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A Description of the Juvenile Phase Colour Patterns of 24 Parrotfish Species (Family Scaridae) from the Great Barrier Reef, Australia

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ABSTRACT. The juvenile colour patterns of 24 of the 27 parrotfish species presently recorded from the Great Barrier Reef are described. Two from the subfamily Sparisomatinae: *Calotomus carolinus* (Valenciennes) and *Leptoscarus vaigiensis* (Quoy & Gaimard). Twenty two from the subfamily Scarinae: *Bolbometopon muricatum* (Valenciennes); *Cetoscarus bicolor* (Rüppell); *Hipposcarus longiceps* (Valenciennes); *Scarus altipinnis* Steindachner; *Scarus bleekeri* (de Beaufort); *Scarus chameleon* Choat & Randall; *Scarus dimidiatus* Bleeker; *Scarus flavipectoralis* Schultz; *Scarus forsteni* (Bleeker); *Scarus frenatus* Lacepède; *Scarus ghobban* Forsskål; *Scarus gibbus* Rüppell; *Scarus globiceps* Valenciennes; *Scarus longipinnis* Randall & Choat; *Scarus niger* Forsskål; *Scarus oviceps* Valenciennes; *Scarus psittacus* Forsskål; *Scarus rivulatus* Valenciennes; *Scarus rubroviolaceus* Bleeker; *Scarus schlegeli* (Bleeker); *Scarus sordidus* Forsskål; *Scarus spinus* (Kner). Descriptions are given of the ontogeny of the colour patterns, where possible, from early post-settlement to the transition to the initial phase. Descriptions are based on field observations with additional colour notes on fresh and preserved specimens. Meristic data are also provided. Particular emphasis is placed on the size related ontogeny of colour patterns, with additional notes on short-term behavioural changes. The descriptions are intended for field identification of juvenile scarids; a rapid field identification guide and ecological notes on each species are given to facilitate field identification; specific notes for distinguishing species in the field are included. All species can be identified to the species level with the exception of two pairs of closely related species: *S. rivulatus* - *S. globiceps* and *S. psittacus* - *S. schlegeli*. Colour plates of live and/or fresh specimens of 22 species are given, sequential colour pattern changes are shown for some species. Most juvenile scarids share a common series of colour pattern changes during the early post-settlement period. These patterns are described and figured, and exceptions noted. Juvenile scarids likewise share a typical pattern of stripes and/or bars. The standard patterns are described and used as a basis for describing intraspecific differences in colour patterns.The juvenile colour patterns are discussed in relation to species complexes and adult relationships. The functions of juvenile colour patterns in relation to the ecology of juvenile scarids are also discussed. Two associations are described: schooling species bearing uniformly pale or striped patterns and solitary species with complex patterns.

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Contents

The Scaridae is a distinctive family of herbivorous coral reef fishes, a prominent feature of which is the striking pattern of colour changes observed in most species. Most scarids display three distinct colour phases: a juvenile phase, an initial phase and a terminal phase, with the latter two phases corresponding to sexual stages in their protogynous life history. These three colour phases are usually distinct.

The changes in colour pattern throughout the life history of scarids have resulted in considerable taxonomic confusion. Only in the last decade have an increased knowledge of sexual ontogeny and detailed field observations on reproductive behaviour provided a reliable basis for linking the sex-related colour phases in many species. Extensive collections have helped resolve many of the problems associated with closely related species complexes distributed across wide geographic areas. Despite these advances, however, the juvenile phase of most species remains either poorly described or unknown.

One of the first steps towards an understanding of the structure and dynamics of reef fish populations is the ability to identify species during the early post-settlement and juvenile phases. Recent studies of the ecology of coral reef fishes have emphasised the importance of settlement and early post-settlement events in determining the structure of reef fish communities. Although scarids are a major component of the herbivorous reef fish community, the biology of juvenile scarids is poorly understood. This is primarily a result of taxonomic difficulties. It is important that this taxonomic impediment be overcome so that studies of the biology of juvenile herbivorous reef fishes may benefit from reliable species identifications of juvenile scarids. An identification guide is therefore a prerequisite to future studies of this group.

Despite the number of taxonomic studies on adult scarids no previous studies have focused solely on the identification of juvenile scarids. Descriptions of the juvenile colour phases of many species are lacking. Some descriptions, as in Schultz (1958), are based on museum specimens and are therefore of limited use for field identifications. A few descriptions of juvenile scarids in recent publications have been accompanied by colour plates and/or notes on the live colouration, but these descriptions are restricted to moderately large specimens.

The problems of identifying juvenile scarids are distinct

from those faced when identifying adults. The external morphology and meristic counts of most scarid species are extremely similar. This is a problem in adults but is further exacerbated in juveniles as many diagnostic characteristics, such as canine teeth or caudal fin extensions, are not developed. Descriptions must therefore be based primarily on colour patterns. Although there are no sex-related differences in juvenile colour patterns, most species do undergo marked changes during the juvenile phase. Descriptions of the colour patterns of variously sized juveniles are therefore of primary importance for field identifications. As the criteria used to distinguish juveniles differ from those used to separate adults, the two life stages need to be considered separately. This study therefore, specifically addresses the problem of identifying juvenile scarids.

In a study of the scarids of the Great Barrier Reef, Choat & Randall (1986) described the adult colour phases of 27 species. Descriptions of the juvenile phase of some species were included but these were typically of specimens larger than 50mm SL. In the present study, the descriptions are concentrated on the identification of juveniles during the early post-settlement period, with notes on the ontogeny of the colour patterns, where possible, from settlement to the initial phase. The present study is primarily restricted to a single geographic region, the Great Barrier Reef, although many of the species are present throughout the Indo-Pacific. Twenty four of the 27 scarid species recorded from the Great Barrier Reef by Choat & Randall (1986) are described. Juvenile specimens of the three remaining species *Calotomus spinidens* (Quoy & Gaimard), *Scarus frontalis* Valenciennes and *Scarus pyrrhurus* (Jordan & Seale) were not observed in the field or represented in collections from eastern Australia. Species designations follow Choat & Randall (1986), who provide a synonymy of each species and notes on their geographic distributions. The present study is primarily aimed as a guide for field identifications based on colour notes, colour plates and field observations. Additional notes on meristics and colour in alcohol also enable most species to be identified in preserved collections.

Materials and Methods

The main study and collection areas were on reefs around Lizard Island (14°40'S, 145°28'E), a continental island 30 km from the mainland and 18 km from the outer barrier reef. Lizard Island has a typical midshelf assemblage of herbivorous reef fishes (Choat & Bellwood, 1985; cf. Williams, 1982; Russ, 1984). Additional specimens were observed and collected by both authors from several other reefs in the vicinity of Lizard Island, Cairns and Townsville. The senior author also observed and collected specimens from the Central Visayas, Philippines; the junior author from the southern Great Barrier Reef (GBR). The study period extended from June 1981 to January 1984, with field work being concentrated during November to January (the peak settlement period). Field observations were made using SCUBA, with notes recorded on PVC sheets. Size and individual variations in colour patterns or the presence of scars enabled individuals of some species to be recognised for periods up to two years. Schooling species or those with variable colour patterns were tagged using subcutaneous injections of paint, following the technique of Thresher & Gronell (1978). Several species were maintained in aquaria for up to ten weeks to follow changes in their colour patterns during ontogeny.

Specimens were collected using a variety of techniques. Individuals under 11 mm SL were collected using small (220 x 125mm), clear self-seal polythene bags. Individuals between 11 and 35mm SL were captured using large, clear polythene bags (940 x 615mm). These bags were used as traps, with the mouth held open by coral or coral rubble. This technique is most efficient for small specimens. Above 35 mm SL, specimens were either speared using a modified Hawaiian sling and multiprong spear or were caught using a small mesh (7 mm square) barrier net and hand-net. Specimens were fixed in 10% seawater-formalin and stored in 70% alcohol.

Photographic records were taken of representative specimens of each species using a modified version of the technique described by Randall (1961). Specimens were killed by placing them in a deep freeze. Immediately after death, they were placed on a polystyrene base. Their fins were raised and held in place by strips of polythene secured by pins and irrigated with 40% formaldehyde for approximately five minutes. Care was taken to keep the eye moist, but not fixed. The specimens were then photographed in a vertical photographic tank. All photographs were taken by the senior author unless stated otherwise.

In the present study, settlement refers to the process of postlarval individuals moving from the plankton to the reef. Recently settled individuals are usually 8 to 10 mm SL and have incomplete pigmentation. The term juvenile refers to immature individuals, from 10 mm SL to the size at which they display the full initial phase colouration. Immature individuals with the full initial phase colouration are referred to as subadults. The size at sexual maturity varies from 67 to at least 315 mm SL, depending on the species, but is usually between 100 to 140 SL. The term initial phase (IP) refers to subadult and adult females, and primary males; terminal phase (TP) refers to secondary males or colour transformed primary males. A key and descriptions of the IP and TP colour phases of all GBR scarid species are given in Choat & Randall (1986).

Diagnostic meristic data include the number of median predorsal scales, the number of cheek scale rows, the number of scales in the ventral cheek scale row, and the number of pectoral fin rays. Median predorsal scales are counted from the most anterior scale. The form of small lateral or overlapping scales anterior to the first median predorsal scale and the relative sizes of the median predorsal scales are also noted. Cheek scale rows are horizontal scale rows between the lower edge of the orbit and the horizontal margin of the preoperculum. Counts of the pectoral rays included the upper rudimentary ray which is unbranched. No distinction is made between the

upper two unbranched rays and the remaining branched rays. All lengths refer to the standard length (SL), the straight-line distance from the tip of the snout to the base of the caudal fin.

The identification of preserved specimens is often dependent upon both scale counts and the pattern of the scales. The form of the median predorsal scales, in particular, is often diagnostic. The various median predorsal scale patterns are summarised in Fig. 1. Scale sizes are measured from the base of the scale or the posterior edge of the preceding scale to the posterior edge of the scale. Small lateral or overlapping scales anterior to the first median predorsal scale are identified but are not included in the median predorsal scale count.

The scale counts of all species increases during the early postsettlement period. The median predorsal scales are usually apparent at about 13 mm, with the full complement of scales developing simultaneously. Cheek scales are apparent at 14 mm and increase slowly in number, with scales developing anteriorly. The third or ventral row is the last of the rows to develop. The full complement of cheek scale rows is present at 20 mm.

