The basic colour pattern of IP individuals is that of a light greyish to brownish fish becoming paler ventrally with a characteristic yellow caudal fin. This colour pattern may change rapidly, with the mid-body region becoming abruptly darker, providing a striking contrast between

the darker dorsal and paler ventral regions (Plate 9E). A series of yellowish saddles may be superimposed on the the darker mid-body regions. The dorsum adjacent to the fin is slightly paler than the mid-body, and the caudal fin is pale rather than distinctly yellow. A further variant pattern displays a distinct yellow band in the mid-body region extending on to the caudal peduncle and fin (Plate 9F). In all variants of this phase the major impression is of a bicoloured fish with a pale ventral region and an abruptly darker dorsum.

In TP individuals the mid-body region may vary abruptly from bright salmon pink (Plate 9G) to a striking whitish yellow (Plate 9H). With the former pattern the background body colouration is pinkish orange against which the green markings of the head and the blue-green areas on each scale stand out in sharp contrast to the background. Switching of the mid-body colouration to whitish yellow is accompanied by a fading of the pinkish background colouration and a deepening of the green pigmentation of the body providing a striking contrast between the darker dorsal and the paler mid-body regions. These changes may occur abruptly in the same individual over a very short time period and without any overt interactions with other individuals.

Scarus chameleon occurs in a wide variety of habitats from the outer part of reef flats at depths of 1 m or less to at least 30 m on reef slopes, and from protected localities such as bays and lagoons to exposed outer reef areas. This scarid is of moderate size; the largest we have examined is a TP male 248 mm SL from Flinder's Reef, Queensland (QM I.14902). It is a relatively common scarid on the Great Barrier Reef. A series of cross-shelf reef surveys revealed that it is present on both mid- and outer-shelf reefs but more abundant on the latter. It is also present on one reef of the Flinders Reef group, Coral Sea (D. Williams, pers. comm). A Coral Sea survey by A.M. Ayling revealed that this species was moderately common on Herald Cay and Lihou Reef. It is usually observed singly or in small mixed species feeding schools. Over the past three years this species has shown strong recruitment on northern reefs in the Lizard Island area.

Scarus chameleon has a wide distribution within Australian waters. Specimens have been recorded from Western Australia (Abrolhos Is.), Lord Howe Island, Flinders Reef (southern Queensland) and a confirmed record of a single juvenile from Sydney Harbour. Choat & Robertson (1975: Table 1A) examined the gonads of 25 specimens of *S. chameleon* (identified as *S. lunula*) from Heron Island, Great Barrier Reef. Thirteen were IP females, one was an IP male (primary male), one was a transitional specimen, and 10 were TP males (all secondary males). In this series the smallest sexually mature female measured 115 mm SL. Our adult type specimens included 11 IP fish, all females, the largest 175.5 mm SL, and 13 TP males, the smallest 149.5 mm SL.

This species is close to *S. festivus* Valenciennes (*S. lunula* is a synonym—see Randall & Bruce, 1983).

The two have the same meristic data; *S. festivus* even has the overlapping pair of scales in the median line anterior to the predorsal series of four scales. The colour patterns of the two are also similar. The easiest way to distinguish them is the more pronounced convexity of the forehead of *S. festivus* at any one size. This hump appears early on *S. festivus* and becomes marked in terminal males, whereas it is only slightly developed on large TP males of *S. chameleon*. *Scarus festivus* does not have the distinctive brown bicoloured pattern of the IP of *S. chameleon* in life. The TP of *S. festivus* differs in lacking the broad salmon zone on the side of the body and in having two green bands crossing the interorbital space (one broad one posteriorly as in *S. chameleon*, plus a narrower one nearly parallel to it in the anterior interorbital). Also, the caudal fin of *S. festivus* has a solid crescentic blue-green band posteriorly in the caudal fin, in contrast to the D-shaped marking of *S. chameleon*.

Scarus festivus and *S. chameleon* overlap over much of the range of the latter, but *S. festivus* extends its range westward to East Africa and east to French Polynesia while *S. chameleon* appears to extend further into southern Pacific waters. Masuda et al. (1984) identify and record *S. festivus* but not *S. chameleon* from the Ryukyu Islands. However Masuda (1984) provides a colour photograph of a TP *S. chameleon* (identified as TP *S. ghobban*) from Kerama Island, south-west Okinawa. Any specimens collected in northern or western Australia should be carefully checked to determine whether they are in fact *S. festivus*.

Scarus dimidiatus Bleeker

Plate 4I,J

Scarus dimidiatus Bleeker, 1859: 17 (type locality, Doreh, New Guinea).

Callyodon zonularis Jordan & Seale, 1906: 321, fig. 60 (type locality, Pago Pago, American Samoa).

Pseudoscarus caudifasciatus var. *zonularis* Gunther, 1909: 312, pl. 153, fig. B (Ponape).

Callyodon fumifrons Jordan & Seale, 1906: 326, pl. 34 (type locality, Pago Pago, American Samoa).

Material examined. One specimen, Heron Island, AMS I.15481-001; one specimen, Swain Reefs, QM I.11410; one specimen, Escape Reef, AMS I.22631-033; one specimen, Solomon Island, AMS I.15630-153; one specimen (juvenile), Lizard Island, AMS I.25785-002; one specimen (juvenile), Yonge Reef, AMS I.25912-006.

Diagnosis. Median predorsal scales 6 (rarely 5); rows of scales on cheek 3, upper row with 6-7 scales, middle row with 6-8 scales, lower row with 1-4 scales; pectoral rays 14; caudal fin slightly rounded to truncate; dental plates usually covered or nearly covered by lips; no canine teeth on sides of dental plates.

Colour pattern. IP: body yellowish, shading to whitish ventrally, with 5 slightly diagonal dark grey-brown bars on upper half of body which are broader than yellow interspaces: first at origin of dorsal fin extending onto nape where dark colour merges with

brown-grey of rest of upper half of head; the last, rather indistinct, dorsally on caudal peduncle; 3 whitish longitudinal lines on abdomen following centres of scale rows; broad near-horizontal band of dark brown extending posteriorly from eye to end of opercular membrane; head below this band, and a continuing demarcation from lower edge of eye to corner of mouth whitish with yellowish cast; dorsal fin pale yellowish grey, upper part of dark bars of body extending onto fin (bars more pronounced on scaled basal portion of fin than on unscaled); anal and pelvic fins whitish; caudal fin yellowish; pectoral fins with yellowish rays (more yellow dorsally than ventrally) and pale membranes. Juveniles coloured much like the initial phase but the ground colour generally a brighter yellow.

TP: upper part of head posterior to mid-interorbital space and anterodorsal part of body to base of seventh dorsal spine solid blue-green; rest of body (except thorax and abdomen which are primarily greenish) blue-green, edges of scales orangish; dark purplish brown band passing from eye to end of opercular membrane just above level of pectoral base; below and adjacent to this a salmon pink band, edged in blue-green, this band continuing in solid blue-green to corner of mouth where it expands to a broad area on front of snout and on chin; edge of upper lip narrowly salmon; dorsal part of snout above blue-green anterior area to mid-interorbital space lavender-grey; dorsal fin coloured like body on basal scaled portion, margin broadly blue, with broad middle zone of salmon bisected by green longitudinal band which may be broken into series of spots posteriorly; anal fin blue-green with longitudinal band of salmon to lavender just above green scaled basal portion; scaled basal portion of caudal fin coloured like body, unscaled part blue-green with four longitudinal streaks of salmon in central part of fin; pectoral fins blue-green with broad zone to dark purplish in central upper portion; pelvic fins light blue-green on lateral half and greyish lavender on medial half. Pair spawning has been observed at both Lizard and One Tree Islands. During spawning TP individuals show a number of modifications to the colour pattern. Upper anterior dorsum back to level of 7th dorsal spine usually dark blue-green, becoming lilac with yellow blotch below 8th spine; remainder of body blackish grey with pale greenish area on lower caudal peduncle; dark blotch on snout above eye, cheek paler, diagonal markings behind eye prominent; upper and lower lobes of caudal fin light grey. The initial phase show no differentiation during spawning. When spawning, TP colouration shows a number of similarities to spawning TP *S. schlegeli*.

Remarks. The IP of *S. dimidiatus* is very similar in colour to that of *Scarus scaber* Valenciennes. However the TP is distinct. Previous identifications of *S. scaber* from Great Barrier Reef waters all refer to IP *S. dimidiatus*. This species is similar to *S. oviceps* in terms of habitat associations, local distribution and abundance patterns. It is characteristic of sheltered areas but may make local migrations to the reef edge for spawning. In all areas of the Great Barrier Reef this species is

relatively rare, occurring singly or in small groups. It is not usually represented in museum collections or recognised in field surveys. *Scarus dimidiatus* has not yet been recorded from Western Australia, nor does it occur in the list of New Guinea species (Munro, 1967). A.M. Ayling, (pers. comm) observed the IP on Coral Sea reefs and noted that the colour pattern was paler than that seen in shelf reef individuals. Marshall (1965) listed a scarid from the Great Barrier Reef identified as *Callyodon mutabilis*. Schultz (1969) concluded that this record represented *S. scaber*, a western Indian Ocean species. Marshall's description is not detailed enough to allow identification of the scarid referred to as *S. mutabilis* although he may have been referring to *S. dimidiatus*. It is a moderately sized scarid with terminal males reaching 300 mm SL. Pair spawning has been observed at One Tree and Lizard Islands.

Scarus flavipectoralis Schultz

Plates 2I,J; 9I,J

Scarus flavipectoralis Schultz, 1958: 5, 31, 34, 52, pl. 9D (type locality, Luzon, Philippine Islands).

Material examined. Two specimens, One Tree Island, AMS I.15682-039, I.15684-034; one specimen Rib reef, QM I.7782; eight specimens Lizard Island, AMS I.19108-006, I.19442-005, I.19464-007, I.19469-006, I.19469-009; one specimen, Malatia, Solomon Islands, AMS I.15360-154; one specimen, Espiritu Santo, Solomon Islands, AMS I.17467-024; three specimens (juveniles), Lizard Island, AMS I.25787-001, I.25784-004; three specimens Heron Island not retained.

Diagnosis. Median predorsal scales 4, scales subequal, second scale largest; scale rows on cheek 3, upper row with 6-7 scales, middle row with 5-7 scales, lower row with 1-2 scales (2 specimens with no scales in third row on one side); pectoral rays 14; caudal fin truncate in initial phase (slightly rounded when fin is spread) to slightly lunate in terminal phase; lips nearly covering dental plates; terminal males with 1-2 upward-projecting canines posteriorly on lower dental plate, and 1 posteriorly on upper plate.

Colour pattern. IP: body grey to brown becoming lighter ventrally, head slightly darker, iris yellow, dental plates white; 2 indistinct whitish longitudinal streaks following scale rows on abdomen; dorsal fin yellowish with medial row of bluish spots and bluish distal margin; anal fin brownish grey becoming paler distally; caudal fin dark purplish grey; pelvic fins light bluish with grey leading edge; pectoral fins yellowish hyaline with distinct yellow base except for small dark spot at upper edge. Viewed underwater the initial phase is a uniform pale grey fish characterised by brownish to purple caudal fin and yellow pectoral fin.

TP: body bicoloured, anterior half orange-brown, thorax bluish brown, posterior half green with pink vertical bar on posterior body scales; mid-region of caudal peduncle yellowish, this becoming distinct yellow patch in reproductively active individuals; head brown to orange with broad horizontal green band from front

of snout through lower part of eye to end of opercle, narrow transverse green band on lower lip, broader green band on chin with series of green markings on throat, iris yellow; mid-ventral green band from isthmus to anus; dorsal fin light orange with median row of green spots, some joined anteriorly to form band, scaled basal portion green, margin blue; anal fin light orange with broad blue distal margin; caudal fin light orange with broad blue upper and lower margins and blue centrobasal area in unscaled part of fin; pectoral fins yellowish with distinct green band at base and blackish spot at upper proximal corner; pelvic fins pale orange with blue leading edge; dental plates white.

Remarks. *Scarus flavipectoralis* is characteristic of sheltered or deeper waters on the Great Barrier Reef. It is a relatively small scarid with terminal males rarely reaching 300 mm SL. The reproductive biology of this species is not well known. Pair spawning has been observed; the species is probably weakly diandric, with a small proportion of primary males. It is often seen in small groups at the reef-sand interface and frequently grazes algal material from the sand surface, often in association with *S. schlegeli*. Russ (1984b) described *S. flavipectoralis* as characteristic of back-reef areas on the mid-shelf reefs. It was also observed by A.M. Ayling in back-reef habitats in fish surveys of 12 northern outer-shelf reefs. This species was not observed on Coral Sea reefs during the extensive surveys of A.M. Ayling and D. Williams (pers. comm.). It has not been recorded from northern or western Australia. *Scarus flavipectoralis* appears to be restricted to the western and central Pacific extending to the northernmost Philippines and to the Great Barrier Reef in the south. Masuda et al. (1984) did not record this species from southern Japan.

Scarus forsteni (Bleeker)

Plates 5E,F; 6H; 10E,F

Pseudoscarus forsteni Bleeker, 1861: 238 (type locality, Celebes and Moluccas)

? *Callyodon laxtoni* Whitley, 1948: 94 (type locality, Ocean Island)

Scarus lepidus.—(not Jenyns, 1842) Schultz, 1958: 81, pl.15 C (in part); 1969: 27 pl.5 D (in part).

Scarus tricolor.—(not Bleeker, 1849) Randall & Choat, 1980: 396, figs.11-12 (in part).

Material examined. HOLOTYPE of *Callyodon laxtoni*, Ocean Island, AMS IB.1888; one specimen, One Tree Island, BPBM 14476; two specimens, Lizard Island, AMS IB.19455-017; two specimens, Malatia, Solomon Islands, AMS I.15360-155; one specimen (juvenile), Yonge Reef, AMS I.25908-001; one specimen, Myrmidon Reef, not retained. In addition 14 specimens of *S. forsteni* (BPBM 4770, 6130, 7141, 7143, 8925, 9215, 10896, 12949, 13033, 16597, 16704, 16839, 17123, 17152), and six specimens of *S. tricolor* (BPBM 7739, 7745, 7751, 21610) from western and central Pacific and Indian Ocean localities were examined.

Diagnosis. Median predorsal scales 6 or 7; 3 rows of

scales on cheek, 5–7 scales in dorsal row, 6–9 scales in middle row, and 2–5 in lower row; pectoral rays 14 rarely 13; TP and large IP individuals with 1–2 canines on upper dental plate; dental plates partially covered by lips; caudal fin of initial phase emarginate, of terminal phase strongly emarginate.

Colour pattern. Juvenile: body brownish with 3 dark longitudinal stripes, first from dorsum of head and body to posterior base of dorsal fin, second from tip of snout through eye to base of caudal fin, third from base of pectoral fin to base of caudal fin (this stripe may extend on to operculum); in life a white spot on side at pectoral fin tip; dark bar at pectoral base; upper and lower lips darker brown, brownish bar on chin extending to orbit; dorsal, anal, caudal and pelvic fins mottled brown and white becoming paler at outer margins; pectorals hyaline yellowish; dental plates white or greenish.

IP: body colour brownish red, becoming paler ventrally, broad longitudinal bluish band on side; in life white spot on side at pectoral tips, this spot sometimes dark bluish; caudal fin orange-red, dorsal fin light olive-brown to dull reddish; anal and pelvic fins light reddish to pink; pectoral fins light orange-red on upper half, pale on lower; dental plates white to pinkish.

TP: body greenish overall, scales of body green posteriorly, pink anteriorly, pink colour predominating on sides and ventral region of body, green on dorsal and posterior regions; green pigment on abdominal scales may be intensified to form 2 green longitudinal lines; head, isthmus and thorax blue-green, dorsal part of head above eye and on to nape violet in life, edges of lips pink then broadly blue-green, pink more prominent on upper lip; blue-green bar on chin; upper and lower margins of orbit blue-green, these lines not extending beyond orbit; dental plates blue-green; dorsal and anal fins with blue-green base, medial salmon pink stripe beginning near origin of these fins and broadening as it passes posteriorly; broad turquoise-blue distal margin to each fin; caudal fin with broad band of salmon pink in each lobe, this colour continuous across base of fin with blue-green markings in central region, outer and distal areas of caudal fin turquoise-blue; pectoral fin with broad turquoise band on upper rays and medial pinkish zone which joins pink at fin base, ventral rays paler; pelvic fins salmon pink with broad lateral margin of turquoise.

Remarks. *Scarus forsteni* was first described by Bleeker from material collected in the Indonesian Archipelago. This species was included with *S. tricolor* in the synonymy of *S. lepidus* by Schultz (1958, 1969). Randall & Choat (1980) demonstrated that the type of *S. lepidus* was in fact *S. globiceps*, and used the next available name, *S. tricolor*. *Scarus forsteni* was included in the synonymy of this species. The junior author subsequently observed that the illustrations of IP *S. lepidus* in Schultz (1969: pl. 5 D,E) represented two different species, *S. forsteni* (5 D) and *S. tricolor* (5 E). The IP of *S. tricolor* is distinctive in life with the head, thorax and dorsum black, and black edges to the scales

in the broad blue band on the side. This persists in preservative as blackish. *Scarus tricolor* is more slender with a slightly pointed snout. Preserved IP specimens are difficult to distinguish from *S. forsteni*. TP individuals may be distinguished by the markings on the head and fins. In *S. forsteni* the upper margin of the orbit is marked by a short green bar which extends only slightly anterior to the orbit. *Scarus tricolor* has a long band through the top of the eye and a more distinctive lower orbital bar running to the upper lip. The turquoise-blue fin markings are more extensive in *S. forsteni*, covering the upper third of the pectoral fin, the outer half of the spinous dorsal and anal fin, and anterior third of the pelvic. *Scarus tricolor* has only a narrow band along the upper four rays of the pectoral with a narrow transverse blue bar at the base; the blue margins of the dorsal anal and pelvic fins are all narrower than in *S. forsteni*. Vertical fin pigmentation appears to be the best criterion for distinguishing the terminal phases of these species. The caudal fin in *S. tricolor* is strongly lunate.

The illustrations in Randall & Choat (1980: figs 11–12) are both of *S. forsteni*. Randall & Bruce (1983 pl. 5G,H) show *S. tricolor*. Both species have overlapping distributions in the western Pacific (*S. tricolor* appears to be rarer in the Pacific), the Phillipines and Indonesia but only *S. tricolor* extends into the Indian Ocean. Masuda et al. (1984) show both phases of *S. forsteni*. At the time of writing only *S. forsteni* has been recorded from the Great Barrier Reef although the distribution patterns (both species are present in the Phillipines and Indonesia) make it likely that increased Australian collecting will also reveal *S. tricolor*.

Callyodon elerae Jordan & Seale (1907: fig. 11) previously included in the synonymy of *S. tricolor* appears from snout and fin markings to represent TP specimen of that species. The type of *Callyodon laxtoni* was examined in the Australian Museum and is a moderately large (230 mm SL) scarid with no obvious colour pattern features remaining. There is no evidence of the blackish body shades characteristic of preserved IP *S. tricolor*. The meristic characters, body shape and emarginate caudal fin strongly suggest an IP *S. forsteni* and *C. laxtoni* is tentatively placed in the synonymy of this species.

This species was never common at any site sampled on the Great Barrier Reef. Most specimens were seen on the slopes and crests of outer-shelf reefs as solitary individuals or in pairs. It extends into deeper water (30 m). A.M. Ayling observed a few individuals at Herald Cay in the Coral Sea. Apart from an observation of pair spawning at One Tree Island nothing is known of the reproductive biology.

Scarus frenatus Lacepède

Plates 5C,D; 6J; 10H,I

Scarus frenatus Lacepède, 1802: 3, 13, pl. 1, fig. 1 (type locality, Mauritius)

Scarus sexvittatus Ruppell, 1835: 26 (type locality, Jeddah).
Callyodon upolepis Jordan & Seale, 1906: 319, fig. 59 (type locality, Apia, Western Samoa)

Callyodon vermiculatus Fowler & Bean, 1928: 472, pl. 49 (type locality, Philippine Islands)

Scarus randalli Schultz, 1958: 46, 97, pl. 19 C, text-fig. 20 (type locality, Onotoa Atoll, Gilbert Islands).

Material examined. One specimen, Heron Island, AMS I.15500-001; five specimens, One Tree Island, AMS I.17445-136, I.20572-013; one specimen, Swain Reefs, AMS IB.2741; one specimen, Great Barrier Reef, QM I.14893; one specimen, Broadhurst Reef, QM I.10355; one specimen, Coral Bay, Western Australia, WAM P.23033; three specimens (juveniles), Lizard Island, I.25799-002, I.25914-001, I.25786-002; three specimens (juveniles), Yonge Reef, AMS I.25912-001, I.25912-002; 24 specimens, Heron Island, not retained; four specimens, Lizard Island, not retained.

Diagnosis. Median predorsal scales 6–7, often two small scales anterior to first median predorsal, scales subequal, 4th or 5th largest; 3 rows of cheek scales, 6–7 scales in upper row, 6–8 scales in middle row, 2–4 scales in lower row; pectoral rays 14–15; mouth slightly inferior with lips covering most of dental plates, 0–1 canines on sides of upper dental plate; caudal truncate in smaller individuals, becoming double emarginate in larger.

Colour pattern. Juvenile: reddish brown anteriorly, darker on dorsum, caudal peduncle abruptly pale white to greenish white, thorax yellowish brown; head dark brown, dark band from snout through eye, cheek below this band pale reddish yellow; dorsal and anal fins with prominent reddish and white reticulated markings, these becoming fainter posteriorly; caudal fin whitish; pectorals hyaline brownish, pelvic light red.

IP: body brownish yellow to light red, dorsum and caudal peduncle whitish yellow; 5 dark brown stripes on side of body following centres of scale rows; fainter 6th ventral row; body scales yellowish, edged with black; head pale reddish, lighter on occiput, darker on snout, cheek and chin, dental plates white, iris orange-yellow; dorsal, anal and pelvic fins reddish; pectoral light hyaline reddish; caudal light red. Coleman (1981) has provided an excellent colour illustration of an IP *S. frenatus*.

TP: body bright green, scales of body anterior to 5th dorsal ray with orange-red vermiculations; dorsum of body and caudal peduncle abruptly lighter green; occiput and upper snout green with dense mass of orange-red vermiculations; cheek lighter green with fainter orange-red markings; tip of snout light green; upper lip orange to pink; two broad orange bands on chin, iris orange; dental plates blue-green; dorsal and anal fins with green bases, blue-green distal margins and broad medial orange-red areas marked with blue-green spots and lines; caudal fin green, basal area darker green, upper and lower lobes of caudal fin with submarginal orange-red lines, central portion of fin with short orange-red lines; pectoral fins with light green upper rays, an orange-red central region, and blue-green ventral portion; pelvic fins orange-red with blue-green

anterior margin. Viewed underwater, this phase often appears as a dark green scarid with an abruptly lighter green caudal peduncle.

Remarks. *Scarus frenatus* is a wide-ranging scarid recorded from the Red Sea and extending eastwards to French Polynesia and the Pitcairn Group. In the western Pacific it ranges from the Ryukyu Islands in the north to Lord Howe Island in the south. On the Great Barrier Reef it is common on mid- and outer-shelf reefs and is moderately common on Coral Sea reefs. This species has been collected from West Australian localities. Previous records of this species from Australia have been identified as *S. sexvittatus* or *S. vermiculatus*. Surprisingly, Munro (1967) did not record it from New Guinea waters.

This species is essentially a reef-crest scarid, occurring in small groups, often associated with crevices and inlets in the reef front. It is frequently aggressive toward other species of scarids. Notes on the taxonomic status of the colour phases of this species are provided by Randall (1963) and Randall & Bruce (1983). Choat & Robertson (1975) described the sexual identity and colour phase of a large sample of this species from Heron Island. Spawning has been observed in the pair mode which may occur above a male's territory or at specific sites reached by local migration. At outer barrier reef locations larger groups (up to 40) of IP individuals may assemble for spawning. TP males do not show colour modifications while spawning. A very small proportion of primary males are present in the IP population. A moderately large scarid with terminal males reaching 330 mm S.L.

Scarus frontalis Valenciennes

Plates 5B; 9A

Scarus frontalis Valenciennes in Cuvier & Valenciennes, 1840: 280 [type locality, Oualan (= Kosrae) Caroline Islands]
Pseudoscarus jonesi Streets, 1877: 80 (type locality, Palmyra Island)

Scarus jonesi.—Schultz, 1958: 72, pl. 13 A, fig. 12.

Diagnosis. (based on central Pacific material) 4 median predorsal scales, 2 rows of cheek scales with 6 scales in each row; pectoral rays 15; mouth terminal, dental plates exposed; adults with 2–3 canines on upper dental plate; dorsal profile of snout steep, with break in contour in anterior interorbital space; caudal fin rounded in juveniles, subtruncate in subadults and emarginate to lunate in adults.

Colour pattern. This species is essentially monochromatic.

Adult colouration: body blue-green with salmon pink to purplish bar on each scale; caudal peduncle may be lighter green; head blue-green, corner of mouth salmon pink to orange; chin with broad irregular salmon pink band; broad irregular pale salmon band or blotches on throat; two narrow salmon pink postorbital bands; interorbital region with irregular broad salmon pink

band which curves on to snout; iris yellow; dorsal and anal fins orange with green markings, outer margin blue-green, the basal scaled part green; caudal fin blue-green, central unscaled region with orange longitudinal markings; pectoral fins blue-green with orange to purplish zone in upper half of fin (dorsal margin blue-green); dental plates white, often with algae growing basally.

Smaller individuals lighter green with orange scale markings not so conspicuous; caudal peduncle light yellowish green. Adult males tend to lose intensity of salmon pink or orange markings on head and body; on some large males markings may be lost, most persistent being the one at corner of mouth.

Remarks. We have no museum specimens of this parrotfish from Australia, but a colour photograph of one measuring 350 mm SL collected by the senior author at Heron Island in 1967 provides positive identification. Unfortunately, the specimen was lost after preservation and storage. An individual approximately 250 mm SL was observed and identified independently at Lizard Island in December 1983 by the senior author and D. Bellwood. A.M. Ayling (pers. comm.) observed and provided colour notes on about twelve specimens of *S. frontalis* on northern Coral Sea reefs in November 1983. This species is easily mistaken for *S. gibbus* because it is similar in colour pattern and adult males develop the same steep dorsal profile of the head as seen in *S. gibbus*.

This species has been previously identified in the literature as *Scarus jonesi* (Streets). Randall and Bruce (1983) have shown this to be a synonym of *S. frontalis*.

Scarus ghobban Forsskål

Plates 5G,H; 10D

Scarus ghobban Forsskål, 1775: 28 (type locality, Jeddah, Red Sea).

Scarus guttatus Bloch & Schneider, 1801: 294 (type locality, Indian Seas).

Scarus maculosus Lacepède, 1802: 5, 21, pl. 1, fig. 3 (type locality, Indian Ocean).

Scarus pepo J.W. Bennett, 1834: 28, fig. 28 (type locality, Ceylon).

Scarus scabriusculus Valenciennes in Cuvier & Valenciennes, 1840: 271 (type locality, Java).

Scarus lacerta Valenciennes in Cuvier & Valenciennes, 1840: 217 (type locality, Pondicherry, India).

Scarus Dussumieri Valenciennes in Cuvier & Valenciennes, 1840: 252 (type locality, Seychelles).

Hemistoma reticulata Swainson, 1839: 226 (based on *Scarus pepo* Bennett).

Scarus pyrrostethus Richardson, 1846: 262 (type locality, Canton, China).

Scarus haridoides Bleeker, 1855a: 344 (type locality, Batavia and Duizend Islands).

Pseudoscarus Cantori Bleeker, 1861: 240 (type localities, Java, Sumatra, Celebes, Ambon, Timor, and Pinang).

Pseudoscarus nudirostris Alleyne & Macleay, 1877: 346, pl. xvii, fig. 1 (type locality, Cape Grenville, Holotype AMS

I.16376-001).

Pseudoscarus flavipinnis De Vis, 1885: 886 (type locality, Cape York, Holotype QM I.11/83).

Pseudoscarus californiensis Pellegrin, 1901: 163 (type locality, La Paz, Gulf of California).

Scarus noyesi Heller & Snodgrass, 1903: 206, pl. 9 (type locality, Tagus Cove, Isla Isabela, Galapagos Islands).

Pseudoscarus garretti Gunther, 1909: 306, pl. 153, fig. C (type locality, Gilbert Islands).

Pseudoscarus natalensis Gilchrist & Thompson, 1909: 259 (type locality, Natal).

Scarus pyrrostethus australianus Paradice in Paradice & Whitley, 1927: 103 (type locality, Cape Wessel, Northern Australia, Holotype AMS IA. 1669).

Scarus azureus Meek & Hildebrand, 1928: 742, pl. 72, fig. 1 (type locality, Panama City market, Panama).

Callyodon toshi Whitley, 1933: 61 (type locality, Southport, Queensland, Syntypes (3) QM I. 14/1634-5).

Callyodon speigleri Smith, 1956: 10, 14 (based on *Scarus dussumieri* Valenciennes, as described and illustrated by Bleeker, 1862).

Callyodon apridentatus Smith, 1956: 14, pl. 44 F (type locality, Malindi, Kenya).

Scarus fehlmanni Schultz, 1969: 24, fig. 2 (type locality, Strait of Jubal, Red Sea).

Material examined. HOLOTYPE of *Pseudoscarus flavipinnis* De Vis, QM I.11/83. HOLOTYPE of *Pseudoscarus nudirostris* Alleyne & Macleay, AMS I.16376-001. HOLOTYPE of *Scarus pyrrostethus australis* Paradice & Whitley, AMS IA.1669. Eight specimens, Paisley Bay, Sydney Harbour, AMS I.18330-001, I.19103-057; one specimen, Tweed Heads, AMS I.16534-001; one specimen, Moreton Bay, QM I.6579; one specimen, Southport, QM I.1633; one specimen, Cowen, QM I.4360; three specimens, One Tree Island, AMS I. 15679-036; two specimens, Townsville, QM I.6971, I.7006; one specimen, Northwest Shelf, AMS I.22802-018; one specimen (juvenile), Lizard Island, AMS 25903-003; two specimens, Rowley Shoals, Western Australia, WAM P.25595-003; two specimens, Monte Bello Islands, WAM P.25354-041, P.25354-055; two specimens, Lacepede Island, Western Australia, WAM P.27671-015; one specimen, Rocky Bay, Western Australia, WAM P. 026615-001; two specimens, Rottne Island, WAM P.25730-001; fourteen specimens from Heron and One Tree Islands, not retained.

Diagnosis. Median predorsal scales nearly always 6, 4th scale largest; 2 small unpaired scales anterior to first scale; 3 rows of scales on cheek, upper row with 6-7 scales, rarely 5, middle row with 5-7 scales, lower row with 1-3 scales; pectoral rays 15, rarely 14 or 16; lips covering three quarters of dental plates; dental plates white to pink; large specimens with 1-3 canines on upper dental plate; posterior nostril 2-5 times larger than anterior, caudal fin emarginate in juvenile and small specimens, lunate in large specimens.

Colour pattern. Juvenile: body and median fins light grey overall; 5 diffuse blue bands on dorsum not extending to ventral mid-line; first band below 2nd and 3rd dorsal spines and last on caudal peduncle; distal margins of the dorsal, anal, outer margins of caudal, upper 2 rays of pectoral and anterior margin of pelvic fins light blue; snout and chin each with faint blue bar; blue band extending from corner of mouth a short distance diagonally downward, then curving upward to

below orbit and passing a short distance behind; short blue band through upper margin of eye; short blue band from posterior margin of orbit. In life the general impression is of a light grey scarid with slightly acute snout; blue bars appear as an intensification of blue on dorsal scales when viewed under strong lighting. Pattern of blue markings on snout and chin may be seen in some preserved specimens. In specimens from inshore areas, body colouration may be yellowish.

IP: body light yellow to orangish overall, becoming paler ventrally; individual body scales bluish, edges yellow to orange-yellow; 5 distinct irregular blue bars formed from intensification of blue on scales within bars, these usually 2 scale rows in width and distributed as follows: first beneath 2nd and 3rd dorsal spines, 2nd beneath 9th spine and 1st dorsal ray, 3rd beneath 4th and 5th dorsal rays, 4th beneath 9th and 10th dorsal rays, 5th across caudal peduncle; bars intensified on dorsum but usually not extending below body mid-line; head light yellowish; broad blue bar across snout and chin with irregular blue spots on throat; blue line from mouth to orbit and lines around orbit as in juveniles; dental plates white; usually 2 pale streaks on abdomen extending from base of pectoral to origin of anal fin; median fins blue basally, orange centrally with blue outer margins; caudal orange-yellow with broad blue upper and lower margins; pectoral pale yellow with upper margin blue; pelvic fins yellow-white with blue anterior margin. Position of blue transverse bars and blue chin and snout markings detectable in preserved specimens.

TP: dorsum of head and body green, each scale narrowly edged with salmon pink or orange; green becoming progressively reduced ventrally resulting in pinkish caste to sides and ventral region of body; cheek and operculum pale orange; chin throat and isthmus blue-green; upper lip orange with green band on snout; lower lip orange followed by green bar; chin with irregular series of green bars; green markings from mouth to orbit, and surrounding orbit as in blue markings of IP, interspaces between postorbital bars pink; median fins orange to pink with broad blue-green distal margin and green base; caudal fin green with band of salmon pink in each lobe; pectoral fins blue-green with broad orange to pink streak extending from mid-base to tips of longest rays; dark spot at upper pectoral base; pelvic fins salmon pink with broad blue anterior margin; dental plates pinkish, white at edges. Underwater, lateral pinkish area of body with green of dorsum, and green and pink head markings are striking characteristics. Green markings remain distinct when preserved. Colour illustrations of *S.gobban* are provided by Grant (1982, IP) and Coleman (1981, IP and TP).

Remarks. *Scarus gobban* has a very wide geographical range and occupies a variety of habitats. It occurs from the Red Sea to the Pacific coast of the tropical Americas (Randall & Bruce, 1983). In Australia *S.gobban* extends into temperate waters and is the commonest scarid in museum collections from Sydney

Harbour on the east coast and from Rottneest Island on the west coast. It is also characteristic of a variety of tropical non-reef environments, including shallow mangrove and seagrass areas (Blaber et al., 1985), as well as deeper water habitats sampled by trawling. *Scarus gobban* is the only scarid regularly collected during trawling operations on the Australian north-west shelf (J.Paxton, pers. comm.).

Observations on northern reefs by the senior author suggest that this species differs from most congeners in that it is not typically a reef associated scarid. At Lizard Island large individuals were uncommon on reefs, which were used mainly as spawning sites. After spawning on deep reef fronts, large TP and IP individuals were observed to move back out over surrounding seagrass and algal beds in water greater than 30m depth.