In most species, the scale counts of specimens greater than 20 mm are indistinguishable from those of larger juveniles and adults. In some species, the relative size of the scales may change. For example, the first median predorsal scale is largest in juvenile *S. psittacus* and *S. schlegeli* whilst the second scale is largest in adults. The embedding of the anterior cheek scales recorded in adult *B. muricatum* and *C. bicolor* does not occur during the

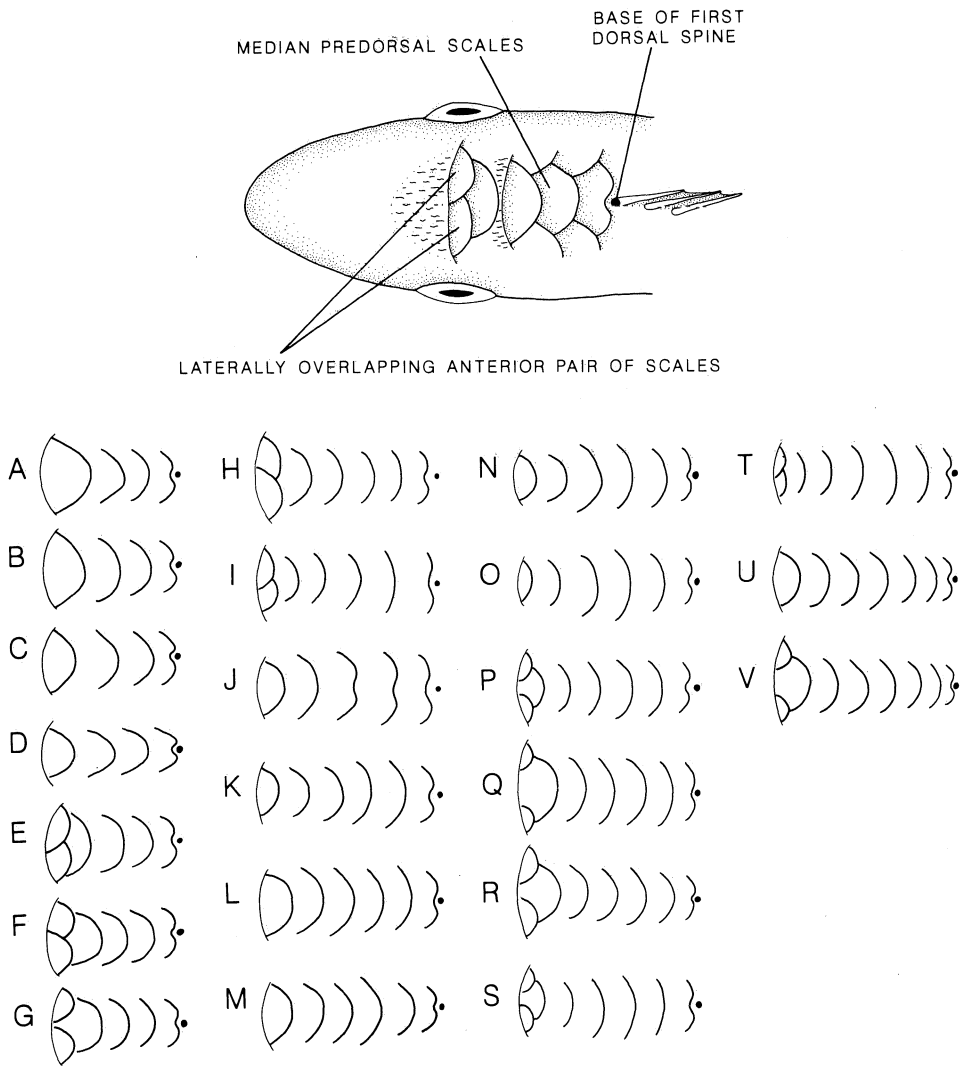


Fig.1. Variations in the form of the median predorsal scales of juvenile scarids from the Great Barrier Reef. *C. carolinus* - A; *L. vaigiensis* - D; *C. bicolor* - K,N; *B. muricatum* - J; *H. longiceps* - A,(B); *S. altipinnis* - O; *S. bleekeri* - B,(A); *S. chameleon* - F,(G,H); *S. dimidiatus* - M,O,(U); *S. flavipectoralis* - A; *S. forsteni* - T,(I); *S. frenatus* - M,R,(U,V); *S. ghobban* - O,(S); *S. gibbus* - B,(A); *S. globiceps* - I,(J,Q,L); *S. longipinnis* - A,C; *S. niger* - U,(M,Q,V); *S. oviceps* - *M,O,(P);* *S.psittacus* - A; *S. rivulatus* - O,L,(T,I); *S. rubroviolaceus* - N; *S. schlegeli* - A; *S. sordidus* - A,(B); *S. spinus* - E. Letters in parentheses refer to the occasional occurrence of unusual scale forms.

juvenile phase.

Voucher specimens were deposited in and specimens examined from the Australian Museum, Sydney (AMS); British Museum (Natural History), London (BMNH); California Academy of Sciences, San Francisco (CAS); National Museum of Natural History, Smithsonian Institution, Washington D.C. (USNM).

Species Descriptions

The species descriptions are in alphabetical order. Each description follows a standard format.

MATERIAL EXAMINED provides reference numbers and details of the preserved specimens examined in this study. In addition, numerous freshly collected specimens were examined.

The DIAGNOSIS is based solely on material examined in this study. The terminology follows that of Choat & Randall (1986). All lengths refer to the standard length (SL). Unless stated otherwise, all specimens have white dental plates, no canine teeth, lips which cover the dental plates, and a rounded caudal fin.

DIAGNOSTIC COLOUR NOTES are a summary of the main diagnostic or characteristic features of the colour pattern of the species. It is intended as a rapid guide for field identifications.

COLOUR NOTES are a detailed description of the ontogeny of the colour patterns over as large a size range as possible, based primarily on field observations, with additional observations on freshly collected specimens and live fish in aquaria. Unless otherwise stated all observations refer to GBR material. In addition to the colour patterns described, all species displayed a mottled pattern at night or when severely stressed. The colour patterns of most species fade upon capture and remain faded in captivity. In the colour descriptions, stripes are longitudinal markings and bands are vertical markings; broad bands may be referred to as bars. The pale regions between dark stripes or bands are referred to as interspaces.

COLOUR IN ALCOHOL descriptions are based on material examined in the present study; all material had been stored in alcohol for at least three months.

ECOLOGY describes the typical behavioural and distributional characteristics of the species which will aid in field identification. Unless otherwise stated, all observations were made at Lizard Island.

FIELD IDENTIFICATION discusses specific aspects of the behaviour or colour patterns of the species which are most important in field identification. This section emphasises those characteristics which enable the species to be distinguished in the field.

PREVIOUS DESCRIPTIONS refer to previous descriptions of the juvenile colour phase. Species synonymies are given in Choat & Randall (1986). In addition to the descriptions noted, the colour patterns of several GBR scarid species during the late juvenile phase (greater than 50 mm SL) are described briefly and figured by Choat (1969) and Choat & Randall (1986). A description of the ontogeny of the juvenile colour patterns of most GBR species is given in Bellwood (1986).

Field Observations

Field identifications were based on both behaviour and colour patterns. The behaviour is of particular value in separating recently settled scarids and labrids. *Scarus* species settle at about 7.5 to 8 mm. They have a characteristic form of swimming, especially when disturbed, with the rear part of the body curled into a 'C'-shape. In this position, they drift from cover to cover propelled by their pectoral fins, periodically reversing the flexion of the body. Labrids may curl in a similar manner, but typically do so for much shorter periods of time. Labrids primarily swim in short spurts with the body remaining straight, or with a slow undulating motion. Some species (e.g. *Coris variegata*) occasionally oscillate vertically between spurts of movement. The 'C'-shaped position was displayed by all *Scarus* species observed. This behaviour ceases at about 11 to 12 mm SL after which a typical labriform swimming motion predominates. The swimming motion of *Leptoscarus, Calotomus, Cetoscarus* and *Hipposcarus* differs from *Scarus* species and is described in the species descriptions. Solitary or schooling behaviour is relatively consistent within a species and aids in field identifications. In addition, many species have restricted or characteristic distributions. These differences aid in field identifications and are summarised in Fig. 2. A more detailed description of the ecology of each species is given in the species descriptions.

Colour Patterns

All the species of *Scarus* examined shared a common colour pattern. This is most apparent shortly after settlement but varies in extent between species. Recently settled scarids have a transparent body with a row of pale dots along the base of the dorsal and anal fins and onto the caudal peduncle (Fig. 3A). Shortly thereafter, two additional rows are apparent on either side of the midline (Fig. 3B, Pl. 5B). The pattern of dots forms both vertical and horizontal rows. As the fish grows, the areas between the rows of pale dots darken particularly along the horizontal rows (Fig. 3C). This results in four dark dashed lines (Fig. 3D).

Depending on the species, these dashes may either fuse to form dark longitudinal stripes (with the medial rows fusing first) as in *S. gibbus, S. psittacus* and *S. rivulatus*, or subdivide to produce further dashed lines which then fuse, as in the dorsal stripe of *S. sordidus* and *S. spinus*. Alternatively, the dashes may become diffused and form vertical bands as in *S. dimidiatus* and *S. longipinnis*. These patterns are not fixed as individuals of several species display both striped and vertically banded patterns or a mixture of the two, as in *S. frenatus* (Pl. 5C) and *S. rubroviolaceus* (Pl. 3F, G). *S. niger* is an exceptional species in that although the pale dots are apparent, the dashed lines do not form. In this species, the characteristic