Probably because of its wide-ranging distribution and occurrence in inshore habitats this species is prominently represented in early Australian collections of fishes. This has resulted in a complex synonymy for *S.gobban*. *Pseudoscarus nudirostris* (Alleyne & Macleay) and *P.flavipinnis* (De Vis) were not assigned identities by Schultz (1969) in his review. Types of both species are lodged in the Queensland and Australian Museum respectively: both proved to be *Scarus gobban*. Examination of the type of *Scarus pyrrhostethus australianus* (Paradice) confirmed the identification reported by Randall & Bruce (1983) as *S.gobban*.

The identity of *Callyodon toshi* Whitley is more problematical. Schultz (1958) initially concluded that *C.toshi* was unidentifiable but later (Schultz, 1969) included it erroneously in the synonymy of *Scarus harid*. Tosh (1903) provided a brief description and a figure of a scarid from Southport, Queensland identified as *Heteroscarus* sp. This material was apparently deposited in the Queensland Museum and later identified as *Callyodon cyanotaenia* (Bleeker) by Ogilby (1915). He noted that there were three examples of this species in the Queensland Museum collected by Tosh at Southport. Whitley (1933), after comparing the figure in Tosh (1903) with Bleeker's description of *Scarus cyanotaenia*, concluded that Tosh had figured an undescribed species and proposed the name *Scarus toshi*. No type of *Scarus toshi* was designated. Three small scarids (82–85 mm SL) collected by Tosh at Southport in 1901, deposited in the Queensland Museum and later registered (I.14/1634-5, 1913) and identified by Ogilby (1915) as *Callyodon cyanotaenia*, were examined by the senior author in the Queensland Museum. All proved to be juveniles of *S.gobban*. In addition, the illustration of *Heteroscarus* sp. in Tosh (1903) strongly suggests this species. Other examples of scarids in the Queensland Museum identified as *S.cyanotaenia* also proved to be *S.gobban*. Material in the Australian Museum identified as *S.toshi* proved to be *S.gobban* or in the case of Whitley (1966: fig.3), *Scarus psittacus*. No candidate for the type of *Scarus toshi* could be located in the Australian Museum. The specimens collected by Tosh at Southport and later deposited in the Queensland Museum must represent the

material on which the description of *Heteroscarus* sp. was based, and are therefore syntypes of *Scarus toshi* Whitley.

Scarus gibbus Rüppell
Plates 2C,D; 6C; 7A,B.

Scarus gibbus Rüppell, 1828: 81, pl.20, fig. 2 (type locality, Mohila, Red Sea).

Scarus microrhinos Bleeker, 1854b: 200 (type locality, Batavia).

Scarus strongylocephalus Bleeker, 1854d: 439 (type locality, Batavia).

Pseudoscarus microcheilos Bleeker, 1861: 231 (type locality, Java).

Callyodon ultramarinus Jordan & Seale in Seale, 1906: 63 (type locality, Samoa).

Material examined. One specimen, Heron Island, AMS I.15504-001; two specimens, Lizard Island, AMS I.19445-016, I.19464-005; three specimens, Swain Reefs, QM I.12732, I.19146, I.16005; one specimen, Rowley Shoals, WAM P.27654-030; four specimens (juveniles), Lizard Island, AMS I.25782-003, I.25905-001, I.25909-002, I.25913-001; 25 specimens Heron Island & One Tree Island not retained.

Diagnosis. Median predorsal scales 4; scale rows on cheek 3, upper and middle rows 5–7 scales, lower row with 3–8 scales (usually 5–6); pectoral rays 16; caudal fin varying from emarginate in subadults to highly lunate in adults; dental plates broadly exposed, 1–2 canines on upper dental plate, none on lower; small adults develop prominence on forehead at level of eye; with growth this develops into a vertical profile.

Colour pattern. Juvenile (20–80 mm): body dark brown to black with 3 longitudinal whitish stripes, first from eye to end of dorsal fin, 2nd from below eye across cheek to base of caudal fin, 3rd across lower margin of cheek, through pectoral base to posterior end of anal fin; dorsal, anal and caudal fins dark brown; posterior margin of caudal fin whitish; pectoral fins hyaline with yellowish base; dental plates whitish.

Between 80 and 150 mm most Great Barrier Reef juveniles uniform blackish brown with whitish dental plates and pale crescentic region on caudal fin.

Green phase (150–280 mm): body dark green with narrow brown to orange bar on each dorsal scale; abdomen and thorax paler (on southern reefs 2 darker green abdominal bars may be present); caudal peduncle light green flecks; snout and sides of head below eye brownish to dark purple; eye rim blue-green, often with two short postorbital bars, upper lip green, lower lip and chin with extensive green blotch which extends into broad irregular green band passing horizontally across cheek and continuing dorsally on margin of opercular membrane; cheek below this line paler; dorsal and anal fins reddish brown with posterior medial light green line, caudal greenish with vertical reddish brown bar and darker posterior margin; pectorals greenish; pelvics reddish brown with lighter margin; dental plates whitish green, becoming darker with increase in size.

Green Phase (> 300 mm): body light green to bluish green with narrow orange to rose bar on each scale; body becoming pale bluish green on abdomen and thorax; caudal peduncle lighter green; sides of body light pinkish; occiput blue-green, sides of head and snout purple, this becoming strongly developed in large male specimens; eye rimmed with blue-green; upper lip bounded by thin blue-green line, lower lip and chin with large blue-green blotch which extends horizontally across cheek as a characteristic irregular green band which continues dorsoposteriorly on opercular membrane; cheek below this line abruptly pale yellowish; dorsal and anal fins orange with blue-green basal and distal margins; anal fin with medial green band of variable length in soft portion; caudal fin green to blue-green with broad zone of purplish to dull rose in each lobe connecting across basal unscaled portion with markings of same colour; pectoral fins purplish green becoming hyaline distally and ventrally, upper edge blue-green; pelvic fins orange to pink, margins broadly blue-green; dental plates green, whitish at margins, iris blue-green. In alcohol-preserved specimens the green pigment, including horizontal cheek band, remains prominent.

These descriptions refer to Great Barrier Reef material. A preserved green-phase specimen from the West Australian museum collection, (P.27654-030; Rowley Shoals) displayed green pigmentation on head region, including horizontal cheek band similar to Great Barrier Reef specimens.

In life, colouration of snout and sides of head in large individuals may vary from purple to light brownish quite rapidly; in Great Barrier Reef specimens there is no evidence of the salmon pink margin to the upper lip as seen in central Pacific specimens.

Red phase (observed developing at approximately 100 mm): dorsum of head and body to mid-line light red, below this light yellowish; cheek below line from corner of mouth to pectoral base abruptly paler; upper lip with distinct yellow margin, lower lip with paler yellow margin; basic head colouration pattern corresponding to that seen in the green phase; dorsal, anal, caudal and pectoral fins uniform pale yellowish, in large specimens outer margins of dorsal and anal fins greenish; pelvics yellow with greenish lateral margin; dental plates green; iris yellow. Alcohol-preserved specimens retain reddish pigment and are readily distinguished from green-phase individuals.

Remarks. Schultz (1958) erroneously placed *S.gibbus* in the synonymy of *Bolbometapon muricatum*; he also considered *S.strongylocephalus* and *S.microcheilus* as junior synonyms of *S.microrhinos* and thus included western Indian Ocean, Indo-West and central Pacific populations under the name *S.microrhinos*.

Smith (1959) clarified the status of *S.gibbus* and recognized it as one of three distinct species in the 'gibbus' complex. He distinguished these from other scarinine parrotfishes with the erection of the genus *Chlorurus*. *Scarus gibbus* and *S.strongylocephalus* were identified as Red Sea and Indian Ocean species

repectively, and *S.microrhinos* as western and central Pacific. Smith considered that the species described by Bleeker as *S.microcheilus* was the female and junior synonym of *S.strongylocephalus*.

Schultz (1969) reviewed a number of problems of scarid taxonomy including the species of the 'gibbus' complex. After comparing structural, meristic and colouration characteristics among *S.gibbus*, *S.microrhinos* and *S.strongylocephalus* he placed all within the synonymy of *S.gibbus*. He also saw no justification for separate generic status for *S.gibbus*. The genus *Chlorurus* was therefore placed in the synonymy of *Scarus*.

Scarus gibbus is a member of a complex of large, deep-bodied scarids with four median predorsal scales, 16 pectoral rays and characterised by a highly convex snout profile, exposed dental plates, and lunate caudal fins. This complex has a broad geographical distribution, extending from the Red Sea, through the Indian Ocean, the Indonesian Archipelago to the western and central Pacific. The recent taxonomic history of this complex is confused. At present a number of populations which may be differentiated on the basis of colour pattern are combined within a single taxon, *Scarus gibbus* Rüppell, following Schultz (1969).

Three nominal species are of interest here: *Scarus gibbus* Rüppell, 1828, *Scarus strongylocephalus* Bleeker, 1854, and *Scarus microrhinos* Bleeker, 1854. The geographical distribution of this complex is similar to that seen in other scarid species; there are distinctive populations in the Red Sea, the Indian Ocean, and the central and west Pacific. The Red Sea populations (from which the type of *S.gibbus* was collected) are distinct from those of the central and west Pacific in several features of colouration (Smith, 1959; Randall & Choat, 1980; Randall & Bruce, 1983). Those members of the *S.gibbus* complex occurring in the western and central Pacific have been identified in earlier works as *S.microrhinos*. The Indian Ocean populations show similarities with the scarid described by Bleeker as *S.strongylocephalus*.

Information available to date does not allow a formal statement about the biological status of the three populations of *Scarus gibbus*. Although the Red Sea and Pacific populations are distinct in terms of colour, the Indian Ocean population shows a considerable degree of overlap with the others. In addition, the unusual pattern of colour phases seen in some populations of *S.gibbus* (Randall & Choat, 1980) suggests the relationship between colour, sexual identity and reproductive behaviour is likely to be complex and possibly different from other scarids. Until more material is available, especially from the Indian Ocean, and there is a better understanding of the reproductive biology of *S.gibbus*, we will follow other workers and provisionally recognize a single taxon, *S.gibbus*.

Scarus gibbus has a wide distribution in Australian waters, being found the entire length of the Great Barrier Reef and extending into Western Australian waters. A juvenile was observed and photographed in

a subtropical reef environment in Western Australia (Rottneest Island; B Hutchins pers. comm.). It occupies a variety of habitats, being recorded from inshore reefs to the Coral Sea. It is a conspicuous member of the Great Barrier Reef scarid fauna, being characteristic of reef crests and adjacent reef flats where it often grazes in small schools. This is one of the larger scarids with a maximum size from Australian collections of 421 mm SL. A major source of interest in *S.gibbus* is the atypical pattern of colour variation with red and green phases occupying a similar size range rather than the usual sequential size-related patterns of colour change. Many individuals in the green colour phase were found to be females. Fourteen green phase specimens from Heron Island, ranging from 120 to 400 mm SL, which were examined histologically proved to be females. In almost all other scarids, individuals with predominantly green colouration have been found to be males. The status of the red phase is discussed by Randall & Choat (1980).

Scarus globiceps Valenciennes

Plates 4E,F; 11B,C

Scarus globiceps Valenciennes in Cuvier & Valenciennes, 1840: 242 (type locality, Tahiti).

Scarus lepidus Jenyns, 1842: 108 (type locality, Tahiti).

Pseudoscarus spilonotus Kner, 1868: 352, pl.9, fig.26 (type locality, Fiji Islands).

? *Pseudoscarus strigipinnis* De Vis, 1885: 886 (type locality, Cardwell, Queensland, Holotype QM I.963).

Pseudoscarus fuscus De Vis, 1885: 887 (type locality, Barrier Reef, Holotype QM I.41).

Scarus pronus Fowler, 1899: 490, pl.18, fig.3 (type locality, Caroline Atoll)

Material examined. HOLOTYPE of *Pseudoscarus fuscus* De Vis, QM I.41. HOLOTYPE of *Pseudoscarus strigipinnis* De Vis, QM I.963. Ten specimens, One Tree Island, AMS I.15686-027, I.17445-137, I.19445-014, I.20464-016; one specimen, Lord Howe Island, AMS I.17357-018; one specimen, Heron Island, QM I.11964; two specimens, Hopkinson Reef, QM I.6007, I.6008; one specimen, Trunk Reef, QM I.6622; one specimen, Rowley Shoals, Western Australia, WAM P.27667-014; 70 specimens Heron and Wistari Reefs, not retained; nine specimens, One Tree Island, not retained; nine specimens, Lizard Island, not retained.

Diagnosis. Median predorsal scales 5-6, rarely 7, subequal, 3rd or 4th scale largest; in specimens with 5 scales, usually a small pair of scales anterior to first; 3 rows of cheek scales, upper row with 5-7 scales, middle row with 6-8, rarely 9 scales, lower row with 1-4 scales; pectoral rays 14; lips covering or nearly covering dental plates; dental plates white; IP fish with no canines on dental plates, TP with 1-2 canines on upper and lower dental plates (small TP individuals may lack canines); caudal fin truncate in IP, double emarginate in TP, in some individuals lobes produced to form lunate caudal fin; dorsal profile of head of TP fish with slight hump in upper interorbital space.

Colour pattern. IP: body colour varies from light grey to dark brown overall, becoming lighter ventrally; 3 pale

lines on abdomen following centres of scale rows, upper 2 most prominent; dorsal fin brownish grey with blue-grey distal margin; anal and pelvic fins reddish brown; caudal fin brownish, distal region paler; pectoral fin brownish becoming paler ventrally, dusky spot at pectoral base; upper region of iris blue in life. In feeding schools, especially in shallow water, body usually light grey overall; in smaller groups or solitary, especially in deeper water, body dark brown or grey with reddish fins, with prominent pale margin to caudal fin. Some individuals with 6–7 indistinct pale blotches along dorsum (Fig.5). Dark body colouration characteristic of individuals prior to group spawning. During group spawning, primary males dusky grey with grey horizontal interorbital band, corresponding to blue-green band in the TP; females either uniform dusky grey or with indistinct dusky transverse bands. Juvenile specimens (smaller than 25 mm) often with series of dark longitudinal bands. On preservation, body and fins uniform greyish brown with the pale longitudinal abdominal bands often visible.

TP: green overall; body scales each with pink to orange bar; abdominal scales with coalescent green pigment forming 3 longitudinal bands along the scale centres; thorax and posterior caudal peduncle uniform green; numerous small green spots on head and anterodorsal region of body; head with narrow green bands radiating from orbit (except ventrally); horizontal pink band passing anteriorly from eye across front of snout, this band extending posterior to orbit across operculum; head below band light green, especially on cheek; front of snout and upper lip blue-green; dorsal and anal fins with broad blue-green basal band, broad median band of orange, and blue border; soft dorsal fin with median row of green spots; small dark spot on dorsal fin near base of 4th dorsal spine; caudal fin green, usually with submarginal streak of orange on each lobe; pectoral fins blue-green, darker dorsally, longitudinal orange streak along upper third of fin, dark spot on upper pectoral base; pelvic fins salmon pink with blue lateral border. Green markings and position of horizontal interorbital band prominent in preserved specimens.

Remarks. De Vis (1885) described *Pseudoscarus strigipinnis* from a fish 6 inches in total length from Cardwell, Queensland. He reported it as having 3 rows of scales on the cheeks, the lowest of 5 scales, 14 pectoral rays, and a truncate caudal fin. He provided the following colour notes: 'Grey clouded with darker grey. Fins black, the caudal with alternating white longitudinal stripes equally the black intervals in breadth. Dorsal, anal and pectoral, with irregular white lines and streaks in the direction of the rays. All the white streaks appearing as if laid on with pigment.' The holotype is in the Queensland Museum (QM I.963, 127 mm SL). It is stuffed, uniform dark brown and in poor condition. We can confirm that there are 14 pectoral rays. We count 4 scales in the third (lowermost) row on the cheek on the right side, and there appear to have

been three on the left side. There are 6 median predorsal scales (though damage to the nape does not rule out the possibility of a seventh scale). Of the species of *Scarus* which are known to occur in Queensland waters, there are seven which share these meristic characters: *S.globiceps*, *S.rivulatus*, *S.oviceps*, *S.dimidiatus*, *S.forsteni*, *S.frenatus* and *S.niger*. None at any size have the colour pattern as described by De Vis. We tentatively place *P.strigipinnis* in the synonymy of *S.globiceps*. Our observations suggest that both *S.rivulatus* and *S.globiceps* might be found in the Cardwell area. The other species are more characteristic of outer reef areas. The cheek scale counts are consistent with *S.globiceps*.

The type of *Pseudoscarus fuscus* De Vis (1885) (QM I.41, 208 mm SL) is also present as a stuffed and mounted specimen in the Queensland Museum. It is now uniform dark brown with some disintegration of the caudal fin but all scales are detectable. There is a nuchal hump. De Vis recorded 2 rows of scales on the cheek but the type has 3 rows with 2 scales in the third row. The type has 6 median predorsal scales and 14 pectoral rays; there are two canines on the lower dental plate. This combination of characters (especially the canine teeth) suggests *S.globiceps* TP. A TP individual correctly identified as *S.globiceps* in the Queensland Museum (I. 11964) also shows a similar nuchal hump. *Pseudoscarus fuscus* is placed in the synonymy of *S.globiceps*. The colour note of De Vis, 'uniform brownish olive' probably refers to the preserved condition.

Grant (1982) provided colour photos of *S.globiceps* identified as the male and female colour phases. Both are of TP males.

IP individuals have proved difficult to differentiate from those of *S.rivulatus* during underwater observation and in preserved collections (Randall & Choat, 1980). Additional material to assist in differentiation is discussed in the Remarks section of *S.rivulatus*.