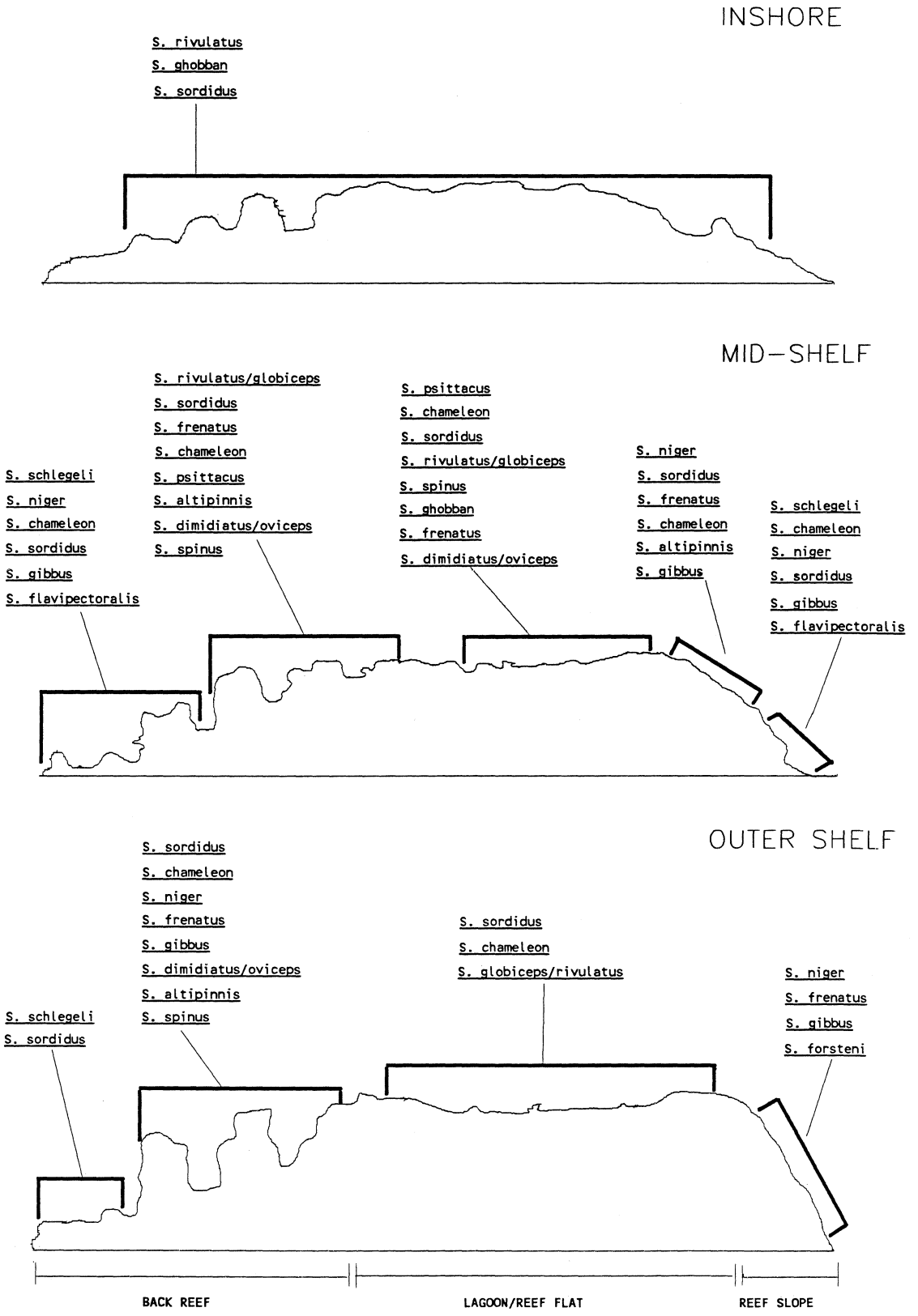


Fig.2. General distribution and abundance of juvenile scarids on reefs across the Great Barrier Reef, Australia. Species are listed in order of decreasing abundance. Distributions may vary markedly between reefs. The overall abundance of juvenile scarid is low on inshore reefs and extremely low on the outer slopes of outer shelf reefs.

dark ventral surface and pale spots develop shortly after settlement (Pl. 5E). The pale dots are lost with increasing size in most species, but remnants are retained in *S. rubroviolaceus, S. forsteni, S. altipinnis* and some colour patterns of *S. sordidus*.

The fusion of the four longitudinal dashed lines produces four dark body stripes. These are designated here as the dorsal, orbital, pectoral and ventral stripes (Fig. 4A). The dorsal stripe extends from the dorsal part of the snout, passes along the dorsal flank, near the base of the dorsal fin and terminates either at the posterior extremity of the dorsal fin base or on the dorsal edge of the caudal peduncle. The orbital stripe arises on the snout, passes through the orbit and terminates on the dorsal part of the caudal peduncle at the base of the caudal fin. The pectoral stripe extends from the lower jaw articulation, passes over the cheek, through the pectoral fin base and terminates on the ventral part of the caudal peduncle at the base of the caudal fin. The ventral stripe extends from the base of the operculum (in the interopercular region), passes along the ventral flank (belly) and terminates either at the base of the anal fin or on the ventral edge of the caudal peduncle. Pale spots which correspond with the pale dots found in recently settled and early dashed phase individuals may remain in either the dark stripes or the pale interspaces.

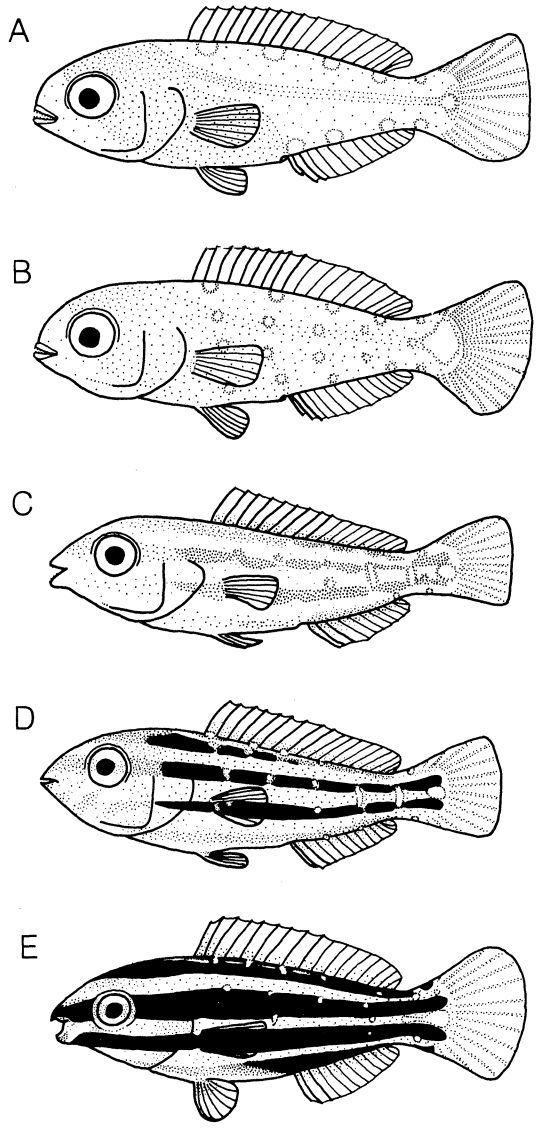


Fig.3. Ontogenetic changes in the colour pattern of juvenile *Scarus* species, leading to the formation of the four primary stripes. This figure is based primarily on the ontogeny of *Scarus frenatus* and *S. spinus*. Approximate lengths: (A) 9-10 mm SL; (B) 10-11 mm SL; (C) 11-13 mm SL; (D) 13-16 mm SL; (E) 20 mm SL.

Most *Scarus* species possess the four primary juvenile stripes, although there is some degree of between-species variation in the form, location, size and intensity of these stripes. The main variation in form is found in the dorsal stripe. As noted above, it may divide during the dashed phase to produce two stripes. In this situation, the ventral division remains in the normal dorsal stripe position, whereas, the dorsal division arises from a point between the orbits and passes along the midline at the base of the dorsal fin, before fusing with the ventral division at the posterior base of the dorsal fin (Fig. 3E). When viewed from above, the dorsal division appears as a single stripe running along the base of the dorsal fin.

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

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

As with juvenile body stripes, vertical bands, if present, have a 'typical' *Scarus* pattern (Fig. 4B), which reflects the pattern of pale dots found in recently settled and small dashed phase individuals (as in *S. oviceps*, Pl. 4B,C; *S. longipinnis*, Pl. 3D, and *S. schlegeli*, Pl. 2G,H). The maximum number of vertical bands displayed by most species is six (seven dark vertical bands only in *S. longipinnis*, Pl. 3D). The first band passes from the region of the first dorsal spine to the base of the pelvic fin, passing through the base of the pectoral fin. The second band passes from the dorsal fin to an area midway between the pelvic fins and anal fin, occasionally extending to the first spine of the anal fin. In species with seven bands, it is the second band that subdivides dorsally to produce the extra band. The third band passes from the midposterior part of the dorsal fin to the midanterior part of the anal fin. The fourth band connects the posterior regions of the dorsal and anal fins. The fifth band crosses the caudal peduncle, and the sixth band lies at the base of the caudal rays. This band may be triangular in shape with an anteriorly pointing apex.

Between each vertical band, the pale interspaces follow the pale dots described in newly settled and early dashed

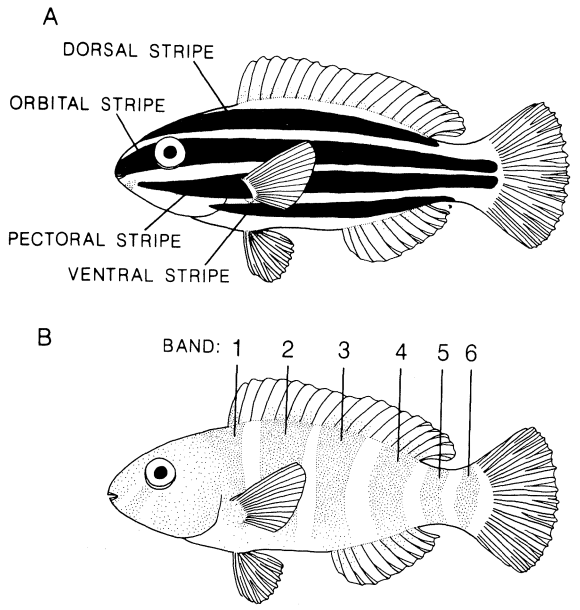
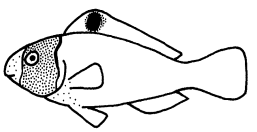


Fig.4. The 'typical' colour patterns of a juvenile *Scarus* species showing: (A) the four primary scarid stripes and (B) the six primary scarid bands.

phase individuals. These pale dots frequently remain as pale highlighted areas in larger juveniles. In some species (e.g. *S. ghobban* and *S. schlegeli*), these interspaces are relatively narrow and give and overall appearance of thin pale vertical bands on a darker background. The vertical bands may be straight as in *S. bleekeri* and *S. ghobban*, but in most species, they have a medial curve or flexion. The bands typically extend over the dorsal and ventral halves of the body, but may be lost ventrally as in *S. dimidiatus* and *S. oviceps*. As with juvenile stripes, the full number of vertical bands is not always present. The bands may (a) represent one of a series of colour patterns as in *S. chameleon*, (b) be combined with other patterns as in *S. rubroviolaceus*, or (c) be incompletely formed as in *S. dimidiatus* and *S. oviceps*. The bands on the caudal peduncle, in particular, are often poorly developed or absent as in *S. schlegeli, S. bleekeri, S. dimidiatus* and *S. oviceps*. Vertical bands are retained in the IP of some species (e.g. *S. bleekeri, S. dimidiatus, S. ghobban, S. longipinnis, S. oviceps, S. schlegeli* and *S. spinus*).

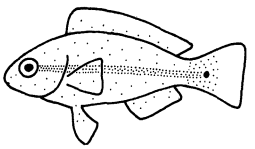
The length of the juvenile phase varies widely between species. In *S. ghobban* and *S. spinus,* the juvenile phase lasts for only a short while. The loss of juvenile phase colour patterns at 90 and 40 mm respectively, represents only 16 to 18% of the maximum length for each species. In contrast, specimens of *S. frenatus* and *C. bicolor* with distinct juvenile colour patterns may be recorded up to 100 and 150 mm respectively. This represents 30 to 33% of the maximum size attained by these species.

A Rapid Field Identification Key to Juvenile Scarids from the Great Barrier Reef, based on the Diurnal Field Colouration of Specimens between 20-60mm SL



1. Body white with single broad band over eye, black ocellus in dorsal fin.....*Cetoscarus*

—— Body not white, no band through eye, no ocellus in dorsal fin.....2



2. Single pale beige horizontal line from orbit terminating in a black dot at base of caudal fin, snout angular.....*Hipposcarus*

—— No single pale beige line from orbit ending in a distinct dark dot, snout not angular.....3

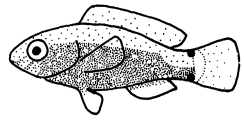
3. Body with series of dots, irregular flecks, bands, mottling, body not uniform or with longitudinal stripes, dorsal and anal fins may have distinct flecks..... .....(*Calotomus, Leptoscarus, Bolbometopon, Scarus* spp.) 4

—— No flecks, bands or mottling, dots if present few in number and restricted within stripes, body with uniform colour or two or more longitudinal stripes, fins not distinctly mottled.....(*Scarus* spp.) 11

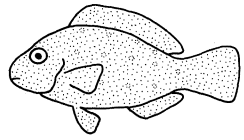
4. Small pale dots on body numerous, in irregular rows and/or in 2-3 even rows of 4-6 dots.....5

—— Pale dots either few and irregular or absent, pale flecks in vertical lines may be present.....7

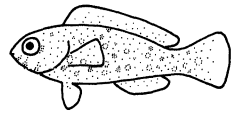
5. Uniformly green-brown body; 2-3 rows of clear pale dots, no dark dots on caudal peduncle.....6



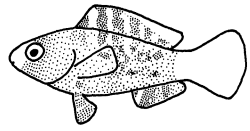
—— Dorsum olive; black ventrally with numerous small white to blue-white dots, two distinct dark dots on caudal peduncle.....*S. niger*



6. Deep body, (depth < 2.6 in SL), 2-3 rows of pale dots without additional small dots or flecks.....*Bolbometopon*

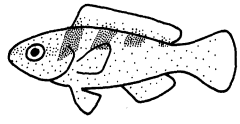


—— Elongate body, (depth > 3.0 in SL), 2-3 rows of pale dots and numerous smaller dots on body, fins with numerous small dots or flecks, occasionally single pale longitudinal stripe.....*Calotomus/Leptoscarus*



7. Body and fins with dark and pale flecks, no dark vertical bands; caudal fin and caudal peduncle pale.....*S. altipinnis/frenatus*

—— Body without dark and pale flecks; with dark vertical bands, caudal fin and caudal peduncle same colour as body.....8

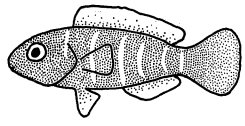


8. Body bright yellow with 2-4 dark bands usually restricted to dorsum.....*S. dimidiatus/oviceps*

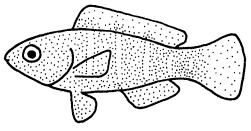
—— Body not bright yellow, vertical bands usually extending onto ventral half of body.....9

9. Bands approximately same width as pale interspaces.....*S. longipinnis*

—— Pale interspaces much narrower than bands.....10



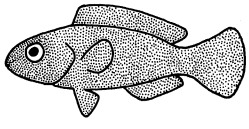
10. Body dark brown-black with pale grey-brown interspaces.....*S. schlegeli*



—— Body pale tan, occasionally with orange hue, paler interspaces white with blue hue.....*S. ghobban*

11. Body brown to black or with brown or black stripes.....12

—— Body tan, pale grey, olivaceous to pale brown, with or without stripes.....16

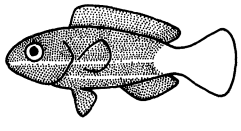


12. Body and caudal peduncle uniformly dark brown-black.....*S. bleekeri, S. gibbus, S. schlegeli, S. sordidus,* or in deep water, *S. chameleon* or *S. longipinnis*

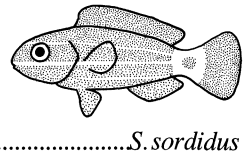
—— Body with pale interspaces between dark stripes or caudal peduncle with pale patches.....13

13. Caudal peduncle pale off-white.....14

—— Dark body stripes extend onto caudal peduncle.....15

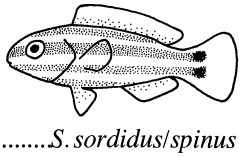


14. Caudal peduncle and caudal fin uniformly off-white.....*S. bleekeri*



——Caudal peduncle and base of caudal fin off-white with dark dot in centre of caudal peduncle.....*S. sordidus*

15. Broad black stripes on body, stripes on caudal peduncle fusing with dark caudal fin base, all vertical fins dark at bases.....*S. gibbus*

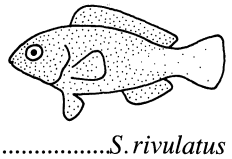


—— Dark orbital and pectoral stripes usually terminating in intense dark black dots, fins mottled or pale hyaline grey.....*S. sordidus/spinus*

16. Body uniformly coloured.....17

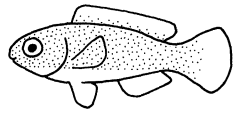
—— Body with horizontal stripes.....19

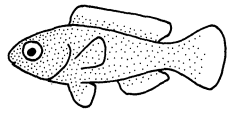
17. Caudal fin and caudal peduncle same colour as body.....18



—— Caudal fin and caudal peduncle with pale yellow hue, body olive tan to grey brown.....*S. rivulatus*

18. Body pale grey, tan or grey brown, abruptly pale off white below level of pectoral fin base.....*S. chameleon, S. psittacus* or *S. rivulatus*





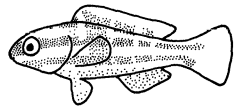
—— Uniformly pale grey brown to brown.....*S. chameleon, S. flavipectoralis, S. forsteni, S. globiceps, S. psittacus, S. rivulatus*

19. Pale dots visible in dark stripes.....20

—— No pale dots in dark stripes.....22

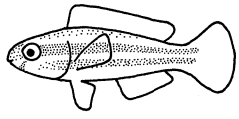
20. Pale dot at tip of pectoral fin larger and clearer than the rest.....*S. forsteni*

—— Pale dots of approximately even size.....21



21. One dark band (No.2) usually visible behind pectoral fin, interspaces pale grey brown.....*S. rubroviolaceus*

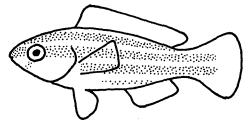
—— No dark band visible, interspaces with metallic bronze hue.....*S. psittacus*



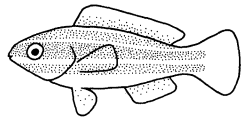
22. Body elongate; medial stripes (orbital and pectoral) distinctly broader and darker than dorsal stripe.....*S. flavipectoralis*

—— Body not elongate, 3 stripes clearly visible on body, medial stripes not distinctly broader and darker than dorsal stripe.....23

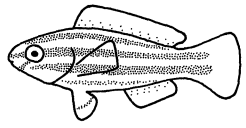
23. Pectoral stripe continues forward onto operculum.....24



—— Pectoral stripe not continuing forward of pectoral base.....*S. chameleon*



24. Orbital stripe slightly broader and darker than dorsal or pectoral stripes (dark cysts often on body).....*S. psittacus*



—— Dorsal, orbital and pectoral stripes of similar breadth and intensity.....*S. forsteni, S. ghobban, S. globiceps, S. psittacus, S. rivulatus, S. rubroviolaceus*

Calotomus carolinus (Valenciennes)

Pl. 1A

Material examined. (1 specimen: 43 mm). AUSTRALIA - Lizard Island, AMS I. 25905-002 (1:43 mm).

Diagnosis. Median predorsal scales 4, no anterior pair, scale size increasing anteriorly; 1 cheek scale row (4 scales); pectoral rays 13; jaws with incisiform imbricate teeth in oblique rows, not fused to form dental plates; body elongate, mouth pointed.

Diagnostic colour notes. Body and fins green to green brown with white and brown dots and flecks; white patch covering first 2 dorsal spines.

Colour notes. Colour patterns change little during juvenile phase, with no rapid colour changes; recently settled specimens (approximately 12 mm), body translucent with few brown and white dots in random pattern, white patch on anterior part of dorsal fin distinctly visible, extending from first dorsal spine to, but not including, third dorsal spine, remaining part of dorsal fin and other fins hyaline; greater than 13 mm (Pl. 1A), body darkens to grey green or green brown, dots and flecks increase in number, with double row of large pale dots along flank, and an indistinct row near dorsal fin base; these dots correspond with pale dots present in juvenile *Scarus* species (Fig. 3B); vertical fins grey green, flecked with brown and white, pectoral fins hyaline, white patch on anterior part of dorsal fin present to 43 mm (Pl. 1A), but lost by 80 mm, iris green. In progressively larger specimens, body darkens with browner hue, pale dots and flecks decrease in relative size and intensity; IP colouration complete at approximately 80mm.

Body form. Small specimens, body elongate, mouth pointed. Large specimens, body relatively deep, head rounded with protruding eyes which are distinctly visible when viewed from rear.

Colour in alcohol. At 31-43 mm, body pale green grey, nape brown, series of brown dots on body and along dorsal fin base, fins indistinctly mottled hyaline.

Ecology. Uncommon; solitary, occasionally in small multispecies schools; site attached when small. Recently settled specimens (12-13 mm) recorded over low algal covered coral rubble on sand, near reef slope base (7-10 m), North Reef, Lizard Island. Juveniles (15-100 mm) observed over coral rubble, coral rock and macroalgae, on or near reef slope base (5-11 m), in exposed and semi-exposed locations at Lizard Island. Moderately large juveniles (60-80 mm) recorded from reef slope (at 12-20 m) of Yonge Reef, an outer shelf reef.

Field identification. This is a member of the subfamily Sparisomatinae and is one of the more labrid-like scarids. In the field, it can be distinguished from other scarids by its unusual body form and colouration but may, when recently settled, be difficult to distinguish from some labrids. It settles at a relatively large size. The smallest transparent early postsettlement specimen observed was approximately 12 mm (cf. 7.5-8 mm in *Scarus* species). The swimming mode of *C. carolinus* is unusual when compared to that of other scarids. At 14-16 mm, it only occasionally moves with a 'C'-shaped body (a characteristic of *Scarus* species) and often swims in a labrid-like manner, i.e. in short bursts, with the body held straight. At 16-25 mm, the labrid-like swimming mode is retained. When disturbed, it often glides away, laying to one side with the dorsal and anal fins extended and the flank exposed to the onlooker. This swimming behaviour is similar to that of the labrid *Novaculichthys taeniourus* (Lacepède). At greater than 25 mm, however, *C. carolinus* swims in a more 'typical' scarid-like manner.

Previous descriptions. A colour plate of a 44.2 mm specimen from Taiwan in Burgess & Axelrod (1974, pl.283, p.995), provisionally identified as *Calotomus japonicus* (Cuvier & Valenciennes), is probably *C. carolinus*. Bruce & Randall (1985) describe and figure the late juvenile phase.

Leptoscarus vaigiensis (Quoy & Gaimard)

Pl. 1B

Material examined. (3 specimens: 30-35 mm). PHILIPPINES - Bantayan Beach, Dumaguete City, AMS I.27814-001 (1:30 mm), AMS I. 27812-001 (1:34 mm), AMS I.27813-001 (1:35 mm).

Diagnosis. Median predorsal scales 4, scales subequal, no anterior pair; 1 cheek scale row; pectoral rays 13; body elongate.

Diagnostic colour notes. Body olive green brown, dorsal, anal and pelvic fins hyaline with faint brown mottling; scale edges often dark; body either (a) uniform, (b) with a broad orbital stripe and narrow pectoral stripe, or (c) with 2-4 narrow dark stripes on the belly and flank.