Scarus globiceps is a widespread species in the Indian Ocean and tropical western and central Pacific. It is common on reef crests and fronts in mid- and outer-shelf reefs in the Great Barrier Reef region, and is present on western Australian reefs. Museum and observational records suggests that it does not occur in inshore non-reef areas or extend into temperate environments. *Scarus globiceps* consistently assembles in large numbers (20–30 per spawning run) for group spawnings, such groups being characterised by a high proportion of primary males (Choat & Robertson, 1975; Randall & Choat, 1980). Sampling of *S.globiceps* populations in non-spawning situations has revealed a consistently high proportion of primary males in the initial colour phase. This species is a relatively small scarid, with TP males not usually exceeding 250 mm SL.

Scarus longipinnis Randall & Choat
Plates 3E,F; 7J

Scarus longipinnis Randall & Choat, 1980: 414, figs 32, 33 (type locality, Pitcairn Island).

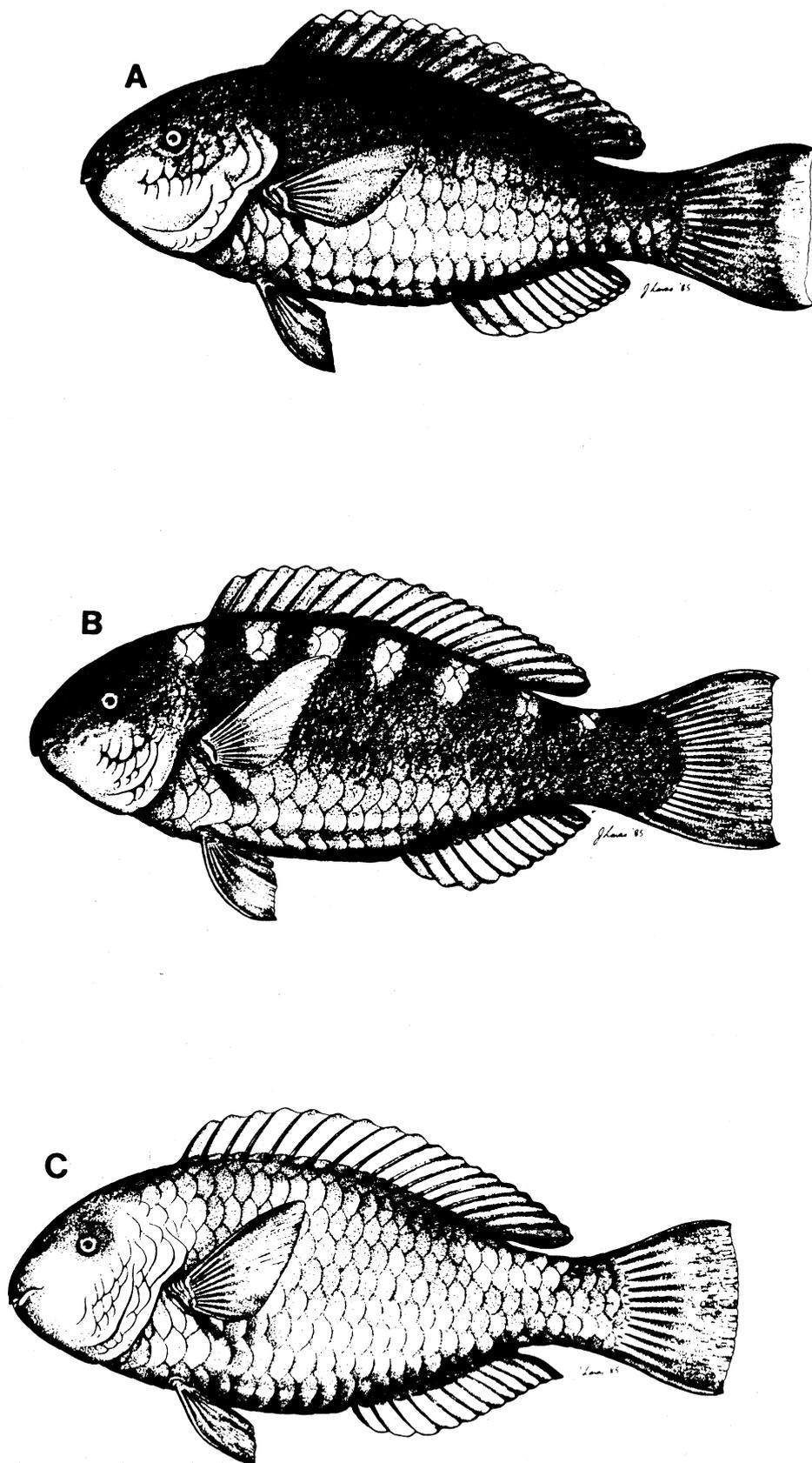


Fig. 5. Diagrams of small IP individuals of A, *S. psittacus* B, *S. globiceps* and C, *S. rivulatus* showing the main criteria for separating these species in the field. Each individual is approximately 120 mm SL and was collected at Lizard Island. See text under the species description of *S. rivulatus* for details.

Material examined. Three specimens, Heron Island, AMS I.21379-001, I.21379-002, I.21279-003; two specimens, One Tree Island, AMS I.17929-013, BPBM 14381; one specimen, Escape Reef, AMS I.22596-002; one specimen, Carter Reef, AMS I.25784-001; one specimen (juvenile), Lizard Island, AMS I.25789-001; one specimen, Kenn Reef, Coral Sea, AMS IB.4995.

Diagnosis. Median predorsal scales 4 (occasionally 3), subequal; 3 rows of scales on cheek, upper row with 5-7 scales, middle row with 5-7 scales, lower row with 1-3 (usually 2) scales; pectoral rays 14; mouth nearly terminal, lips covering the dental plates, adults with 1-2 canines on upper dental plates; body deeper than average for the genus with depth about 2.5 in SL; dorsal fin elevated, longest dorsal ray 1.7-2.1 in head; pelvic fins long for genus, longest ray in adults 1.2-1.5 in head; caudal fin rounded in juveniles, slightly emarginate to very lunate in adults.

Colour pattern. IP: yellowish brown shading to light reddish brown ventrally; 3 bluish stripes on thorax and abdomen; posterior region of body with 5 dusky bars which vary in intensity, first at level of pectoral tips, last on base of caudal peduncle; body between first dusky bar and operculum paler; bluish bar crossing cheek diagonally from lower margin of orbit to posterior opercular margin, faint dusky bar above this, bluish spot on snout below nostrils; slender anterior projection of this spot reaching upper lip, bluish band arching downward behind mouth, running posteriorly along lower edge of operculum, bluish blotch above each eye, iris brownish orange; occiput brownish, upper and lower lips brownish red; dorsal fin yellow-brown anteriorly with narrow blue-grey edge, becoming darker posteriorly, in larger specimens purple area basally on each interradiation membrane posterior to 7th spine; anal fin with outer third green, basal two thirds orange-brown with greenish spot at base behind each ray; caudal fin brownish orange with median posterior crescent of yellow-green, extreme posterior margin dusky; pectoral fins light yellow with greenish bar at base; pelvic fins light reddish with light blue lateral edge.

Viewed underwater IP individuals give impression of dark brown posterior body with faint dusky bars, pale anterior body region, lateral and ventral regions of head lighter with bluish lines of head discernable, and the posterior margin of caudal fin abruptly yellowish. In smaller specimens, bluish head lines appear dusky.

TP: body orange-brown, body scales with vertical green bar; 5 green bars on body, first beneath base of 6th dorsal spine, 4th at rear base of dorsal fin, last on caudal peduncle, curved 6th green bar on scaled base of caudal fin; first green bar of body continuous with band of green 2 scale rows in width on back passing to nape; 2 green stripes ventrally on body and a third on the lower abdomen; dark green band passing from upper interorbital to front of eye where briefly interrupted, thence to corner of mouth where a branch extends on to upper lip and a broader lower branch on to chin; lower part of head greenish, cheeks orange-brown; dark green band from lower edge of eye to upper

pectoral base and another more diffuse one above it from centre of eye, broadening over upper opercle, lower lip with green line; dorsal fin yellowish red anteriorly, edged in blue, first interspinous membrane darker, fin becoming broadly yellowish green on outer part and purplish in lower portion posterior to 7th dorsal spine; anal fin with broad outer margin of blue, middle pinkish zone and basal zone of greenish spots, one on each interradiation membrane; unscaled part of caudal fin pinkish across base and on to lobes, edges of lobes dark green, posterior central region of fin yellow-green with dark green edges; pectoral fins light orange-yellow, becoming green and lavender at base; pelvic fins greenish yellow with broad blue lateral edge. Underwater, orange areas of head and body may appear pinkish or lavender, contrasting strongly with the green bars. On preservation, green cheek bar remains as dusky line after most other markings have faded.

Remarks. This scarid is recognized by its deep body, elevated dorsal and long pelvic fins. On the Great Barrier Reef this species is generally confined to deeper waters off reef fronts. On the southern reefs such as the Capricorn-Bunker Group this species may be encountered in 10-15 m depth, but on northern reefs it is rarer and characteristic of deeper areas (20-30m) on outer-reef fronts. It is generally solitary or occurs in small groups.

The abundance of this species dramatically increases on Coral Sea reefs. Here it is consistently the most abundant scarid and may congregate in large groups. A.M. Ayling found this species to be an order of magnitude more abundant than other scarids on two cays of Lihou Reef. D. Williams also recorded high abundances at Flinders Reefs and Middleton Reef. This species has also been observed to occur at high densities on the eastern-most reefs of the Swain Group (A.M. Ayling pers. comm.). Other than the identification of protogyny and the observation of pair spawning we have no information on the reproductive biology.

Scarus niger Forsskål, 1775

Plates 5A; 6G; 10J; 11A

- Scarus niger* Forsskål, 1775: x,28 (type locality, Red Sea).
Scarus nuchipunctatus Valenciennes in Cuvier & Valenciennes, 1840: 224 (type locality, Dutch East Indies).
Scarus limbatus Valenciennes in Cuvier & Valenciennes, 1840: 271 (type locality, Macao).
Pseudoscarus flavomarginatus Kner, 1866: 262, pl. 10, fig. 2 (type locality, Java).
Pseudoscarus madagascariensis Steindachner, 1888: 61, pl. 2, fig. 1 (type locality, Madagascar).
Callyodon mauricus Jordan & Seale, 1906: 328, pl. 48, fig. 3 (type locality, Pago Pago, Samoa).
Pseudoscarus godeffroyi Gunther, 1909: 326, pl. 159 (type locality, Society Islands).
Callyodon lineolabiatatus Fowler & Bean, 1928: 257, pl. 47 (type locality, Butauanan Island, Philippine Islands).

Material examined. One specimen, Heron Island, AMS I.15477-001; two specimens, One Tree Island, AMS

I.15679-038, I.20680-005; one specimen, Big Broadhurst Reef, QM I.10355; two specimens, Escape Reef, AMS I.22581-029, I.22586-041; three specimens, Lizard Island, AMS I.19464-006; three specimens (juveniles), Lizard Island, AMS I.25907-001, I.25914-002, I.25909-004; two specimens (juveniles), Yonge Reef, AMS I.25912-004; three specimens, Raine Island, AMS I.20775-009, I.20775-010; seven specimens, Heron Island, not retained; four specimens, Lizard Island, not retained.

Diagnosis. Median predorsal scales 6–7, subequal (first may be small and partially embedded), fourth usually largest; 3 rows of scales on cheek, 6–7 scales in upper row, 6–9 scales in middle row, 3–5 scales in lower row; pectoral rays 14, occasionally 15; dental plates largely covered by lips, upper dental plate with 0–2 canines on each side; caudal fin in small individuals rounded, in larger individuals lobes become extended, dorsal more than ventral, in large males fin double emarginate with extended lobes; penultimate anal ray prolonged in large males.

Colour pattern. In the western and central Pacific there is no obvious sexual differentiation in colour patterns into an initial and terminal phase. Juveniles are distinct.

Juvenile: body dark brown to blackish with paler caudal peduncle, white in very small specimens to reddish brown in larger, dark spot on dorsal and ventral aspects of caudal peduncle; series of fine bluish white dots on body, snout pale brown; dorsal fin pale brown with darker distal margin, anal fin brownish, caudal fin pale, pectorals light yellow, pelvics dark brown.

Adult: body dark blackish brown; scales in mid-region of body each with 3–4 darker spots on posterior region, these scales with greenish cast which fades rapidly with removal from water, green spot with darker margin on body adjacent to upper opercular membrane, snout reddish with green band crossing snout above upper lip, chin with 2 green bars; greenish band from corner of mouth to lower margin of orbit, 2 short green postorbital bands, sides of head with darker dots and reticulated markings; subopercular area often with greenish dots, dental plates blue-green; dorsal and anal fins reddish brown, distal margins blue-green; caudal fin brownish, upper and lower margins blue-green, then submarginally reddish brown, posterior margin narrowly greenish; upper part of pectoral fins light brown, dorsal-most ray slightly darker, lower rays hyaline dark brown; pelvic fins brownish, spine and anterior rays blue-green. Larger males, body colouration becomes progressively darker purplish green, black spots on body scales and head less prominent. A colour illustration of a large male *S.niger* is provided by Coleman (1981).

Remarks. *Scarus niger* has a similar distribution pattern to *S.frenatus*, ranging from the Red Sea to the central Pacific. Western and central Pacific populations of *S.niger* have mainly secondary males (Choat & Robertson, 1975) but do not have the characteristic IP and TP colours usually associated with this pattern of sexual ontogeny. In Red Sea and western Indian Ocean

populations there are initial and terminal phases although they are not as distinctive as in most other scarid species. TP individuals are very similar to the large males described here, the major distinction being a red pectoral fin in western Indian Ocean populations. Details of these colour phases are provided by Randall & Bruce (1983). Gunther (1909) has provided an excellent illustration of *Pseudoscarus godeffroyi* (type locality Society Islands). This is clearly *S.niger* and is included above in the synonymy of this species.

Scarus niger is widely distributed on mid, outer and Coral Sea reefs of the Great Barrier Reef. It is usually found on reef front habitats in small groups, a characteristic it shares with *S.frenatus*. However it occupies a greater range of habitat types than *S.frenatus* and typically occurs in slightly deeper water. It has not been recorded from Western Australia although it occurs on northern Australian reefs (B. Russell, pers. comm.).

Large males are often observed on reef fronts swimming rapidly with the caudal fin elevated, the elongate rays of the anal fin produced downward and the upper lip curled back to expose the dental plates. These characteristics are associated with reproductive behaviour prior to pair spawning. This species defends specific feeding sites against other scarids.

Scarus niger may be the only monandric scarid on the Great Barrier Reef. Histological studies have revealed no primary males (Choat & Robertson, 1975) although additional work is required to confirm this. Recent observations demonstrate that this species makes local migrations to specific spawning sites and is not restricted to male territorial areas when spawning, as suggested by Choat & Robertson (1975). It is a moderate-sized scarid, with large males reaching 350 mm SL.

Scaris oviceps Valenciennes

Plates 4G,H; 10G

Scarus oviceps Valenciennes in Cuvier & Valenciennes, 1840: 244 (type locality, Tahiti)

Pseudoscarus zonatus Macleay, 1883: 591 (type locality, New Guinea)

Callyodon lazulinus Jordan & Seale, 1906: 333, fig. 65 (type locality, Samoa)

Material examined. HOLOTYPE of *Pseudoscarus zonatus*, AMS I.16379-001, New Guinea. One specimen, Heron Island, AMS I.15492-001; one specimen, Cairns, QM I.19098; one specimen, Rowley Shoals, Western Australia, WAM P.27667-013; one specimen, New Guinea, QM I.11449; one specimen (juvenile), Lizard Island, AMS I.25794-002; two specimens, Heron Island, not retained; five specimens, Lizard Island, not retained.

Diagnosis. Median predorsal scales 6; 3 rows of scales on cheek, upper row with 6–7 scales, middle row with 6–9 scales, lower row with 2–3 scales; 14 pectoral rays; caudal fin lunate in both IP and TP individuals; lips

covering teeth; no canine teeth on dental plates.

Colour pattern. Juvenile: body pale yellow, upper snout, occiput and dorsum to end of spinous dorsal dark, 2 pale bars dividing dark dorsal pigmentation, dark colouration not extending below mid-line of body; characteristic darker band from snout, through eye, to beyond opercular membrane, cheek below this abruptly paler; fins hyaline yellow (Plate 10G).

IP: lower body yellowish brown, becoming lighter ventrally; scales may be edged with grey; upper body darker, becoming less pronounced posteriorly; snout, occiput and dorsum to level of 8th dorsal spine dark brown to black; dorsum with 2 yellow saddles, 1st between 7th spine and first dorsal ray, 2nd between 6th and 7th dorsal rays, these pale saddles diagonal and pointing forward; dorsal fin dusky, distal margin reddish brown; anal and pelvic fins reddish yellow; caudal hyaline light brown; pectoral hyaline yellowish, upper rays darker; dental plates white.

TP: body blue-green with anterior portion of each scale pinkish, body colouration becoming paler ventrally; head above lower edge of eye and body above pectoral fin and anterior to 8th dorsal spine abruptly dark purplish; cheek lighter blue-green, separated from darker region of head by greenish band running from snout, below eye to opercular margin; lips blue-green and a blue-green bar on chin; dorsal and anal fins greenish with narrow blue margins; caudal fin greenish with posterior blue margin; pectorals greenish, becoming lighter ventrally, upper rays yellowish green; pelvics blue-green, spine and anterior rays darker; dental plates green.

Remarks. *Scarus oviceps* is a member of a complex of closely related species including *S.scaber* and *S.dimidiatus*. These are characterised by an IP colour pattern comprising diagonal dark and yellow saddles on the dorsum. *Scarus oviceps* and *S.dimidiatus* co-occur on the Great Barrier Reef and in the western Pacific, while *S.scaber* is restricted to the western Indian Ocean. A point of interest is the relationship between similarity of colour patterns and geographic distribution. The IP of *S.scaber* is almost identical to that of *S.dimidiatus*; while the TP of *S.oviceps* is very similar to that of *S.scaber* (Randall & Bruce, 1983). The strongest similarities occur in geographically separated members of the complex. The marked similarities between the terminal phases of *S.oviceps* and *S.scaber* and resultant taxonomic confusion are discussed by Randall & Choat (1980).