Colour notes. 1 specimen, 50 mm, Sydney Harbour (Pl. 1B): body green brown, fading ventrally to off-white belly, 3 distinct series of 4-6 pale dots on body, 2 on midflank, 1 near dorsal fin base, dots correspond with pale dots on recently recruited *Scarus* species (Fig. 3B), medial fins mottled white and brown basally, hyaline distally, caudal olivaceous hyaline, pectoral fins hyaline.

A variable species, capable of rapid changes in its colour pattern; because of lack of detailed observations on GBR specimens, following notes are of Philippine specimens 30.5-38.5 mm. (A) Freshly collected: body olive green, belly and cheek off-white with golden sheen, especially on operculum and pectoral fin base, scales with dark edges,

iris pale silver, golden-orange near pupil, dorsal, anal and caudal fins hyaline brown, dorsal fin with 4 dark brownish patches basally, anal fin with 3 dark patches basally, scaled region of caudal fin green, pelvic fins hyaline with reddish-brown patch anteriorly, pectoral fins hyaline with very faint pink-brown hue. (B) In field: body olive-green brown, with broad dark stripe extending from snout through orbit, terminating in upper part of caudal peduncle, narrow pale interspace separates this stripe from narrow dark stripe which arises on cheek, passes through pectoral fin base, and terminates near posterior part of anal fin base (these stripes are comparable to orbital and pectoral stripes of *Scarus* species); may display stripe composed of fine tan mottling, arising abruptly in interorbital region, passing along dorsal fin base, and tapering to posterior end of dorsal fin base; belly off white, iris green to olive green with gold ring around pupil, dorsal, anal and pelvic fins hyaline with faint brown mottling, pectoral fins hyaline. (C) In captivity: as in field, except body and fins paler with green hue, 2 series of 5-6 pale dots on midflank become clearly visible (as in Pl. 1B), third row near dorsal fin base often indistinct, dorsum mottled with network of dark scale edges; 2-4 narrow dark stripes on flank and belly following scale rows, formed by dark dorsal and ventral scale edges; these stripes do not follow 'typical' scarid pattern (Fig. 4).

At greater than 38 mm, body remains olivaceous to grey green, series of relatively large pale dots lost but body peppered with small pale dots, especially ventrally; these dots increase in relative size throughout the juvenile phase; belly pale with 4 pale lines following scale rows, dorsal and anal fins hyaline with brown spines and rays, caudal fin hyaline with olive-green rays, pectoral fins with olivaceous hue, iris golden orange; faint mottling on body and fins becomes increasingly distinct during late juvenile stage, before gradual transition to IP colouration, which is complete at about 70 mm.

Colour in alcohol. At 30.5 mm, body pale-olive green with darker grey-green mottling; pale stripes in belly, series of pale dots on body, dark orbital stripe and grey brown and white mottling of unpaired fins clearly visible; at greater than 34 mm, body pale grey green dorsally, pale olive green ventrally, pale markings on body and fins not retained, pale grey-green mottling retained but indistinct, pale stripe from opercular margin (dorsal to pectoral fin base) to midcaudal peduncle indistinct (stripe corresponds to interspace between orbital and pectoral stripes).

Ecology. Not observed on GBR. In Philippines: solitary; moderately common in large dense shallow seagrass beds (0.5-3.0 m; *Thalassia* and *Cymodocea*), usually observed swimming between blades, probably settles in seagrass beds; when disturbed, juveniles swim in labrid-like manner, often in short bursts interspersed by stationary periods, hanging tail-down or laying among seagrasses; small juveniles appear to feed on seagrass epiphytes.

Field identification. This is one of the few scarid species found in seagrass beds. Its swimming mode and distinctive colouration distinguish it from all GBR *Scarus* species. It may, however, be confused with *Calotomus* species and some labrids. *L. vaigiensis* can be distinguished from labrids by its more rounded, shorter snout and distinctive colour pattern, and from *Calotomus carolinus* by its more elongate body, rounded snout, and lack of a white patch on the anterior part of the dorsal fin. The second *Calotomus* species, *Calotomus spinidens* is rare on the GBR (Choat & Randall, 1986), but in areas where this seagrass species is abundant, it can easily be distinguished from *L. vaigiensis* by its deeper body and a prominent pale stripe on the flank.

Previous descriptions. The field colour patterns of juvenile *L. vaigiensis* have not been described previously. Bruce & Randall (1985) describe the colour of juveniles in alcohol. This is a small species, which may mature at sizes as small as 69 mm (Robertson *et al.*, 1982). Only specimens below 69 mm are therefore considered juvenile.

Remarks. Despite its widespread distribution along the length of the GBR (Choat & Randall, 1986), *L. vaigiensis* was not observed on any of the GBR reefs examined. In the Philippines, juvenile *L. vaigiensis* were only recorded from seagrass beds. It is likely therefore, that juveniles may be observed in similar areas on the GBR. The single Australian specimen recorded in this study was observed among macroalgae in Sydney Harbour (R. Kuiter, personal communication). As this location is on the edge of the geographic range of the species, i.e. a sub-tropical region, its habitat location may be atypical.

Cetoscarus bicolor (Rüppell)

Pl. 1C

Material examined. (5 specimens: 11-96 mm). AUSTRALIA - Lizard Island, lost (1:11 mm); MICRONESIA - Kayangel Island, Palau, CAS 62588 (1:59 mm); PHILIPPINES - Sumilon Island, AMS I.27810-001 (1:36.5 mm), AMS I.27811-001 (1:56mm); SEYCHELLES - Mahe Island, CAS 58531 (1:96 mm).

Diagnosis. Median predorsal scales 6 (occasionally 7), posterior 4 largest; cheek scale rows 2-3, 0-6 in ventral row; pectoral rays 14; anterior dorsal spines elongate, especially in smaller specimens (greater than 2 times longest ray at 11 mm; 1.5 times at 36.5 mm; 1.3 times at 56 mm).

Diagnostic colour notes. Body white, with broad single brick-orange bar from anterior edge of orbit to origin of dorsal, bar edged in black; dorsal fin with large black ocellus with orange border; caudal fin margin orange; belly and pelvic fins with yellow hue.

Colour notes. The most distinctive and easily identified juvenile scarid; at 11-12 mm, body white, head brick red, fins hyaline, except first few spines of dorsal fin which are white, exceptionally long (greater than 2 times

longest ray) and usually held erect, dorsal ocellus absent; 30-40 mm, colour pattern dominated by broad vertical orange bar with black anterior and posterior margins, bar extending from anterior margin of orbit to base of first dorsal spine and pectoral fin, it does not correspond with bars found in *Scarus* species, body, mouth, snout, anterior part of dorsal fin and caudal fin white, caudal fin with orange posterior margin, anterior part of dorsal fin bearing large black ocellus with orange margin (Pl. 1C; N.B. fish viewed from rear); larger specimens (40-60 mm), orange margin of caudal fin extending along dorsal and ventral edges, white colouration in anterior part of dorsal and anal fins extending posteriorly, yellow colouration extending from pectoral base onto pelvic fins and belly to base of anal fin; at greater than 60 mm, orange bar slowly diffuses, body and fins darken, orange markings fade, ocellus decreases in relative size (as in 123 mm specimen figured in Randall & Bruce, 1983); at greater than 150 mm, bar almost completely lost, only diffuse brown patches remain, especially along outlines, body pale grey with scattered small darker dots, dorsal ocellus fades, fins pale grey; IP colouration complete at 180 mm.

Colour in alcohol. At 36-39 mm, body off white, grey to brown; orbital bar may be slightly darker; orange and yellow markings extremely faint or lost; black ocellus on dorsal and dark lines marking anterior and posterior edges of orbital bar remain distinct to at least 96 mm.

Ecology. Rare; solitary; site attached; settlement site of single individual recorded November 1980, in large piece of algal covered arborescent coral at base of semi-exposed reef slope, at North Reef, Lizard Island. Most juveniles observed amongst coral rubble and boulders, in gullies or near reef slope base, 3-11 m, typically in moderately exposed locations, including backreef bommies; a shy species, small specimens, in particular, remain close to substratum and rapidly dive for cover if disturbed, in contrast to flight of *Scarus* species.

Field identification. The striking colour pattern enables this species to be rapidly distinguished from all other scarids. The only possible confusion may be with *Amphiprion* species as noted below, however, the white body and lack of any association with an anemone clearly distinguish this species.

Previous descriptions. The juvenile phase of *C. bicolor* has been described as a new species on two occasions: as *Scarus ocellatus* by Valenciennes (in Cuvier & Valenciennes, 1840) and as *Scarus ophthalmistius* by Herre (1933). The juvenile of *C. bicolor* has subsequently been described by numerous authors, partially as a result of its popularity as an aquarium species. Scientific descriptions include those of Schultz (1958), Randall & Bruce (1983) and Choat & Randall (1986). Colour plates are given in Axelrod & Emmens (1969, pp. 247-248), Burgess & Axelrod (1972, pl. 271, p. 154; 1973a, pl. 348, p. 458; 1974, pls 260,261, p. 984; as *Bolbometapon bicolor*) and Masuda *et al.* (1984; pl. 212A). Many authors, especially those of popular aquarium books, place this species in the genus *Bolbometopon*. In the present study it is placed in the genus *Cetoscarus* following Randall & Bruce (1983) and Choat & Randall (1986). The status of this genus is currently under investigation.

Remarks. At 11 mm, *C. bicolor* swims in an undulating manner, strikingly similar to that of similarly sized *Amphiprion* species. This swimming behaviour is slowly lost with increasing size. With their undulating swimming mode, unusual colour pattern, and shy, cover seeking behaviour, recently settled *C. bicolor* bear a striking resemblance to recently settled *Amphiprion* species. This similarity may represent mimicry (Bellwood, 1986).

Bolbometopon muricatum (Valenciennes)

Fig. 5

Material examined. (12 specimens: 47-315 mm). AUSTRALIA - Lizard Island, GBR, AMS I.18755-077 (1:60 mm); LINE ISLANDS - Fanning Island, USNM 293162 (4:61-93 mm); MICRONESIA - Map Island, Yap Island, CAS 62586 (1:47 mm); Ponape Island, USNM 175268 (1:51 mm); Garayamo Island, Palau, CAS 62587 (1:67 mm); Koror Island, Palau, CAS 62584 (1:74 mm); Pelelio Island, Palau, BMNH 1874.11.16:5 (1:171 mm); Urukthapel Island, Palau, CAS 62585 (1:205mm); PHILIPPINES - Bais Bay, AMS I. 27865-001 (1:315 mm).

Diagnosis. Median predorsal scales 5 (occasionally 4), scales subequal, no anterior pair; 3 cheek scale rows, 2 (occasionally 1) in ventral row; pectoral rays 16; dental plates white; gill raker count ca. 20 (cf. 38-81 in Scarus species).

Diagnostic colour notes. At 315 mm, body and fins dark grey brown; numerous small brown dots on head, dorsum and vertical fins; distinct series of pale white dots on body, in 2-3 rows of 4-5 dots.