Scarus oviceps is widely distributed on the Great Barrier Reef, occurring on mid- and outer-shelf reefs. Specimens have also been recorded from Western Australia. It tends to be solitary or occurs in small groups in more sheltered habitats, often amongst large *Acropora* growths. Care should be taken with field identifications of the terminal phase which may be confused with *S.forsteni*. This is a moderately sized scarid, with terminal males reaching 300 mm SL.

Scarus psittacus Forsskål
Plates 2E,F; 6D; 8A,B,C,D.

- Scarus psittacus* Forsskål, 1775:29 (type locality, Jeddah).
Scarus venosus Valenciennes in Cuvier & Valenciennes, 1840: 212 (type locality, Reunion).
Scarus taeniurus Valenciennes in Cuvier & Valenciennes, 1840: 257 (type locality, Mauritius).
Scarus heritii Ehrenberg in Cuvier & Valenciennes, 1840: 215 (type locality, Red Sea).
Scarus forsteri Valenciennes in Cuvier & Valenciennes, 1840: 275 (type locality, Tahiti).
Pseudoscarus Filholi Sauvage, 1880: 225 (type locality, Fiji Islands).
Pseudoscarus labiosus MacLeay, 1883: 585, (type locality, Port Moresby).
Scarus gilberti Jenkins, 1900: 59, fig. 17 (type locality, Hawaiian Islands).
Scarus jenkinsi Jordan & Evermann, 1903: 195 (type locality, Honolulu).

Material examined. NEOTYPE of *Scarus psittacus*, Red Sea, BPBM 19789; HOLOTYPE of *Pseudoscarus labiosus*, New Guinea, AMS I.16376-001. Three specimens, Heron Island, AMS I.154800-001; four specimens, One Tree Island, AMS I.15686-027, I.1717445-131, I.20479-018; one specimen, Lord Howe Island, AMS I.17388-004; four specimens, Gillett Cay, Swain Reefs, AMS IB.6082, IB.6084, IB.6085, IB.6086; ten specimens, Lizard Island, AMS I.18805-019, I.19445-014, I.19445-016, I.19464-008, I.19469-009, I.19482-105, I.21343-014; one specimen, Rowley Shoals, Western Australia, WAM P.27658-035; 45 specimens, Heron Island, not retained; eighteen specimens, Lizard Island, not retained.

Diagnosis. Median predorsal scales 4, subequal (largest scale 1st in juveniles, 2nd in adults); no anterior paired scales; 2 rows of cheek scales; upper row 5–7 scales, lower row 4–7 scales; pectoral rays 14, rarely 15; lips covering dental plates; 0–2 canine teeth on upper and lower dental plates; large TP males with 2 upper and 1 lower tooth; large IP with 1 upper tooth; caudal fin in IP emarginate, this becomes strongly developed in TP.

Colour pattern. Juvenile: schooling groups in life pale grey with series of white flecks on dorsum and sides of body; in Great Barrier Reef waters, juveniles with sprinkling of black cysts over body and fins; solitary individuals often with series of 4 dark longitudinal stripes, 1st on dorsum of body and head, 2nd on mid-body through eye and snout, 3rd on lower body through pectoral fin base on to cheek, 4th (often indistinct) on abdomen (Plate 6D).

IP: body grey to reddish brown shading to light reddish on thorax; dorsal fin light brown with paler distal margin, diffuse dark spot at base of first interspinous dorsal membrane; anal fin reddish brown becoming paler distally; caudal fin light brownish becoming paler distally with narrow whitish distal margin; pectoral fins pale brown to yellowish, diffuse black spot at upper base; pelvic fins brownish red; iris uniform yellow; dental plates white.

IP phase individuals in feeding schools usually pale grey with series of 6–7 diffuse pale spots on dorsum; distal and anterior margins of dorsal, anal and pelvic

fins brownish; posterior region of caudal fin paler with distinct narrow white distal margin; dark blotch on first dorsal interspinous membrane visible. Non-feeding individuals, especially prior to group spawning, uniform dark charcoal-grey with pale whitish snout; distal and anterior margins of dorsal, anal and pelvic fins strongly reddish; caudal grey with distinct pale distal margin (Plate 8A,B).

Preserved body uniform grey with pale distal margin to caudal, with black spot on anterior dorsal membrane and upper pectoral base visible. In some specimens the pale blotches on dorsum are retained.

TP: scales of body green and salmon pink; green pigmentation predominating on dorsum of body and head; green coalescing into 3 green stripes on abdomen, and in some specimens 4 or 5 longitudinal series of spots on caudal peduncle; often yellowish zone covering central region of body from pectoral base to level of first dorsal rays, not extending to abdominal region; lower part of head and thorax pink, purple region on snout at level of eye; blue band on upper lip extending across snout to lower edge of orbit and short distance beyond; 2 blue bands, one central, the other dorsal, from posterior margin of orbit, extending a short distance across head; lower lip blue; blue bar on chin sometimes joining with blue band from upper lip; posterior margin of opercular membrane opposite pectoral base blue; ventral part of head with longitudinal blue band; iris yellow to orange, upper edge green; dental plates white; dorsal and anal fins light orange with broad blue bases and blue distal margins; dorsal fin with median longitudinal series of diffuse green spots which may be partially or completely joined to form a diffuse stripe; dark spot on first spinous dorsal membrane present but indistinct; caudal fin light orange, with blue upper and lower margins and reverse 'D'-shaped blue mark centroposteriorly on fin, vertical part on posterior border of fin, and curved anterior part sometimes broken into spots; pectorals pinkish orange, base and upper rays dark blue, lower rays light blue, lower basal region of fin pink; pelvic fins blue, 2nd and 3rd rays orange.

TP colouration varies in life. Body may be dominated by yellow pigmentation on medial region (Plate 8D) or appear largely green with pinkish ventral regions (Plate 8C). Pink pigment on cheek is characteristic of most TP individuals. Prior to and during spawning, TP individuals become pale pinkish green with distinctive purple blotch on snout at level of eye (Plate 8D). Broad blackish zone on side of body observed in Red Sea spawning individuals (Randall & Ormond, 1978) not obvious in Great Barrier Reef individuals. On preservation, pattern of blue, green and pink markings on snout, head and fins remains distinct.

Remarks. Details of the distribution and reproductive biology of this widespread species are provided in Choat & Robertson (1975), Randall & Ormond (1978), Bruce (1980), and Randall & Bruce (1983). On the Great Barrier Reef it is encountered in moderate numbers on mid-, outer-shelf and Coral Sea reefs. A small scarid

with TP males not usually exceeding 260 mm SL. Great Barrier Reef populations of this species are diandric (Choat & Robertson, 1975), although most spawning appears to occur in pairs or small groups. *Scarus psittacus* is found in a variety of habitats: large groups of small, IP individuals occur in shallow areas beyond reef crests. Small IP individuals are frequently confused with IP *S.globiceps* and small IP *S.rivulatus*. Key features for separating these stages are considered under the species description of *S.rivulatus* (Fig. 5).

The taxonomic status of this species and the identity of the type of *S.psittacus* was clarified by Randall & Ormond (1978). Many previous works and most Australian studies have referred this widespread species to *Scarus forsteri*, a junior synonym. *Scarus psittacus* is present throughout tropical Australia including the west coast, and has often been misidentified in museum collections as *Scarus toshi* and *Xanophon bataviensis*. The type of *Pseudoscarus labiosus* (type locality, Port Moresby) was examined in the Australian Museum and identified as a TP *Scarus psittacus*.

Scarus pyrrhurus (Jordan & Seale)

Plate 3G,H

Callyodon pyrrhurus Jordan & Seale, 1906: 314, fig.55 (type locality, Pago Pago, Samoa).

Callyodon abacurus Jordan & Seale, 1906: 324, pl.23 (type locality, Pago Pago, Samoa).

Scarus capistratoides (not Bleeker).—Schultz, 1969: 22, pl.4E (in part).

Scarus japonensis (not Bloch).—Randall & Choat, 1980: 406, figs 25,26.

Material examined. One specimen, MacGillivray Reef, AMS I.23483-001.

Diagnosis. Median predorsal scales 4; 2 rows of scales on cheek with 5-6 scales in each row; 15 pectoral rays; dental plates exposed; initial phase with 0-2 canines on upper dental plate, terminal phase with 2 canines on upper dental plate; no canines on lower dental plate; canines stout, projecting downward and backward.

Colour pattern. IP: body and head uniform dark brown, slightly paler on cheek; caudal peduncle yellowish; caudal fin orange-red with a narrow black posterior margin; dorsal fin may show faint orange basal band; anal, pectoral and pelvic fins uniform dark brown; dental plates white.

TP: body dark anteriorly and dorsally, greenish yellow posteriorly; caudal peduncle blue-green; dark oblique transverse bar from below anterior dorsal fin to vent, becoming indistinct ventrally; in some specimens, this bar restricted to dorsal region of body; body scales with orange markings, these markings reduced to anterior rim of scales in dark anterior regions of body, as elongate vertical bars in mid-body and ventral regions, and as orange dots on scales of caudal peduncle; top of head and snout purplish grey; cheek orange-yellow; chin and upper lip salmon pink; transverse blue band on chin and upper lip, merging to

form a blue-green band running to and beyond lower margin of orbit; a horizontal green band from upper snout through and beyond upper edge of orbit; short green band passing posteriorly from centre of orbit; dorsal and anal fins blue with median band of orange (broader on dorsal fin), caudal fin blue with dull pink streak in each lobe and pinkish spots in central region of fin; pectoral fins purplish with broad zone of orange on upper part, upper edge blue-green; pelvic fins pale orange with blue lateral edge; dental plates pale bluish.

Remarks. To date only a single specimen has been captured from Australian waters, a 180 mm SL TP male at MacGillivray Reef collected by D.R. Robertson, March 1982. Recent surveys by the authors and A.M. Ayling have recorded isolated groups on mid-shelf and outer reefs (Normanby Island, North-West Reef, Day Reef) of the northern Great Barrier Reef. A single individual was also observed off Townsville outer reefs (G. Russ, pers. comm.), and D. Bellwood observed two IP specimens at Lizard Island.

TP individuals of *S.pyrrhurus* have been identified in the recent literature both as *S.capistratoides* and *S.japanensis*. Recent field work by the junior author has clarified problems associated with these identities. *Scarus japonensis* (Bloch), with a probable type locality of Java, is a senior synonym of *S.capistratoides* Bleeker. *Scarus japonensis* is a west Indian Ocean species with a range which extends to south-west Indonesia. Most previous records of *S.japanensis* from the Indian Ocean appear as *S.capistratoides*.

Scarus pyrrhurus appears to be restricted to the western Pacific from the Ryukyu Islands through the Philippines, the Solomons, eastern Australia to Samoa. Colour illustrations of both IP and TP individuals can be found in the recent literature. Schultz (1969: pl.4E) illustrates a TP individual from the Philippines identified as *S.capistratoides*. On this specimen the oblique dark zone of the body is reduced. Masuda et al. (1984) and Randall & Choat (1980) have provided colour plates of *S.pyrrhurus* which were misidentified as *S.japanensis*.

As the ranges of *S.japanensis* and *S.pyrrhurus* do not overlap there is no problem of confusion in the field. However, *S.pyrrhurus* may be confused with *S.sordidus* and possibly small *S.bleekeri* in Australian waters. The best field characteristic for IP *S.pyrrhurus* is the orange-red caudal fin. In TP individuals the contrasting dark oblique band, the yellowish green of the posterior body and the blue-green caudal peduncle are characteristic.

Scarus rivulatus Valenciennes

Plates 4C,D; 11D-J

Scarus rivulatus Valenciennes in Cuvier & Valenciennes, 1840: 223 (type locality, Java).

Scarus fasciatus Valenciennes in Cuvier & Valenciennes, 1840: 222 (type locality, Moluccas).

Scarus arcuatus Valenciennes in Cuvier & Valenciennes, 1840: 276 (type locality, Siam).

Pseudoscarus flavolineatus Alleyne & Macleay, 1877: 346, (type locality, Cape Grenville, Queensland, three syntypes AMS I.16373-001)

Material examined. Three SYNTYPES of *Pseudoscarus flavolineatus* AMS I. 16373-001. Two specimens, Heron Island, QM I. 11379, I.11965; one specimen, One Tree Island, AMS I.20498-009; three specimens, Capricorn Reef Group, AMS I.15681-073, I.15683-043; one specimen, Swain Reefs, AMS IB.6085; one specimen, Palm Island, QM I.6416; three specimens, Curacoa Reef, QM I.5845, I.6415, I.11390; two specimens, York Island, QM I.6321, I.6322; one specimen, Lizard Island, AMS I.19461-004; two specimens (juveniles), Lizard Island, I.25785-001, I.25796-001; one specimen, Torres Strait, QM I.14992; one specimen, Pt.Quobba, Western Australia, WAM P.12865; one specimen, Kendrew Island, Western Australia, WAM P.22871; one specimen, Rottne Island, Western Australia, WAM P.25742-006; 82 specimens, Heron Island, not retained; nine specimens, Lizard Island, not retained; one specimen, Moreton Bay, lost after identification and preservation.

Diagnosis. Median predorsal scales 6, rarely 5 or 7, subequal, 3rd or 4th largest, 2 small scales anterior to 1st median predorsal; scale rows on cheek 3, upper and middle rows with 5-7 scales, lower row with 1-3 scales; pectoral rays 14; caudal fin slightly rounded to truncate in juvenile and IP specimens, lobe tips slightly produced in TP; dental plates white, covered by lips; IP without canines; TP usually with 2 small upper and 0-1 lower canines, dorsal profile of snout steep giving characteristic rounded head, especially in terminal phase. Diagnosis of *S.rivulatus* in Randall & Choat (1980) contains a typographical error. Pectoral fins have 14 not 15 rays.

Colour pattern. IP: initial phase has many subtle variants reflecting different aspects of schooling and sexual activity.

(a) In large (especially multispecific) feeding schools: body uniform pale grey to light brown with 2 pale stripes on lower abdominal region; upper margin of eye light blue; dorsal and anal fins light grey to brown, distal margins blue-grey; pectoral fins light grey to brown with upper rays slightly darker, no dark markings at base; caudal and pelvics uniform light grey or brown (Plate 11D).

(b) Single individuals and small feeding schools: body pale yellowish grey; darker mid-body region extending from posterior margin of eye to upper base of caudal fin; scales of central region darker with dusky vertical bars on bases; anterior (behind eye) and posterior (upper caudal peduncle) regions of this darker band distinctly yellow; body and cheek below this central darker region abruptly paler (especially cheek); dorsum of body slightly paler than dark central region (Plate 11F); in smaller individuals yellow colour predominates. Yellowish body colour more pronounced in northern and inshore populations. Interactions amongst feeding IP individuals may be associated with abrupt darkening of central body region giving distinct dark central and abruptly pale ventral region. These individuals have strong resemblance to IP *S.chameleon* (Plate 11G).

(c) Reproductively active individuals: prior to

reproductive activity IP individuals frequently become uniform dark grey with distinct pale abdominal stripes and distinct pale margin to spinous portion of dorsal fin. Group spawning females: body uniform gunmetal grey with distinct dark bars at bases of body scales; uniform darker area on upper head and dorsum extending back to level of 5th dorsal spine; cheek abruptly paler with yellowish tinge (Plate 11H). Group spawning IP males with similar colour pattern but dark bar extending backward from eye, this containing series of dark spots; anterior margin of dorsal fin pale (Plate 11I). In both sexes, pale patch on cheek corresponds to orange cheek patch of TP. Individual females in spawning aggregations may display an overall yellowish colour.

TP: body scales green with basal orange bar, these best developed centrally and posteriorly corresponding to dark scale bars in IP; lower half of operculum bright orange; snout and chin orange with bright green reticulations; regions of dorsal and anal fins blue-green basally, orange centrally with blue margins; dorsal with large green spot in middle of each interradiation membrane; caudal fin orange with broad blue dorsal and ventral margins; posterior margin with blue streaks, remainder of caudal membrane with green spots and streaks; pectoral fins chartreuse, upper margin blue-green with submarginal rose streak; pelvic fins orange with broad blue lateral margin.

Reproductively active individuals: body distinctly bicoloured with posterior region (behind level of spinous dorsal) light green, anterior region dark brownish green; pale green strip along anterior dorsum of body below spinous portion of fin; cheek bright orange; pectoral fin standing out sharply against dark anterior background (Plate 11J).

IP individuals become brownish on death and retain this colour on preservation; pale abdominal streaks generally visible. TP individuals gradually lose colour, but relationships between green and orange and blue markings (especially green reticulations on cheek) are detectable after long periods of preservation.

Remarks. Schultz (1969) listed *Pseudoscarus flavolineatus* Alleyne & Macleay as unidentifiable. The three syntypes of *P. flavolineatus* (AMS I.16373-001) proved to be TP specimens of *S. rivulatus* ranging from 235 to 257 mm SL. These all bore clear evidence of the characteristic reticulations around the snout and chin. The original description of Alleyne & Macleay notes only two series of scales on the cheek but all three specimens have the usual three series, each with 2 scales in the ventral row. A more general statement on the taxonomy of *S. rivulatus* is provided by Randall & Choat (1980). Australian collections and literature provide some information on this species. The IP has usually been misidentified and occurs in collections as *Scarus aeruginosus* or *S. dubius*. Examples of the scarid identified as *S. dubius* by Woodland & Slack-Smith (1963) were examined in the University of Queensland Zoology Department (now in the Queensland Museum). These all proved to be IP *S. rivulatus*. Coleman (1981:

pl.237) and Grant (1982: pl.293) provide colour illustrations of the TP. The illustrations of Marshall (1965: 322, pl.48) depicting male and female colour phases are both poor representations of TP individuals and thus males.