Colour notes. Body greenish with 3 series of 4-5 pale dots on flank, comparable to pale dots on recently settled *Scarus* species (Fig. 3B), vertical fins dark greenish, pectorals hyaline yellowish, pelvic fins greenish, iris yellow, white spots on body distinct to 300 mm. At 315 mm, (immature specimen, based on gonad status) freshly collected: body dark grey with brown hue, paler ventrally, scale edges brown in midbody, black posteriorly, each scale on dorsum with 1-3 (usually 1-2) brown dots one third pupil width, scales on caudal peduncle with dark area medially, series of pale orbit-sized dots on body, 2 distinct rows of 4-5 dots medially, 2 rows of 2-3 indistinct dots along dorsal fin base and between medial rows, dots in positions corresponding to those of recently settled *Scarus* species (Fig. 3B, cf. Pls 4F, 4G & 5B), forehead and snout dark grey, orbit, cheek and operculum grey with numerous brown dots and a few short undulating lines one third pupil width, cheek scales edged with brown, lower lip and chin with pale pink hue, iris brown medially, pale gold distally,

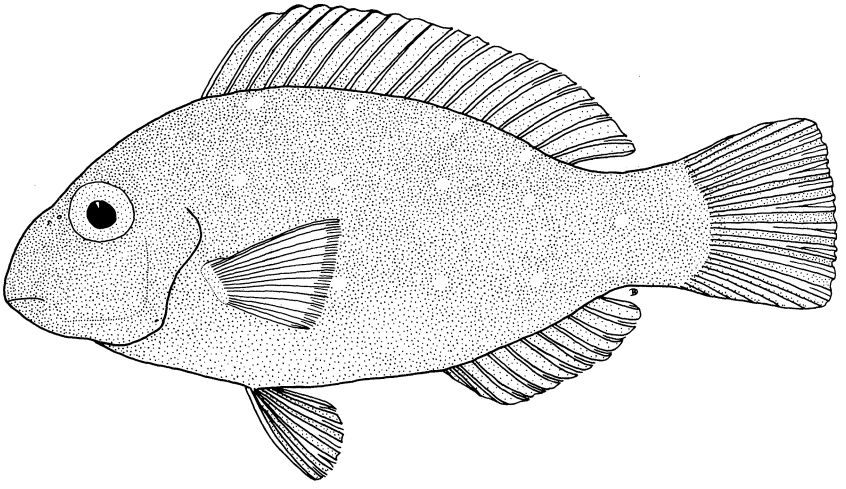


Fig.5. *Bolbometopon muricatum* 61 mm SL, 75.5 mm TL. Based on USNM 293162, Fanning Island, Line Islands.

dorsal, anal and pelvic fins grey with brownish-purplish hue, dorsal fin with few dark brown-black dots near base, anal fin with several indistinct brown dots half to one third pupil width, pelvic fin off white near belly, caudal fin black with numerous brown streaks in inter-ray areas, pectoral fin pale grey with brown streaks on dorsal half, fin base with 1-5 small black dots; in field, pale body dots lost by approximately 500 mm, greater than 500 mm body and fins uniformly grey green, as in adult specimens.

Body form. Small specimens 47-51 mm, body deep, maximum depth at first dorsal spine approximately 2.1 in SL, snout somewhat angular; forehead becomes steeper with increasing size, resulting in steep blunt profile at 205 mm; small hump on forehead first apparent at approximately 300 mm SL.

Colour in alcohol. Body pale brown to dark-grey brown, darkest dorsally, belly and anal fin palest, dorsal, anal, and pelvic fins hyaline brown grey to dark-brown grey, posterior edge of caudal fin rays often darker grey; 47-93 mm usually 15-50 small dark brown dots (less than one half times pupil width) scattered over body especially on dorsum; 75-315 mm, 3 rows of pale dots visible on flank as in live individuals.

Ecology. Very rare; only 1 juvenile specimen collected from GBR, from Lizard Island; junior author observed several solitary juveniles (250-300 mm) on Ellison Reef, an inner midshelf reef off Innisfail, Queensland.

On western Pacific reefs, several juveniles collected in shallow waters: 2 specimens in turbid waters 0-3 m, near mangrove vegetation at Yap and Palau Islands; 4 specimens in lagoon at Fanning Island and Ponape; 1 specimen from small shallow reef in estuarine area of Bais Bay, Negros Oriental, Central Philippines.

Field identification. This species is relatively easy to identify by its deep uniformly green body and series of pale dots. Pale dots are probably visible at less than 75 mm and remain to at least 315 mm.

Identification notes. In preserved collections, *B. muricatum* is easily distinguished from all other scarids by its deep body, and unusual combination of brown-dark brown body, with scattered dark dots and/or series of pale dots. This species may be distinguished from GBR *Scarus* species as it possesses fewer gill rakers (approx. 20 versus greater than 38 in *Scarus* spp.) and three distinct rows of upper pharyngeal teeth (ratio 3:3:1). The outer row of pharyngeal teeth is greatly reduced or absent in *Scarus* species (ratio approx. 5:2:1).

Previous descriptions. There are few published descriptions of the early juvenile colour patterns of *B. muricatum.* The ontogeny of the colour patterns of relatively small individuals (approx. 200 mm) through to the adult stage are described in Smith (1956). A description of the juvenile phase and a colour plate of a 105 mm specimen from Seribu Island, Java are given in Choat & Randall (1986).

Hipposcarus longiceps (Valenciennes)

Pl. 1D

Material examined. (35 specimens: 29-85 mm). AUSTRALIA - Lizard Island, AMS I. 25783-001 (1:48 mm), AMS I. 25798-001 (1:48 mm); MICRONESIA - Palau, CAS 62579 (3:29-42 mm), CAS 62577 (5:30-67 mm), CAS 62578 (2:30-38 mm), CAS 62576 (3:32-36 mm), CAS 62580 (2:49-59 mm), CAS 62581 (2:40-65 mm), CAS 62582 (1:68 mm), CAS 62594 (15:30-85 mm).

Diagnosis. Median predorsal scales 4, no anterior pair, anterior scale largest; cheek scale rows 3, 2-6 in ventral row, scale rows often indistinct and scales loose; pectoral

rays 15; deep body with distinctly angular snout.

Diagnostic colour notes. Body silver grey to pale tan; caudal fin and caudal peduncle pale yellow; thin beige-orange stripe from snout, through orbit to caudal fin base, terminating with small black dot.

Colour notes. At 48 mm, body silvery grey to pale tan, fading to whitish ventrally, caudal fin and caudal peduncle pale yellow, single thin beige-orange stripe extending from snout, through lower portion of orbit, along flank to caudal fin base, terminating with prominent small black dot (Pl. 1D); stripe particularly striking in field and greatly eases identification; stripe differs from typical orbital stripe of *Scarus* species as passes through lower part of orbit, rather than pupil, and terminates in middle of caudal fin base; caudal fin and caudal peduncle pale yellow, dorsal and anal fins pale tan with off-white mottling and yellow hue medially; in aquaria, 4-5 narrow pale vertical lines may be displayed (faintly visible in Pl. 1D), their locations correspond with pale interspaces of *Scarus* species; colour patterns during transition from juvenile to IP not known, although beige stripe and dark caudal spot lost by 120 mm, leaving uniformly pale body and pale yellow caudal fin closely resembling IP colouration.

Body form. Unusual, body deep with distinctly angular head and snout; body tapers posteriorly to narrow caudal peduncle; dorsal fin appears raised anteriorly.

Colour in alcohol. Body pale brown to brown, pale ventrally, body stripe off yellow to pale brown, terminating with black-brown spot; pale stripe distinct at 29-30 mm, indistinct from 32-67 mm, may be absent greater than 38 mm, usually lost greater than 44 mm; black spot distinct to 42 mm, indistinct to 67 mm, may be absent greater than 53 mm, usually lost greater than 67 mm; vertical fins hyaline to pale brown, dorsal fin darkest, occasionally with faint darker mottling.

Ecology. Rare; solitary, probably site attached; 1 specimen (48 mm) collected over coral rock and rubble, 5 m, Mermaid Cove, Lizard Island; 1 specimen (48mm) over coral rock and boulders at reef slope base (9 m) in semi-exposed site near Crystal Beach, Lizard Island.

In Palau, juveniles collected from rocky shores and near mangroves, 0-13 m, but most abundant in shallow turbid water 0-2 m, in eel-grass beds.

Field identification. Easily distinguished from other GBR scarids by its unusual colour pattern and body shape; care must be taken to distinguish it from *Lethrinus* species (noted below).

Previous descriptions. Masuda *et al.* (1984) figure a 20 mm specimen from the Japanese Archipelago. Choat & Randall (1986) describe the juvenile phase and figure a 38 mm specimen from Papua New Guinea.

Remarks. The body shape and colour pattern of *H. longiceps* more closely resemble those of a *Lethrinus* species rather than those of a *Scarus* species. Some juvenile *Lethrinus* species only differ from *H. longiceps* in the absence of the dark dot at the end of the single medial stripe. The behaviour likewise resembles that of *Lethrinus* species: *H. longiceps* remains motionless above the substratum for extended periods and swims in shorts bursts, periodically feeding on turf algae. It does not school with other scarids and is occasionally aggressive towards them. Overall, its colour pattern and behaviour suggest that it may mimic *Lethrinus* species (Bellwood, 1986).

The unusual features of *H. longiceps* appear to be characteristic of the genus *Hipposcarus*, as the juvenile colour pattern of the Indian Ocean species *H. harid* (Forsskål) (described and figured by Smith, 1959 and described briefly by Randall & Bruce, 1983) is extremely similar to that of juvenile *H. longiceps*.

Scarus altipinnis (Steindachner)

Pl. 4D-G

Material examined. (8 specimens: 20-54 mm). AUSTRALIA - Lizard Island, AMS I.25911-001 (1:20 mm), AMS I.27836-001 (1:24 mm), AMS I.27842-001 (1:25 mm), AMS I.25909-001 (1:28 mm), AMS I.25795-001 (1:29 mm), AMS I.25791-001 (1:52 mm), AMS I.25903-001 (1:54 mm); Yonge Reef, AMS I.25912-007 (1:25 mm).

Diagnosis. Median predorsal scales 6, no anterior pair, scale size decreases anteriorly; cheek scale rows 3, 2-3 in ventral row; pectoral rays 15.

Diagnostic colour notes. Snout yellow orange; less than 30 mm, body and fins with black and white flecks; greater than 30 mm, body grey to brown with white flecks, dorsal, anal and pelvic fins with dark flecks, caudal and caudal peduncle off white.