Details of the sexual ontogeny of this species and the relationship of sex, size and colour phase are provided by Choat & Robertson (1975). The species is strongly diandric. Subsequent observations of spawning groups of *S. rivulatus* have provided details of the colour phases characteristic of the different sexual identities while spawning (see above). A surprising feature of spawning episodes was the participation of TP individuals in small group spawning episodes involving females and primary males.

Scarus rivulatus is widespread in tropical and subtropical Australian waters and extends beyond the latitude of primary reef environments both on the western (Rottnest Island) and eastern (Moreton Bay) coasts. It is also found on inshore tropical reefs and mangrove areas. This is reflected in the longitudinal distribution pattern in Great Barrier Reef waters. Data provided by D. Williams (pers. comm.) shows that on a cross-shelf transect at 19° S on the Great Barrier Reef *S. rivulatus* was the most abundant scarid on inshore reefs, was also an abundant member of the mid-shelf fauna but was absent from outer-shelf and Coral Sea reefs. These data were collected on windward outer-reef slopes. A.M. Ayling made a similar series of observations (not including Coral Sea reefs) on back reefs and lagoonal areas and encountered *S. rivulatus* in small numbers on outer-shelf reefs. On mid-shelf reefs *S. rivulatus* consistently forms large feeding schools.

Small IP *S. rivulatus* are abundant on mid-shelf reefs and frequently form schools in association with IP of other species, often *S. globiceps* and *S. psittacus*. When viewed underwater the initial phases of these species are difficult to distinguish. Although each species has distinctive elements in their colouration they tend to display very similar patterns when in mixed schools. All can display a uniform light grey colouration with two or three pale abdominal bars. They may however, be distinguished by the following features. *Scarus rivulatus* usually has a lighter colouration than *S. globiceps* with a yellowish caste on the medial regions of the body. The caudal margin is rounded compared with the truncate fins of the other two species. *Scarus globiceps* often displays a temporary series of pale saddles along the dorsum, a feature shared with *S. psittacus*. *Scarus psittacus*, however, has a more acute snout, a distinctive pale posterior margin to the caudal fin and a dark blotch on the anterior dorsal fin. The body is generally a lighter grey than *S. globiceps* and lacks the yellowish caste of *S. rivulatus*. These features are illustrated in Fig.5. When swimming, *S. psittacus* generally holds the caudal fin in a folded position which accentuates the truncate outline of the fin.

Scarus rivulatus is widespread in the western Pacific but does not extend into the Indian Ocean. It is a

moderately large scarid with terminal males reaching 400 mm SL.

Scarus rubroviolaceus Bleeker

Plates 2A,B; 9B,C.

Scarus rubroviolaceus Bleeker, 1847: 162 (type locality, Batavia).

Pseudoscarus rubroviolaceus Bleeker, 1862: 37, pl.13, fig.3.

Pseudoscarus frontalis Macleay, 1883: 590 (type locality, New Guinea); preoccupied by *Scarus frontalis* Valenciennes in Cuvier & Valenciennes, 1840.

Scarus paluca Jenkins, 1900: 60, fig.18 (type locality, Hawaiian Islands).

Pseudoscarus jordani Jenkins, 1900: 63, fig.20 (type locality, Hawaiian Islands).

Scarus calus Fowler, 1904: 542, pl.21 lower fig. (type locality, Padang).

Callyodon ruberrimus Jordan & Seale, 1906: 316, fig.56 (type locality, Pago Pago).

Callyodon macleayi Jordan & Seale, 1906: 331 (replacement name for *Pseudoscarus frontalis* Macleay).

Pseudoscarus heliotropus Bryan, 1906: 23, fig.3 (type locality, Honolulu).

Pseudoscarus rostratus Gunther, 1909: 315, pl.154 (type locality, Society Islands).

Callyodon africanus Smith, 1955b: 19, pl.3, fig 26, text fig 26 (type locality, Shimoni, Kenya).

Material examined. HOLOTYPE of *Pseudoscarus frontalis*, AMS I.16374-001. Two specimens, Heron Island, AMS I.15487-001, I.15498-001; six specimens (juveniles), Lizard Island, AMS I.25790-001, I.25902-001, I.25909-003; one specimen, Heron Island, not retained.

Diagnosis. Median predorsal scales 6; 3 rows of scales on cheek, upper and middle rows with 5–7 scales each, lower row with 1–3 scales; pectoral rays 14–15; lips covering $\frac{1}{3}$ – $\frac{2}{3}$ dental plate, IP with 0–1 canines on upper dental plate, TP with 1–3; snout of adults with characteristic shape, dorsal profile rising sharply from level of eye then curving sharply to straight dorsal profile; each upper pharyngeal bone with 12–14 ridged molariform teeth, no lateral row of small teeth alternating with molars in adults (rudimentary lateral row may be present in juveniles); caudal fin truncate in small IP fish, becoming strongly lunate in large individuals.

Colour pattern. Juvenile (80–130 mm): body light grey, scales with dark posterior margins, body with 3 longitudinal stripes, 1st from occiput along dorsal region to end of dorsal fin, 2nd from tip of snout through eye to centre of caudal peduncle, 3rd across cheek through pectoral base to end of anal fin; body bicoloured with anterior third darker than posterior regions; series of white dots on posterior region of body, these in 4 pairs from body mid-point extending equally spaced to caudal peduncle, dots tending to lie on dark longitudinal lines; median fins greyish, pectorals hyaline. This phase may change rapidly with the dark longitudinal stripes and pale dots being lost or intensified.

IP: body reddish or greyish dorsally and on side, scales with narrow blackish edges and numerous short

radiating black lines, these reduced on head and caudal scales; ventral part of body lighter; body often bicoloured with head and anterior third of body abruptly darker; median fins light reddish to orange, pectoral fins light red on dorsal third becoming paler ventrally, pelvic fins orange-red; iris yellow, dental plates light reddish to white. Colour in life usually greyish white posteriorly with the anterior third abruptly reddish-brown, this pattern usually fading to uniform reddish on death.

TP: body green dorsally, fading to greenish yellow on sides, scales with light orange vertical bar, body becoming blue-green ventrally, caudal peduncle lighter green; edge of upper lip narrowly salmon pink with broad band of blue-green above it, edge of lower lip blue-green; chin salmon pink, crossed by blue-green bar which joins with blue-green bar on lower lip and continues dorsally as blue line to lower margin of orbit; horizontal blue-green streak through upper margin of eye and single blue-green postorbital bar; longitudinal green line on lower cheek; dorsal fin orange with blue-green distal margin, blue-green marking on each ray, these becoming reduced posteriorly; anal fin orange with broad blue-green distal margin and basal line of blue-green blotches; caudal with upper and lower margins blue, central part light orange this colour extending onto upper and lower caudal rays, posterior portion of fin with thin orange margin; pectorals broadly blue-green on upper edge, usually horizontal light orange streak below this, rest of fin blue-green becoming paler ventrally; pelvic fins orange with broad blue anterior margin; iris orange, dental plates dark green, edged with white.

In life TP individuals on the Great Barrier Reef may also be bicoloured with anterior third of body dark green and posterior $\frac{2}{3}$ light green.

Remarks. This species has a very wide distribution, extending from East Africa to the coast of tropical eastern America. Minor differences in colouration occur in different parts of the range (eg. bicolouration of the IP is not as distinct in Indian Ocean material) but the basic colour pattern described above is maintained over this wide geographic area. This species is common in southern New Guinea where both colour phases were recorded by Munro (1967).

The type of *Pseudoscarus frontalis* (AMS I. 16374-001, 360 mm SL) proved to be an IP *S.rubroviolaceus* and represents the first record of this species from New Guinea. *Pseudoscarus frontalis* Macleay has had a confused history, being initially referred to *S.gibbus* by Schultz (1958) and later to *B.muricatum* by Schultz (1969). As the name *frontalis* was preoccupied, Jordan & Seale proposed the replacement name *macleayi*, under which name it was included by Schultz (1969) in the synonymy of *Bolbometopon muricatum*.

This species is one of a member of a group of large scarids including *C.bicolor* which is characteristic of reef-crest areas; it is usually encountered as solitary

individuals or in pairs. Although never observed to be common on the Great Barrier Reef, it has a wide distribution across the shelf, occurring on the crests and outer slopes of reefs from the mid shelf to the Coral Sea. This species has not been recorded from Western Australia, but three specimens were collected in Arnhem Land, northern Australia (Taylor, 1964). It attains a large size, approximately 500 mm SL in terminal males. A 502 mm SL terminal male was collected at Heron Island.

Scarus schlegeli (Bleeker)

Plates 2G,H; 7D-I

Pseudoscarus Schlegeli Bleeker, 1861: 242 (type locality, Celebes).

Pseudoscarus pentazona Bleeker, 1861: 241 (type locality, Celebes).

Scarus cypho Seale, 1901: 95 (type locality, Guam).

Material examined. One specimen, One Tree Island, AMS I.15647-065; one specimen, Keeper Reef, QM I.6999; eleven specimens, Lizard Island, AMS I.15647-065, I.19445-014, I.19445-016, I.19471-006; one specimen, Abrolhos Islands, WAM P.25307-001; one specimen, Pelsart Island, Western Australia, WAM P.84; one specimen, Northwest Cape, WAM P.12866; four specimens, Enewetak, BPBM 6256, 6301; two specimens, Rapa, BPBM 12835, 13008; one specimen, Okinawa, BPBM 22266; one specimen, Papeete, BPBM 6128; two specimens, Ponape, Carolines, BPBM 9694; 35 specimens, Heron Island, not retained; six specimens, Lizard Island, not retained.

Diagnosis. Median predorsal scales 4, subequal, second scale largest; 2 rows of cheek scales; upper row with 6-7 scales, lower row with 5-7 scales; pectoral rays 14, occasionally 15; caudal fin of initial phase slightly rounded, terminal phase with lobes slightly produced giving double emarginate effect; dental plates nearly covered by teeth; IP fish lacking canines on dental plates; TP males usually with a single canine on upper dental plate and 2 on lower; small TP individuals may lack these completely.

Colour pattern. Juvenile: body dark brown with 5 pale vertical bars, first beneath 5th dorsal spine, last on caudal peduncle; snout and chin paler, each with faint transverse bluish band; median and caudal fins dark brownish; pectoral fins hyaline with slightly darker upper rays and base. In life, general impression is of dark fish with indistinct pale vertical bars (Plate 7D); when juvenile fish are schooling, bars may be absent. Small individuals may be confused with IP *S. spinus* (cf Plate 7C,D).

IP: body colouration ranges from pale brownish to darker purplish brown; in paler individuals faint orange bars at bases of body scales may be detected; 5 pale vertical bars on body as in juvenile phase, these varying in development and intensity, but always visible; snout pale grey to orangish with pale bluish margin to upper and lower lip, bluish bar on chin, faint bluish band extending from corner of mouth to anterior margin of eye; median fins brownish to light orange with medial

series of bluish blotches; distal margins blue; caudal fin light brownish with vertical faint green markings; pectoral fins pale with indistinct dark spot at upper base; pelvic fins with light brownish anterior margins. When feeding in small groups, background colouration in IP individuals may be pale grey (especially on the anterior regions) with expanded pale vertical bars; this gives an impression of a pale mottled fish (compare Plate 7E & F). In larger schools and especially when moving to and at spawning sites, body purplish with narrowed and sometimes indistinct pale vertical bars. Females retain this pattern while spawning. IP males in spawning aggregations distinguished by uniform dark colouration of body and fins with vertical pale bars being reduced to indistinct pale saddles on dorsum. Anterior dorsal region from 3rd dorsal spine to snout tip paler, this pale area not extending below lower margin of eye (corresponds to lilac dorsal patch developed in spawning TP individuals); distal margin of spinous portion of dorsal fin pale; dental plates white.

TP: body dark greenish, margins of scales broadly edged with orange-red, this colour best developed on scale bases; anterior dorsal region of body back to 6th dorsal spine solid green to greenish grey, this colour not extending below lower margin of orbit; body with greenish yellow band extending from dorsal spines VII-IX to origin of anal fin; this band covers 10th to 13th scale rows of dorsum; upper region of this band bright yellow; anterior regions of body and head below dorsal green area dark brown to greenish, cheek slightly paler; snout pale reddish to brown; lips edged with blue; distinct pale bar on chin (in some specimens this may extend as faint line to eye); chin and isthmus paler; broad blue-green band from corner of mouth to anterior margin of eye; 2 horizontal green bands extending backward from eye; subopercle blue-green; dark green medial stripe extending from isthmus to vent; median fins orange, spotted with green, spots in single median row on dorsal and anal fins, usually confluent to form single median line on anterior dorsal and anal fins, distal margins of fins blue-green; caudal fin with spots aligned in 3 vertical bands; dorsal and ventral margins of caudal fin blue-green; pectoral fins pale greenish, becoming light brownish dorsally, base and upper margin blue-green, a dark spot in upper corner of pectoral base; pelvic fins blue with band of orange on first soft ray; dental plates greenish. During spawning episodes the following modifications occur in terminal colour pattern: body becomes dark brown to purplish overall; anterior dorsal green region becomes intense lilac colour with pinkish blotch over anterior region of snout; dorsal yellow spot and transverse greenish bar strongly emphasised against general darkening of body.

Major characteristic of living TP specimens is green area on head and dorsum, yellow dorsal patch and transverse band. These contrast strongly with dark body colouration. On removal from water these contrasts immediately reduced. In IP individuals removal from water is often followed by lightening of body colouration and loss of definition of pale bars.

On preservation most body markings of terminal phase are lost although blue-green markings on head and fins, and position of transverse bar and its yellow pigment remain distinct. IP individuals uniform dark brown after preservation with bluish bars on snout and chin remaining distinct. Preserved IP specimens are often confused with *S.psittacus*.

Colour transitional individuals of *S.schlegeli* (Plate 7G) are observed more frequently than in most other species of scarids.

Remarks. This species has previously been misidentified as *Scarus venosus*. However *S.venosus* is a junior synonym of *S.psittacus*, and *S.schlegeli* was therefore re-established as the valid name for this species (Randall & Choat, 1980). *Scarus schlegeli* is present in the western and central Pacific and the Indonesian Archipelago. It is replaced in the western Indian Ocean by the closely related *Scarus russelli* Valenciennes (Randall & Bruce, 1983). The Red Sea representative of this complex is *S.fuscopurpureus* (Fig.2).

TP specimens of *S.schlegeli* from the Great Barrier Reef differ from those in the central and western Pacific (Compare Plate 7 H & I). The main differences are in the disposition and extent of the transverse bar and associated vertical markings but there are also minor differences in fin shape and body proportions. Specimens from the Indo-west Pacific and northern tropical regions have two pale transverse bars on the body; the first below the 8th and 9th dorsal spines, and the second below the 3rd and 4th dorsal rays, commencing at the 14th scale row on the dorsum; these bars are separated by a dark area on the dorsum at the 12th and 13th scale rows; the anterior bar does not usually extend to the abdominal region and may be lost on death; the second bar extends the entire width of the body; both bars have characteristic bright yellow marks on the dorsal region; the body between the two transverse bars and immediately posterior to the second bar may be slightly darker. The greatest body depth is contained three times in the standard length.

TP individuals from the Great Barrier Reef and the southern Pacific (four specimens from Rapa and Tahiti examined in the Bishop Museum) display only a single transverse bar with the yellow marking below the 7th to 9th dorsal spines as described above. The greatest body depth is contained 2.4–2.6 times in the standard length. Five specimens from Okinawa, the Marshalls and the Carolines show the double transverse bars. The Great Barrier Reef material seems to be part of a southern Pacific distribution of this colour variant. The status of these variants is unclear. Bleeker's figure (1862: pl.12 fig.2) of a TP specimen from the Celebes (now Sulawesi) shows clearly that the original description refers to the central Pacific colour variant as does the original description of *Scarus cypho*. A specimen from the Abrolhos Islands, Western Australia (W.A. Museum P25307-001) display the double transverse bar colour pattern. More collecting in northern Australian waters is required to clarify the status of the TP colour variants. A number of recent works have provided good

illustrations of the central Pacific form of TP *S.schlegeli*. Schultz (1969: pl. 4A) shows a TP individual from the Philippines; Masuda et al. (1984) show a specimen from Japanese waters clearly illustrating the disposition of the transverse bars. Randall & Choat (1980: fig. 20) show the characteristic position of the yellow marking in central Pacific specimens.

Scarus schlegeli is a common scarid of sheltered habitats on mid-shelf reefs. Members of small feeding schools may often be observed browsing the algal and diatom covering of sand flats in lagoonal or deep reef habitats. It frequently forms mixed feeding schools with other scarids. This species is weakly diandric (Choat & Robertson, 1975). Both group and pair spawning have been observed at Lizard Island. Group spawning involved only 4 to 5 initial phase males. It is a scarid of moderate size, with terminal males reaching approximately 300 mm SL.