Colour notes. Distinctive colour pattern, no rapid colour changes; yellow snout and golden-yellow iris visible at 13 mm and persist throughout early juvenile phase; at 12 mm, body off white with 5-7 large black and white flecks approximately equal to orbit, flecks decrease in relative size with growth and at 14 mm are approximately equal to pupil; at 14 mm, white patch similar to that of larger *S. niger* (Pl. 5F) present on caudal fin base; greater than 15 mm (Pl. 4D), white patch fades (remnants visible in Pl. 4D), flecks on body fuse to form broken stripes, dorsal, anal and pelvic fins become mottled; greater than 27 mm (Pl. 4E), caudal fin and caudal peduncle slowly fade to white, body darkens to grey, only few white body flecks or spots remain (although mottled pattern on dorsal and anal fins remains distinct); snout deepens to orange/yellow (Pl. 4F) then to tan; greater than 50 mm, body and fins slowly darken to grey brown; pale body flecks remain, snout darkens to

colour of body (Pl. 4G); during transition to IP, snout, body and fins turn brown, caudal fin and caudal peduncle pale brown, but intensity variable, pale flecks on body remain but of variable intensity; IP colouration complete at approximately 140 mm.

Colour in alcohol. Body pale grey in small specimens, brown in larger specimens; pale snout, caudal fin and caudal peduncle darken but remain distinct; dark body flecks and mottling on fins distinct; white body flecks distinct in large specimens.

Ecology. Uncommon; solitary throughout juvenile phase, often aggressive towards other scarids, especially conspecifics; site attached; settlement sites variable, but usually in spatially complex areas of coral rubble or live coral, from 2-9 m; on Lizard Island, small individuals (12-20 mm) most often recorded at base of reef slope (5-9 m), over coral rock or rubble, larger individuals (20-60 mm) most often recorded near reef crest (2-3 m) or on upper reef slope (3-5 m), in areas of open coral rock and live corals; on Lizard Island and mid-shelf reefs, recorded primarily from moderately exposed reef slopes, occasionally from edge of lagoon patch reefs; on outer reefs, recorded only from backreef bommies.

Field identification. Distinctive colour patterns distinguish this species from all other GBR *Scarus* species. The dark flecks in the dorsal and anal fins are clear throughout most of the juvenile phase and are useful diagnostic features. This is one of the few species that can be identified shortly after settlement by its characteristic yellow snout.

Previous descriptions. The ontogeny of the colour patterns of juvenile *S. altipinnis* were described by Schultz (1958), [as *S. brevifilis* (Günther)]. However, these descriptions were based on preserved material and are therefore of limited use for field identifications. Choat & Randall (1986) briefly describe the late juvenile phase and give a colour plate of a 38 mm specimen from Tongtapo, Tonga and a 47 mm specimen from Tahiti.

Remarks. Choat & Randall (1986) describe *S. altipinnis* as a member of a closely related species complex which comprises *S. altipinnis* in the western, central and southern Pacific, *S. prasiognathos* Valenciennes in the eastern Indian Ocean, Indonesia, Philippines, and north-western Pacific, and *S. falcipinnis* (Playfair) in the western Indian Ocean. The juvenile colour phases of these species are extremely similar, as demonstrated by the published colour plates of *S. falcipinnis* in Randall & Bruce (1983) and of *S. prasiognathos* in Masuda *et al.*, (1984; as juvenile *S. frenatus*). The identity of the latter is based on observations of juvenile *S. prasiognathos* in the Philippines (Bellwood, 1988). However, the restricted geographic ranges of these species minimises potential confusion. Of the three species, only *S. altipinnis* has been recorded from the GBR where it is easily identified.

Scarus bleekeri (de Beaufort)

Pl. 1G,H

Material examined. (5 specimens: 33-60 mm). AUSTRALIA - Lizard Island, AMS I.25916-001 (1:33 mm), AMS I.25903-002 (1:46 mm), AMS I.27815-001 (1:54 mm); Yonge Reef, AMS I.25792-001 (1:60 mm); PHILIPPINES - Sumilon Island, AMS I.27459-002 (1:38 mm).

Diagnosis. Median predorsal scales 4, no anterior pair, anterior 2 scales largest; cheek scale rows 2; pectoral rays 15; based on specimens greater than 33 mm; dental plates exposed in larger specimens.

Diagnostic colour notes. Small individuals with 4 dark brown primary stripes; larger individuals with dark brown body, occasionally with pale vertical bands. All sizes with distinct off-white caudal fin and caudal peduncle.

Colour notes. At less than 25 mm, body off white to grey brown with 4 dark brown-black stripes, medial 2 stripes most distinct, no dorsal division of dorsal stripe, dorsal and anal fins hyaline but darken basally with growth, caudal fin progresses from hyaline to off white; greater than 25 mm, dorsal and ventral stripes slowly fuse with dark bases of dorsal and anal fins, dark orbital and pectoral stripes increasingly pale in caudal peduncle region (Pl. 1G), pale interspaces slowly darken, giving rise to uniformly dark colour pattern, although caudal peduncle and caudal fin remain off white, vertical fins brown at base, hyaline distally; 25-50 mm, intensity of pale interspaces may vary rapidly, resulting in striped or uniformly dark colour patterns; greater than 40 mm, caudal fin and caudal peduncle may also darken resulting in a uniformly dark colour pattern, stripes usually indistinct, caudal fin may have dark distal edge (Pl. 1H). Typical colour pattern of juveniles in field: body and fins uniformly dark-brown black, caudal and caudal peduncle pale off white, but wide range of colour patterns may be displayed (Table 1); greater than 40 mm, this range includes pale vertical bars, a characteristic IP feature, in progressively larger specimens, bars more distinct and displayed more frequently; typical IP colour pattern, with distinctive pale vertical bars and moderately pale caudal fin and caudal peduncle predominates in specimens greater than 110 mm.

Colour in alcohol. Pattern as in live specimens, although dark areas or stripes fade to dark grey and pale interspaces turn pale grey.

Ecology. Uncommon; solitary; site attached; settlement sites unknown; small specimens recorded most frequently in areas of complex coral rubble, 3-9 m, on seaward reef slopes at Lizard Island and backreef bommies of outer barrier reefs; 1 specimen, 3 m, Lizard Island lagoon, over arborescent live coral and soft coral on coral rock; juveniles usually solitary although may occasionally join small multispecies groups; if in areas occupied by adults,

may join 'harems' with individuals ranging from 60-200 mm (=TP).

Field identification. *S. bleekeri* closely resembles *S. sordidus*. Although the two species share a number of colour patterns (Table 1), it can be distinguished from *S. sordidus* and other dark coloured scarids by its pale caudal fin and caudal peduncle.

Scarus chameleon Choat & Randall

Pl. 3C

Material examined. (34 specimens: 9-45 mm). AUSTRALIA - Lizard Island, AMS I.27858-002 (1:23 mm), AMS I.27855-001 to I.27855-005 (5:24-33 mm), AMS I.27831-001 (1:24 mm), AMS I.27833-001 (1:26 mm), AMS I.27840-001 (1:27 mm), AMS I.27830-002 (1:28 mm), AMS I.27837-001 (1:29 mm), AMS I.27832-001 (1:29 mm), AMS I.27832-002 (1:30 mm), AMS I.27856-001 to I.27856-003 (3:30-32 mm), AMS I.25904-001 (3:30-45 mm), AMS I.25799-001 (2:30-43 mm), AMS I.27841-001 (1:31 mm), AMS I.25782-002 (1:32 mm), AMS I.25793-001 (1:33 mm), AMS I.27839-001 (1:34 mm), AMS I.27830-001 (1:35 mm), AMS I.27837-002 (1:38 mm), AMS I.27843-002 (1:41 mm); MacGillivary Reef, Lizard Island, AMS I.27850-001 (1:26 mm), AMS I.27850-003 (1:30 mm), AMS I.27850-002 (1:37mm). Provisional identifications: Lizard Island, AMS 27848-002 (1:9 mm), AMS I.27851-001 (1:11 mm), AMS 27849-009 (1:14 mm).

Diagnosis. Median predorsal scales 4 (occasionally 5), anterior scale moderately large, preceded by a pair of laterally overlapping scales; cheek scale rows 3, 1-3 in ventral row; pectoral rays 14.

Diagnostic colour notes. Snout and/or orbital region of orbital stripe with golden hue, body striped or uniformly brown, pectoral stripe usually terminates at pectoral base; body often with overall golden hue or abruptly pale ventrally; extremely variable colour patterns.

Colour notes. Extremely variable with wide range of colour patterns, able to change patterns rapidly; recently settled specimens (10-14 mm) undergo 'typical' series of colour pattern changes outlined in Fig. 3A-E, body off white, dark stripes pale brown; greater than 15 mm, 2 basic colour patterns predominate: striped or uniform. Striped pattern with 4 basic scarid stripes, body usually off white with pale brown stripes, although whole body often with overall golden hue; striped phase has 3 distinctive features: (1) anterior portion of the orbital stripe frequently golden, golden hue may extend onto opercular portion of stripe, over snout and orbital region, including iris; (2) pectoral stripe typically terminates at pectoral fin base leaving cheek off white; (3) ventral stripe often lost, with ventral region of body being abruptly paler below level of pectoral stripe; less than 40 mm, 2 rows of faint dots may be present in orbital and pectoral stripes, dots clear in newly collected specimens, but often indistinct in field; intensity of striped pattern and frequency of appearance decreases in progressively larger specimens; maximum size at which striped pattern clearly displayed approximately 70-80 mm.

Uniform colour pattern first displayed at approximately 15 mm, becoming increasingly prevalent with increasing size; basic body colour varies from pale tan to dark brown; in shallow water (less than 5 m), body often pale tan with an abruptly off-white belly, in deeper water (greater than 8 m), body often dark brown or mahogany brown; if uniformly dark, iris, snout and orbital region often distinctly golden (golden colouration indistinctly visible in Pl. 3C), alternatively, snout remains pale grey; at 15 mm, fins hyaline, with growth, fins darken, slowly taking on body colour, except caudal fin which may have faint olive-yellow hue greater than 60 mm; 25-45 mm, body may have overall golden hue, which in dark specimens may form reddish colour like burnished copper; 2 series of pale dots along flank visible in dead or captive specimens (Pl. 3C) occasionally apparent in field; golden colour in orbital

Table 1. Variation in the colour patterns of a group of predominantly dark juvenile *Scarus* species.

Species:	bl	gib	so	spi	sch
Uniformly black	+	+	+	+	+
Black, white caudal and caudal peduncle	+				
Black, pale crescent on caudal fin		+			
Black, white caudal peduncle with dark dot			+		
Black, pale vertical bands	+				+
Four dark stripes:	+	+			
- deep black, fins dark basally		+			
- pale caudal and caudal peduncle	+				
Five dark stripes			+	+	
- medial stripes dark or enlarged on caudal peduncle			+	+	
- dorsal stripe with dashed dorsal division			+	+	
- white caudal peduncle with dark dot			+		

Species: bl, *S. bleekeri;* gib, *S. gibbus;* so, *S. sordidus;* spi, *S. spinus;* sch, *S. schlegeli.*

Changes in the colour pattern of a species occur rapidly, usually in less than four seconds and sometimes in less than a second.

region rapidly lost upon capture; dark, random spots on body and fins appear to be cysts or parasite scars, as in *S. psittacus;* characteristic IP colour pattern, with pale yellow caudal fin and brown body, first displayed at about 80mm.

Scarus chameleon can change colour patterns rapidly, especially upon capture; colour patterns described above are based on numerous observations over a range of habitat types; colour pattern appears to correlate with size, location and social behaviour of individuals; in shallow water (less than 5 m), small solitary and schooling specimens tend to be striped, larger specimens uniformly pale; in deeper water (greater than 5 m), all specimens tend to be solitary and uniformly dark.