Scarus sordidus Forsskål
Plates 3I,J; 6E; 8E,F,G,H

- Scarus sordidus* Forsskål, 1775: X, 30 (type locality, Red Sea).
Scarus erythrodon Valenciennes in Cuvier & Valenciennes, 1840: 255 (type locality, Mauritius).
Scarus variegatus Valenciennes in Cuvier & Valenciennes, 1840: 256 (type locality, Mauritius).
Scarus purpureus Valenciennes in Cuvier & Valenciennes, 1840: 277 (type locality, Ulea = Woleai, Caroline Islands; preoccupied by *Scarus purpureus* Forsskål, 1775).
Scarus spilurus Valenciennes in Cuvier & Valenciennes, 1840: 279 (type locality, Caroline Islands).
Scarus gymnognathos Bleeker, 1853a: 498 (type locality, Batavia).
Scarus celebicus Bleeker, 1854c: 253 (type locality, Makassar, Celebes).
Pseudoscarus Goldiei Macleay, 1883: 590 (type locality, New Guinea).
Pseudoscarus margaritus Cartier, 1874: 105 (type locality, Cebu, Philippines).
Callyodon cyanogrammus Jordan & Seale, 1906: 330, fig. 63 (type locality, Apia, Samoa).
Pseudoscarus vitriolinus Bryan, 1906: 27, fig. 4 (type locality, Honolulu).
Callyodon rostratus Seale, 1909: 524, (type locality, Zamboanga, Mindanao; homonym of *Scarus rostratus* Poey).
Callyodon albipunctatus Seale, 1909: 526 (type locality, Sitanki Island, Jolo Archipelago, Philippine Islands).
Callyodon bipallidus Smith, 1955a: 936 (type locality, Pinda, Mozambique).

Material examined. HOLOTYPE of *Pseudoscarus goldei*, AMS I.16376-001. One specimen, Lord Howe Island, AMS I.17367-012; one specimen, Heron Island, AMS IB. 3862; seven specimens, One Tree Island, AMS I.15632-011, I.20205-023, I.20213-004, I.20826-016; one specimen, Sir Charles Hardy Island, I.20770-062; one specimen, Broadhurst Reef, QM 10353; three specimens, Escape Reef, AMS I.22601-008, I.22611-009, I.22586-041; 15 specimens, Lizard Island, AMS I.18739-020, I.18755-102, I.19444-008, I.19462-001, I.19482-105; one specimen, Rowley Shoals, Western Australia, WAM P.27658-035; 30 specimens, Heron Island, not retained; 18 specimens, Lizard Island, not retained.

Diagnosis. Median predorsal scales 4, subequal becoming progressively larger anteriorly; 2 rows of cheek scales, upper with 5–7 scales, lower with 5–7 scales; pectoral rays 14–15, usually 15; mouth terminal, dental plates broadly exposed, lips covering less than half plates; large individuals with up to 2 canines on side of upper dental plate, none on lower.

Colour pattern. Juvenile: body white to pale brownish with 4 dark brown to black longitudinal stripes, first from occipital region along dorsum to end of dorsal fin, 2nd from snout through eye to caudal peduncle, 3rd from chin through pectoral base to caudal peduncle, 4th from opercular margin along abdomen to end of anal fin; dark mid-dorsal stripe along base of dorsal fin, ends of 2nd and 3rd longitudinal stripes may be enlarged to form black blotch at base of caudal peduncle; fins pale hyaline brown, lacking any distinctive markings. Intensity of dark stripes may vary rapidly in same individual to extent that black stripes merge into a darker background colouration.

IP: body dark brown scales sometimes edged in dull yellow, general body colouration becoming paler anterodorsally, 2 longitudinal rows of 3–4 whitish spots often present on the darker posterior region of body; head grey-brown shading to light red ventrally and around mouth, dental plates pale salmon becoming whitish on edges, series of yellowish reticulations on head across interorbital and especially on post-orbital region, cheek scales faintly edged in yellowish brown, iris yellow; dorsal fin reddish brown; anal, caudal and pelvic fins brown; pectoral fins with pale membranes and dark brown rays. Body of IP and large juvenile individuals may be darker brown overall with caudal peduncle and fin abruptly greyish white with large round dark spot in centre of the caudal peduncle. These colour patterns may interchange rapidly in the same individual.

TP: body green with edges of scales pinkish; caudal peduncle and base of fin light green; thorax and abdomen bluish, often with a pink caste, with 2 longitudinal green stripes and median green ventral stripe from chin to vent; occiput green with snout bluish green; sides of head above cheek faintly pink, cheek green then yellowish to orange ventrally; 2 green postorbital bands, upper extending anterior to orbit, green band on snout and broad green band on chin joining behind mouth to form diffuse green line running to posterior margin of orbit and opercular margin; dental plates green; basal region of dorsal fin green, medial region pinkish with dark green spots on each interradiation membrane, outer margin dark green; anal fin with narrow basal green area, pink stripe then broad green band; caudal fin dark green or bluish green, upper and lower margins green with submarginal pink zone (fin membranes may be pinkish); pectorals pale green with upper and medial rays darker green; pelvics pale green, spine and anterior rays darker green.

Small TP individuals often darker green overall with abruptly paler caudal peduncle (Plate 8G); larger individuals paler. When reproductively active, dorsoposterior region of body becomes yellow (Plate

8H), remainder of body yellowish green with snout and caudal fin bluish.

Remarks. Randall & Bruce (1983) provided a review of some aspects of the synonymy of *S.sordidus* which belongs to a complex of closely related species, most of which replace each other in a series from the Red Sea to the central Pacific. Apart from *S.sordidus*, which occurs across the whole range of this complex, Great Barrier Reef waters harbour the closely related *S.pyrrhurus* which is the western-most member of this series. This species was recorded from New Guinea by Munro (1967) as *Xanophon erythrodon* and *S.sordidus*.

Scarus sordidus is one of the most abundant and widely distributed of all scarids. It is probably the commonest scarid on the Great Barrier Reef and one of the few to occupy all the reef habitats examined. *Scarus sordidus* is consistently abundant through mid-shelf, outer and Coral Sea reefs (D. Williams, pers. comm.). It extends through northern Australian waters into Western Australia where it may be found in temperate reef environments (Hutchins & Thompson, 1983). This species is diandric; its reproductive behaviour appears to be highly variable, with populations in deeper water having a smaller proportion of primary males than those on the reef crest (Choat & Robertson, 1975). Group spawning has not been observed on the Great Barrier Reef although it is highly probable that it occurs in a fashion similar to that seen in *S.schlegeli*.

Scarus spinus (Kner)

Plates 3A,B; 7C

Pseudoscarus spinus Kner, 1868: 354, pl. 9, fig. 27 (type locality, Kandavu, Fiji Islands).

Callyodon kelloggi Jordan & Seale, 1906: 327, fig. 62 (type locality, Apia, Samoa).

Material examined. Two specimens, One Tree Island, AMS I.20582-003, I.20583; one specimen, Escape Reef, AMS 22611-009; three specimens, Lizard Island, AMS I.19445-015, I.19462-012, I.19473-034; ten specimens, Heron Island, not retained.

Diagnosis. Median predorsal scales generally 4, but varies from 3–5 (anterior scale may be small and embedded); directly anterior to first median scale (hence above posterior part of eye) a transverse pair of smaller scales which overlap medially in mid-dorsal line, these not counted as median predorsals; rows of scales on cheek 3, upper row 5–7 scales (usually 5) middle row with 5–7 scales, ventral row with 1–2 (usually 2) scales; pectoral rays 13–14 (usually 14); caudal fin of IP slightly rounded to truncate, of TP moderately to deeply emarginate; dental plates covered by lips; adults in IP generally with no canines on upper dental plate and 1 on lower; TP fish with 1–2 upper canines and 1–2 lowers, the lowermost (when there are 2) very large and projecting diagonally backward. Shape of front of head of TP distinctive, being bluntly rounded, dorsal and

ventral profiles being almost identical. Heads of IP fish not as obtuse.

Colour pattern. IP: body dark brown with distinctive velvety appearance, shading on side of head and ventrally on head and body to reddish brown; body with 4–5 indistinct pale bars 1–2 scales in width (bars formed by pale central parts of scales), 1st beneath 3rd to 4th dorsal spines, 2nd below 8th dorsal spine, 3rd below 3rd–4th dorsal rays, 4th below 8th–9th dorsal rays, and 5th, when visible, crossing caudal peduncle; fins reddish brown except membranes of about lower $\frac{2}{3}$ of pectoral fins which are pale; dental plates white. In life, pale bars may appear almost white; fish can turn this pattern on and off rapidly. Care should be taken when identifying IP individuals underwater to ensure that they are not confused with small IP *S. schlegeli*. (See Plate 7 C&D).

TP: Scales of body green, narrowly edged in rose; most of upper lip and snout above it chartreuse; operculum and cheek yellow to yellowish; broad zone of blue-green from interorbital down side of snout to lower lip and chin; nape green; large individuals may have pale rose to violet streak passing ventrally from front of eye; upper lip narrowly salmon (though this colour may not be continuous along entire margin); 2 large curved transverse salmon bands on chin, uppermost nearly reaching margin of lower lip and ending just below corner of mouth; dorsal and anal fins with basal band of green, median band of salmon, and margin of blue; unscaled part of caudal fin with blue lobes, each containing median streak of salmon to orange, broad hemispherical posterior part of fin green; upper half of pectorals blue-green with streak of rose, lower half greenish shading to pale distally; pelvic fins blue to blue-green with broad band of orange submarginal to lateral edge. Coleman (1981) provides an excellent underwater illustration of a TP individual.

Remarks. This parrotfish has been previously identified in the literature as *Scarus formosus* Valenciennes. A review of recent taxonomic changes and the distribution of this species is provided by Randall & Choat (1980). *Scarus spinus* is known from the Philippines and the western and central Pacific; it is very similar to *Scarus viridifucatus* of the Indian Ocean. On the Great Barrier Reef it is most common on mid-shelf reefs but has also been observed on outer shelf and Coral Sea reefs. It is characteristic of reef crest and the shallower parts of outer-reef slope habitats. *Scarus spinus* feeds individually or may join mixed schools. It is nowhere abundant. Pair spawning has been observed and the species is diandric. It is one of the smaller scarids on the Great Barrier Reef, the largest individual collected being 225 mm SL.

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PLATE 1

- 1A *L. vaigiensis* IP ♀
179 mm Mauritius
- 1C *C. spinidens* IP ♀
119 mm Negras,
Philippines
- 1E *C. carolinus* TP ♂
318 mm Honolulu
- 1G *C. bicolor* IP ♀
370 mm Guam
- 1I *H. longiceps* IP ♀
282 mm Rangiroa,
Tuamotu Islands
- 1B *L. vaigiensis* TP ♂
159 mm Mauritius
- 1D *C. carolinus* IP ♀
235 mm Honolulu
- 1F *B. muricatum* Adult ♂
510 mm Fanning Is.,
Line Islands
- 1H *C. bicolor* TP ♂
347 mm Takarao,
Tuamotu Islands
- 1J *H. longiceps* TP ♂
303 mm Half Mile
Pass, GBR

PLATE 2

- 2A *S. rubroviolaceus* IP ♀
308 mm La Digue,
Seychelles
- 2C *S. gibbus* Red Phase ♀
393 mm Papeete, Tahiti
- 2E *S. psittacus* IP ♀
171 mm Lizard Is.,
GBR
- 2G *S. schlegeli* IP ♀
175 mm Tongatapu,
Tonga
- 2I *S. flavipectoralis* IP ♀
158 mm Alele Reef,
Solomons
- 2B *S. rubroviolaceus* TP ♂
355 mm Enewetak,
Marshall Islands
- 2D *S. gibbus* Green Phase
♂, 417 mm Teavaraa
Pass, Tahiti
- 2F *S. psittacus* TP ♂
228 mm Lizard Is.,
GBR
- 2H *S. schlegeli* TP ♂
240 mm Lizard Is.,
GBR
- 2J *S. flavipectoralis* TP ♂
206 mm Enewetak,
Marshall Islands

PLATE 3

- 3A *S. spinus* IP ♂
118 mm Heron Is.,
GBR
- 3C *S. chameleon* IP ♀
170 mm Lizard Is.,
GBR
- 3E *S. longipinnis* IP ♀
212 mm Pitcairn Is.
- 3G *S. pyrrhurus* IP ♀
117 mm Guadalcanal,
Solomons
- 3I *S. sordidus* IP ♀
164 mm Moorea, Tahiti
- 3B *S. spinus* TP ♂
144 mm Ponape,
Caroline Islands
- 3D *S. chameleon* TP ♂
209 mm Sumilon Is.,
Philippines
- 3F *S. longipinnis* TP ♂
193 mm One Tree Is.,
GBR
- 3H *S. pyrrhurus* TP ♂
220 mm Guadalcanal,
Solomons
- 3J *S. sordidus* TP ♂
227 mm Lizard Is.,
GBR

PLATE 4

- 4A *S. bleekeri* IP ♂
185 mm Fiji
- 4C *S. rivulatus* IP ♀
213 mm Lizard Is.,
GBR
- 4E *S. globiceps* IP ♀
166 mm Lizard Is.,
GBR
- 4G *S. oviceps* IP ♀
198 mm Teavaraa Pass,
Tahiti
- 4I *S. dimidiatus* IP ♀
192 mm Alele Reef,
Solomons
- 4B *S. bleekeri* TP ♂
200 mm Truk
- 4D *S. rivulatus* TP ♂
275 mm One Tree Is.,
GBR
- 4F *S. globiceps* TP ♂
222 mm Palmyra, Line
Islands
- 4H *S. oviceps* TP ♂
218 mm Alele Reef,
Solomons
- 4J *S. dimidiatus* TP ♂
189 mm Alele Reef,
Solomons

PLATE 5

- 5A *S. niger* Adult ♀
198 mm Enewetak,
Marshall Islands
- 5C *S. frenatus* IP ♀
217 mm Lord Howe Is.
- 5E *S. forsteni* IP ♀
249 mm One Tree Is.,
GBR
- 5G *S. ghobban* IP ♀
228 mm Ponape,
Caroline Islands
- 5I *S. altipinnis* IP ♀
262 mm Teavaraa Pass,
Tahiti
- 5B *S. frontalis* Adult ♂
350 mm Marcus Is.
- 5D *S. frenatus* TP ♂
234 mm Sudan, Red
Sea
- 5F *S. forsteni* TP ♂
252 mm Tahiti
- 5H *S. ghobban* TP ♂
255 mm Fanning Is.,
Line Islands
- 5J *S. altipinnis* TP ♂
234 mm Palmyra, Line
Islands

PLATE 6

- 6A *B. muricatum* Juvenile
105 mm Seribu Is.,
Java
- 6C *S. gibbus* Juvenile
59 mm Tahiti
- 6E *S. sordidus* Juvenile
37 mm Jana Is.,
Persian Gulf
- 6G *S. niger* Juvenile
45 mm Tahiti
- 6I *C. bicolor* Juvenile
100 mm Maldives
- 6B *H. longiceps* Juvenile
38 mm Port Moresby,
Papua New Guinea
- 6D *S. psittacus* Juvenile
43 mm Enewetak,
Marshall Islands
- 6F *S. altipinnis* Juvenile
47 mm Tahiti
- 6H *S. forsteni* Juvenile
41 mm Tutuila, Samoa
- 6J *S. frenatus* Juvenile
100 mm Lizard Is.,
GBR

PLATE 7

- 7A *S. gibbus* Juvenile
65 mm Enewetak,
Marshall Islands
- 7C *S. spinus* IP
140 mm Heron Is.,
GBR (D.R. Robertson)
- 7E *S. schlegeli* IP
185 mm Vava'u, Tonga
- 7G *S. schlegeli* Transitional
220 mm Lizard Is.,
GBR (A.M. Ayling)
- 7I *S. schlegeli* TP
200 mm Enewetak,
Marshall Islands
Central Pacific Variant
- 7B *S. gibbus* Green Phase
480 mm Enewetak,
Marshall Islands
- 7D *S. spinus* IP
110 mm Heron Is.,
GBR (D.R. Robertson)
- 7F *S. schlegeli* IP
210 mm Lizard Is.,
GBR (A.M. Ayling)
- 7H *S. schlegeli* TP
Lizard Is., GBR
(R. Kuitert)
- 7J *S. longipinnis* IP
165 mm Vava'u, Tonga

PLATE 8

- 8A *S. psittacus* Juvenile
50 mm Enewetak,
Marshall Islands
- 8C *S. psittacus* TP
Maldives
- 8E *S. sordidus* Juvenile
50 mm Lizard Is., GBR
- 8G *S. sordidus* TP
180 mm Lizard Is.,
GBR (A.M. Ayling)
- 8I *S. bleekeri* IP
Carter Reef, GBR
- 8B *S. psittacus* IP
150 mm Maldives
- 8D *S. psittacus* TP
Lizard Is., GBR
(R. Kuitert)
Reproductive
colouration
- 8F *S. sordidus* IP
150 mm Lizard Is.,
GBR
- 8H *S. sordidus* TP
Lizard Is., GBR
(R. Kuitert)
Reproductive
colouration
- 8J *S. bleekeri* TP
Lizard Is., GBR (R.
Kuitert)

Unless stated all photographs taken by the junior author. All lengths refer to Standard Length. All specimens from tank shots (Plates 1-6) deposited in the Bishop Museum.

PLATE 9

- | | |
|---|--|
| 9A <i>S. frontalis</i> Adult
240 mm Enewetak,
Marshall Islands | 9B <i>S. rubroviolaceus</i> IP
Lizard Is., GBR
(R. Kuiter) |
| 9C <i>S. rubroviolaceus</i> TP
550 mm Enewetak,
Marshall Islands
(Night) | 9D <i>S. chameleon</i> Juvenile
60 mm Lizard Is., GBR |
| 9E <i>S. chameleon</i> IP
160 mm Lizard Is.,
GBR | 9F <i>S. chameleon</i> IP
180 mm Lizard Is.,
GBR |
| 9G <i>S. chameleon</i> TP
Lizard Is., GBR
(A.M. Ayling) | 9H <i>S. chameleon</i> TP
Lizard Is., GBR
(R. Kuiter) |
| 9I <i>S. flavivectoralis</i> IP
190 mm Enewetak,
Marshall Islands | 9J <i>S. flavivectoralis</i> TP
240 mm Lizard Is.,
GBR |

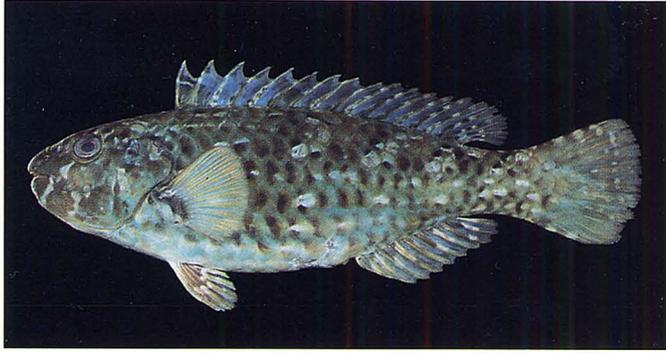
PLATE 10

- | | |
|---|--|
| 10A <i>S. altipinnis</i> Juvenile
38 mm Tongtapu,
Tonga | 10B <i>S. altipinnis</i> IP
415 mm Enewetak,
Marshall Islands
(Night) |
| 10C <i>S. altipinnis</i> TP
470 mm Enewetak,
Marshall Islands | 10D <i>S. ghobban</i> IP
215 mm Kwajalein,
Marshall Islands |
| 10E <i>S. forsteni</i> IP
Lizard Is., GBR | 10F <i>S. forsteni</i> TP
Lizard Is., GBR |
| 10G <i>S. oviceps</i> Juvenile
95 mm Tongtapu,
Tonga | 10H <i>S. frenatus</i> IP
Seychelles |
| 10I <i>S. frenatus</i> TP
Seychelles | 10J <i>S. niger</i> Juvenile
50 mm Lizard Is., GBR |

PLATE 11

- | | |
|---|---|
| 11A <i>S. niger</i> Adult
240 mm Lizard Is.,
GBR | 11B <i>S. globiceps</i> IP
150 mm Heron Is.,
GBR (D.R. Robertson) |
| 11C <i>S. globiceps</i> TP
180 mm Half Mile Pass,
GBR | 11D <i>S. rivulatus</i> IP
Lizard Is., GBR
(R. Kuiter) |
| 11E <i>S. rivulatus</i> TP
Lizard Is., GBR
(A.M. Ayling) | 11F <i>S. rivulatus</i> IP
Lizard Is., GBR
Normal IP Colouration |
| 11G <i>S. rivulatus</i> IP
Lizard Is., GBR
Variant IP colouration | 11H <i>S. rivulatus</i> IP
Lizard Is., GBR
♀ Reproductive
colouration |
| 11I <i>S. rivulatus</i> IP
Lizard Is., GBR
IP ♂ Reproductive
colouration | 11J <i>S. rivulatus</i> TP
Lizard Is., GBR
TP ♂ Reproductive
colouration |

PLATE 1



A



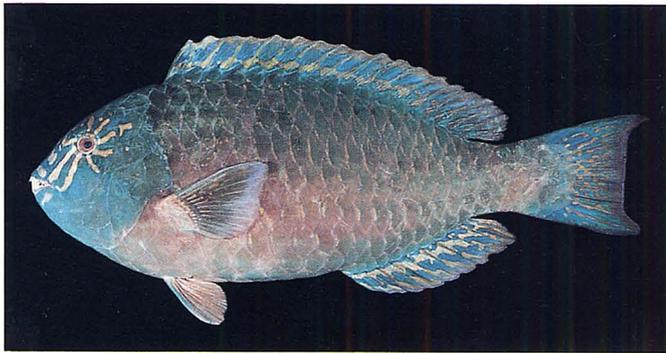
B



C



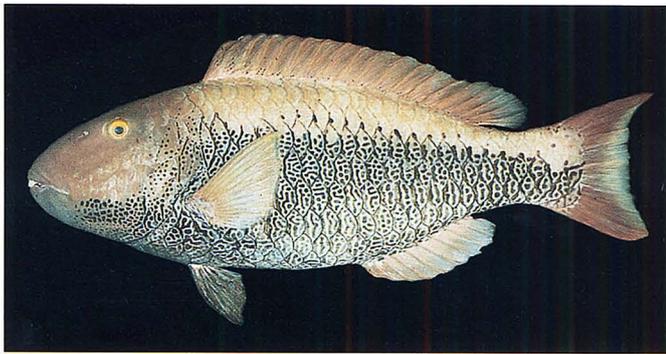
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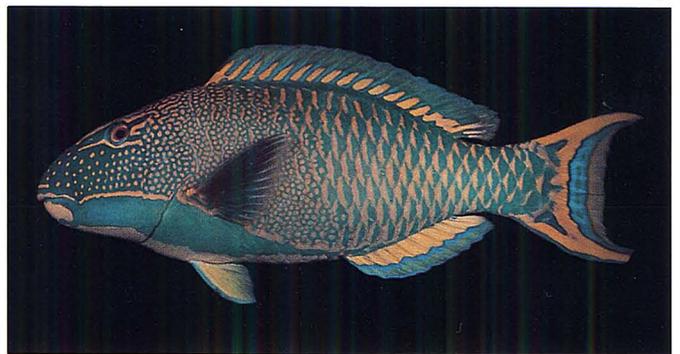
E



F



G



H

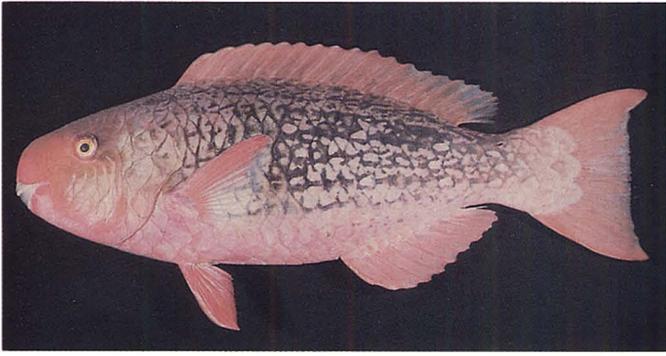


I

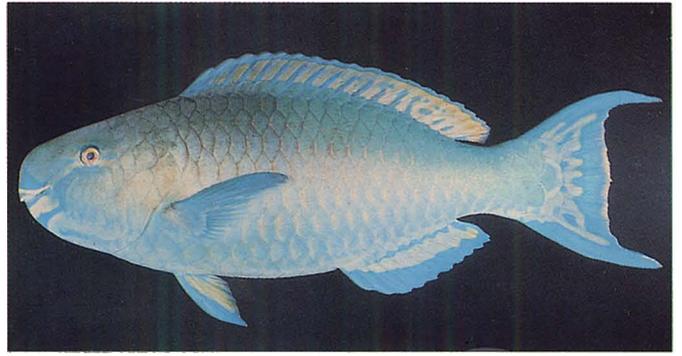


J

PLATE 2



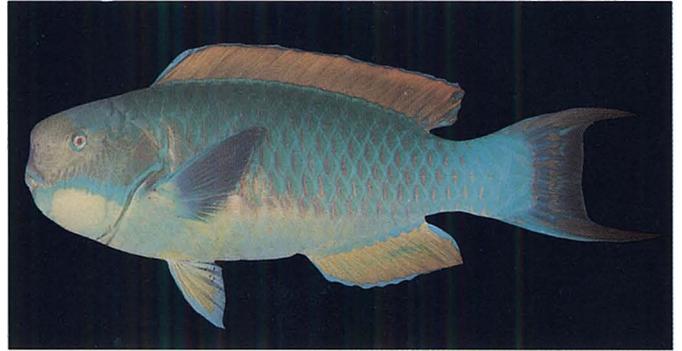
A



B



C



D



E



F



G



H

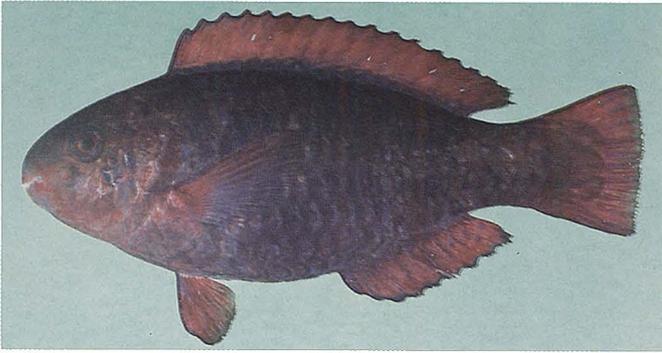


I



J

PLATE 3



A



B



C



D



E



F



G



H

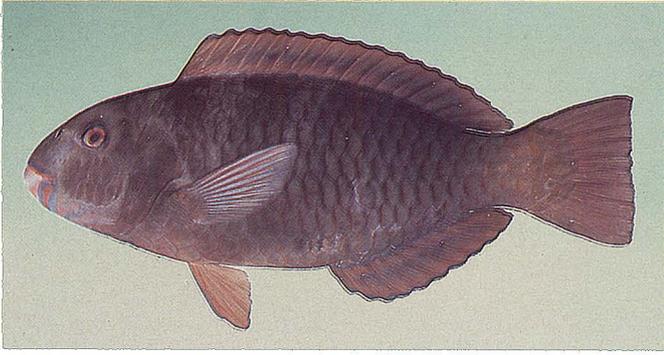


I



J

PLATE 4



A



B



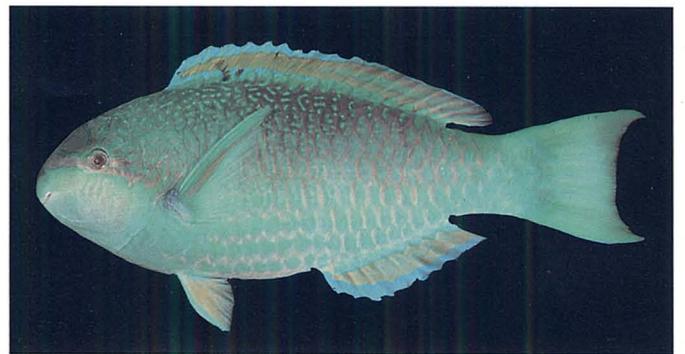
C



D



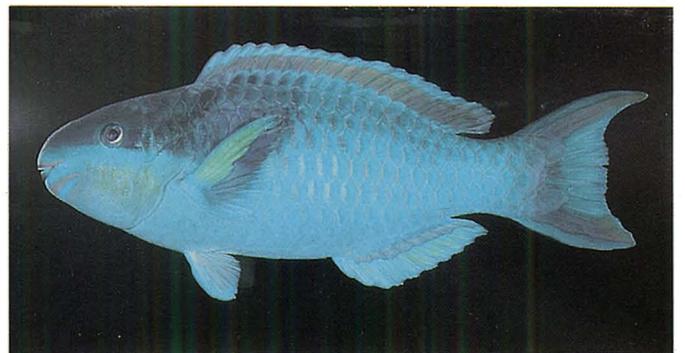
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F



G



H

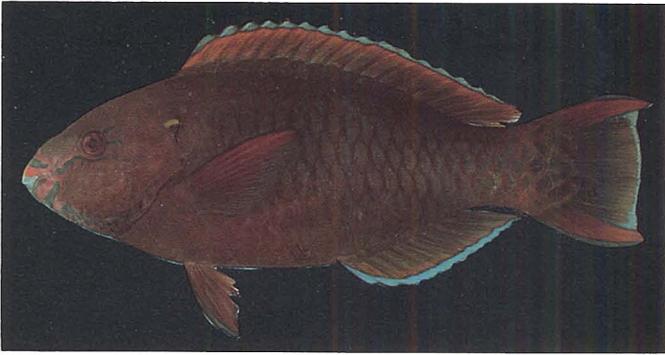


I



J

PLATE 5



A



B



C



D



E



F



G



H



I



J

PLATE 6



A



B



C



D



E



F



G



H



I



J

PLATE 7



A



B



C



D



E



F



G



H



I



J

PLATE 8



A



B



C



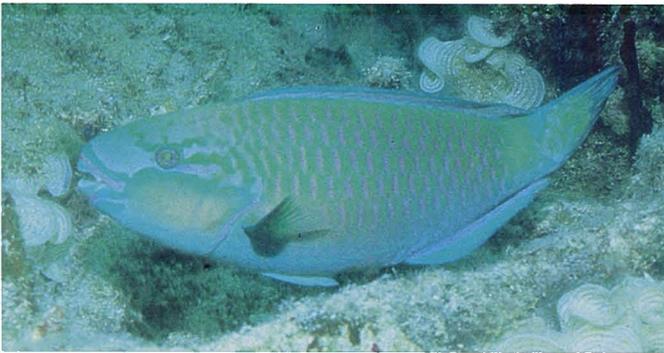
D



E



F



G



H



I

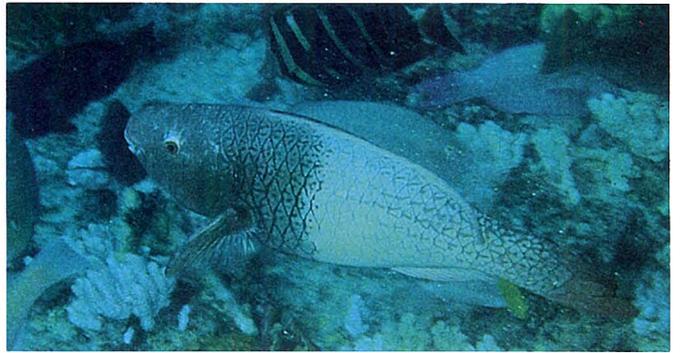


J

PLATE 9



A



B



C



D



E



F



G



H



I



J

PLATE 10



A



B



C



D



E



F



G



H



I



J

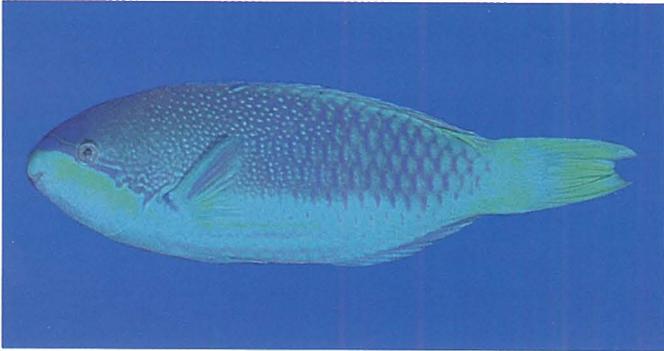
PLATE 11



A



B



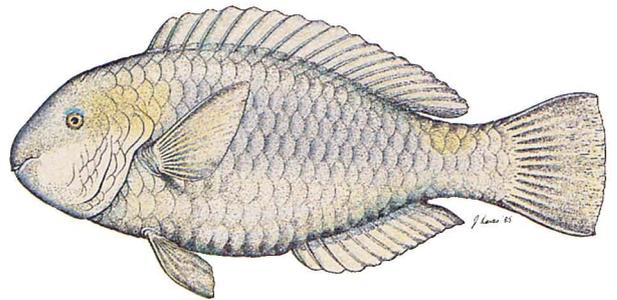
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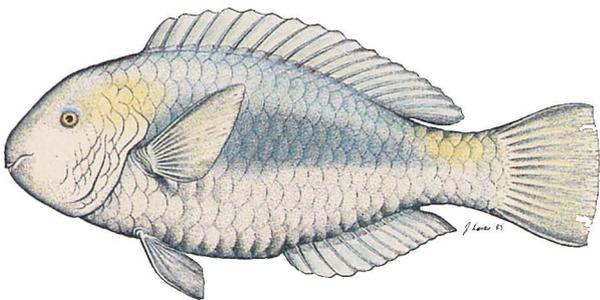
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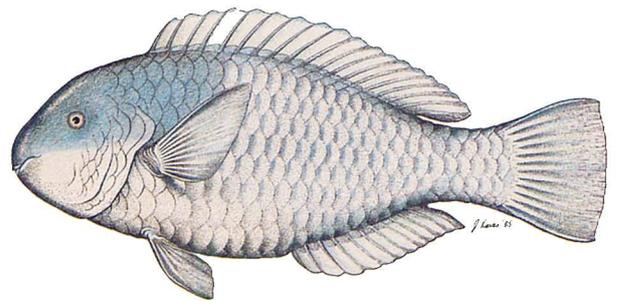
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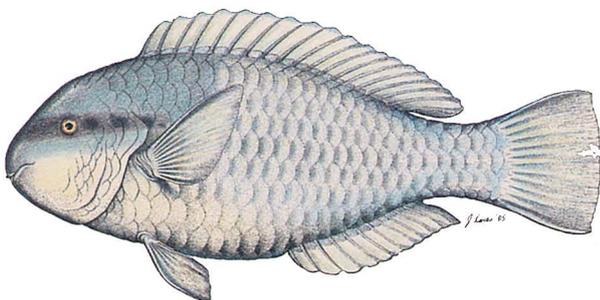
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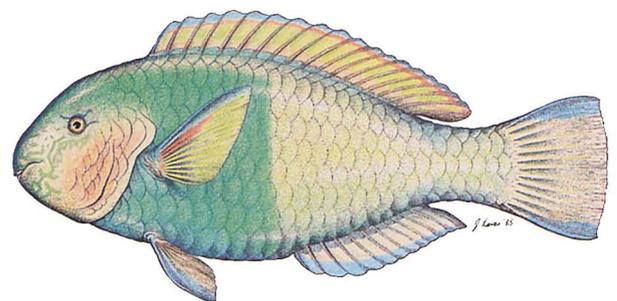
G



H



I



J