Colour in alcohol. Colour extremely variable, body uniformly pale or dark, banded, striped or with indistinct dark patches corresponding with regions of overlap of 'typical' scarid bands and stripes, often pale brown with 5-6 pale brown bands on body; orbital and pectoral stripes may be darker at posterior extremities, but not as intensely as in *S. spinus* or *S. sordidus; S. chameleon* retains no characteristic colour pattern.

Ecology. Common; solitary or in small or large (greater than 25 individuals), conspecific or multispecies schools; some individuals site attached when small; settlement sites variable, but include dead coral and coral rubble, 1-9 m, in wide range of habitats including lagoon patch reefs, lower reef slope and rubble covered base of moderately exposed reef slopes; larger juveniles recorded over all substratum types with exception of open sand, from all reef habitats, 1-12 m, most abundant at Lizard Island, on sheltered reef slopes, recorded from reef flat, lagoon and backreef areas of outer shelf reefs; in lagoon and sheltered areas most often observed in small multispecies schools, often with *S. psittacus* and *S. rivulatus*; in deeper water, usually solitary, only occasionally schooling with other species, such as *S. schlegeli* or *S. sordidus.*

Field identification. This is one of the most ubiquitous juvenile scarids. It has a wide range of colour patterns which can change rapidly and is, therefore, one of the most difficult species to identify, particularly as many of the colour patterns are shared with other *Scarus* species. It can be identified when it displays a golden hue restricted to the orbital region, or a truncated pectoral stripe. The abruptly pale belly is also a useful diagnostic feature. However, individuals may have to be followed for several minutes or hours before they display these colour patterns. In shallow water, *S. chameleon* often schools with *S. psittacus* and *S. rivulatus. S. chameleon* is most easily distinguished from these congeners by the abruptly pale ventral region, although it may be necessary to collect specimens for confirmation based on meristic analyses. *S. chameleon* is most difficult to identify in deep water when it has an overall dark hue like that of *S. schlegeli.* It is usually necessary to collect these specimens for meristic analyses. Fortunately, *S. chameleon* can be separated from most other GBR scarids by scale counts.

When recently settled, *S. chameleon* cannot be distinguished from *S. psittacus, S. rivulatus* or *S. schlegeli* in the field; specimens must be reared in aquaria to an identifiable size.

Previous descriptions. A colour description of a 23 mm specimen and a colour plate of a 60 mm specimen from Lizard Island are given in Choat & Randall (1986).

Scarus dimidiatus Bleeker

Pl. 4A

Material examined. (3 specimens: 17-53 mm). AUSTRALIA - Lizard Island, AMS I.25785-002 (1:53 mm); Yonge Reef, AMS I.25912-006 (2:17-30 mm).

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

Diagnostic colour notes. Body yellowish, whitish ventrally, with 5 broad slightly diagonal dark bands on dorsum; bands as wide as pale interspaces and increasingly distinct greater than 20 mm.

Colour notes. A distinctive species, body yellowish to canary yellow, with 5 dark bands on dorsum each as wide as pale interspaces, bands correspond to bands 1-5 of 'typical' scarid banding pattern (Fig. 3), bands faint less than 20 mm and fade in larger specimens when individuals are disturbed; in large specimens (greater than 40 mm), bands 4 and 5 often indistinct; less than 35 mm (Pl. 4A), bands may extend onto lower half of body and onto dorsal fin base, fins hyaline-pale yellow; in larger specimens, bands restricted to dorsum and base of dorsal fin, fins pale yellow; colour patterns of large juveniles (greater than 50 mm) indistinguishable from those of IP individuals; dark medial stripe, often displayed by large juveniles and IPs in central and western Pacific, not noted in juvenile specimens observed on GBR; does not undergo rapid colour changes, with exception of fading of dark bands when stressed or disturbed.

Colour in alcohol. Body yellow green to grey with brown bands; at 17 mm, bands restricted to dorsal part of dorsum near dorsal fin base, fins hyaline; at 30 mm, bands extend faintly onto lower half of body; at 53 mm, bands restricted to upper half of body and along basal part of dorsal fin; fins pale yellow grey.

Ecology. Uncommon; solitary, site attached, rarely joins small multispecies schools; settlement sites probably in live arborescent corals in shallow water (1-5 m); juveniles only recorded in large stands of arborescent coral (primarily *Acropora* spp.; occasionally *Porites cylindrica*), in sheltered, shallow (1-5 m) backreef and lagoonal areas of midshelf reefs, and backreef and reef flat areas of outer

shelf reefs; at Lizard Island, no large juveniles (greater than 80 mm) found in lagoon, may indicate migratory movement as in *S. oviceps*; small individuals (20-25 mm) observed on several occasions in schools of yellow damselfishes (*Pomacentrus molluccensis* and *P. amboinensis*), occasionally feeding within school, possibly on damselfish faecal pellets, as recorded in adult *S. oviceps* by Bailey & Robertson (1982); on GBR, usually solitary, but in areas where they form a dominant part of juvenile scarid populations (e.g. Philippines) will often form small schools with conspecifics or join multispecies schools.

Field identification. The bright yellow body distinguishes this species from all GBR scarid species with the exception of *S. oviceps*. *S. dimidiatus* may be distinguished from the closely related *S. oviceps* by the presence of 4-5 distinct dark bands as wide as the pale interspaces and the lack of a dark orbital stripe on the head.

Remarks. The close relationship between *S. dimidiatus* and the Indian Ocean species, *S. scaber* Valenciennes, and the strong similarity between their IP colour patterns (Randall & Choat, 1980), strongly suggest that the juvenile phase of *S. scaber* will be similar to that of *S. dimidiatus*.

Scarus flavipectoralis Schultz

Pl. 3A,B

Material examined. (4 specimens: 26-45 mm). AUSTRALIA - Lizard Island, AMS I.27858-001 (1:26 mm), AMS I.25782-004 (1:33 mm), AMS I.25787-001 (2: 44-45 mm).

Diagnosis. Median predorsal scales 4, no anterior pair, anterior scale largest; cheek scale rows 3, 1-2 in ventral row; pectoral rays 14; body elongate, spindle shaped.

Diagnostic colour notes. At less than 40 mm, dorsal, orbital and pectoral stripes present, last 2 being darkest; larger specimens with pale body and dark grey caudal fin; pectoral fin pale yellow.

Colour notes. At less than 40 mm, body pale grey tan, prominent dark grey-green orbital and pectoral stripes (Pl. 3A), which may fuse slightly on caudal peduncle, dark dorsal stripe present but often indistinct, belly typically pale, vertical fins pale brown basally, hyaline distally, pectoral fins with faint yellow hue; greater than 40 mm, body pale grey brown, caudal fin dark-grey brown but of variable intensity (e.g. pale in Pl. 3B), dorsal and anal fins pale-grey brown with indistinct mottling, pectoral fins pale yellow; colour patterns change infrequently, most notably in individuals 30-40 mm, which may display either striped or uniformly pale colour patterns; yellow pectoral fin useful diagnostic feature but often exceedingly pale in small specimens; in field, large juveniles typified by elongate pale body and dark caudal fin, closely resembling IP colouration, which is first displayed at approximately 70 mm.

Colour in alcohol. Small specimens (26-33 mm), body pale brown, dark orbital and pectoral stripes retained, dorsal stripe fades; larger specimens (44-45 mm), body pale with dark patches where 'typical' scarid bands and stripes intersect, dorsal, anal and caudal fins pale-grey brown with no distinctive markings.

Ecology. Uncommon; solitary, occasionally joining small multispecies schools; probably site attached; settlement sites unknown; at Lizard Island, juveniles (greater than 26 mm) most frequently recorded over coral rock or rubble at base of reef slope, invariably in deeper water (5-14 m), on both sheltered and exposed reef slopes.

Field identification. This species may be difficult to identify in the field. The most distinctive feature is the elongate spindle-shaped body. The yellow pectoral fins are often too faint to be of diagnostic use. In small specimens, the dominance of the two medial stripes is a useful diagnostic feature, whilst the pale body and dark caudal fin are useful for identifying larger juveniles. However, collection and meristic analyses are recommended, particularly for small specimens.

Scarus forsteni (Bleeker)

Pl. 5H

Material examined. (4 specimens: 49-62 mm). AUSTRALIA - Yonge Reef, AMS I.25908-001 (1:61 mm); PHILIPPINES - Apo Island, AMS I.27461-001 (1:62 mm); Sumilon Island, AMS I.27457-001 (2:49-61 mm).

Diagnosis. Median predorsal scales 5-7, preceded by a pair of laterally overlapping scales; scale size increases posteriorly, third and fourth scales largest; cheek scale rows 3, 2-5 in ventral row; pectoral rays 14; dental plates pale blue-green or off white (see below).

Diagnostic colour notes. At less than 25mm, body off white to pale brown, 4 brown stripes, pale dots in orbital and pectoral stripes; greater than 25 mm, body pale brown, stripes may not be present, single prominent pale dot often present near pectoral fin tip.

Colour notes. A variable species capable of rapid colour changes; smallest specimen observed on GBR 25 mm, colour notes of specimens less than 25 mm based on Philippine specimens; 15-25 mm, body off white with 4 brick red to brown stripes which appear brown in field, 2 rows of pale dots present in orbital and pectoral stripes, corresponding with pale dots in recently settled juveniles (Fig. 3B), dark bar at pectoral fin base not visible; 25-50 mm, contrast decreases between 4 dark stripes and pale interspaces, body and fins take on overall pale brown hue, 2 rows of pale dots in orbital and pectoral stripes slowly fade, lower row first, only 1 dot near pectoral fin tip remains distinct at 50 mm (faint in Pl. 5H); intensity of this pale dot can

change rapidly, but greater than 50 mm becomes increasingly prominent, increasing in relative size; greater than 50 mm, body brown, with pale brown interspaces, anterior region of belly with pale red hue, midbody occasionally with darker slate-blue grey hue, although intensity can vary considerably, often rapidly, dorsal, anal and pelvic fins pale brown (faintly mottled when collected), caudal fin olive-green yellow, pectoral fins hyaline yellow, single dot on body prominent, 2 smaller pale dots may be visible posterior to it; in some individuals, pale dot and dark medial region may be absent, colour pattern therefore uniformly pale brown to brown with faint pale interspaces; greater than 60 mm, pale dot may have a dark bluish patch of variable intensity on its upper border which may extend over pale dot; maximum size at which pale interspaces are displayed approximately 70 mm; IP colour patterns predominate greater than 90 mm; dark bar on pectoral fin base present in freshly collected juveniles greater than 60 mm (Pl. 5H), but not visible in field, dark bar develops shortly after death.

Colour in alcohol. Single 61 mm GBR specimen: body grey, darker dorsally, pale interspaces faintly visible, dark bar at pectoral fin base distinct. Philippine specimens (42-69 mm): body grey brown to brown, palest ventrally, pale interspaces and dots only visible in 62 mm specimen, vertical fins grey brown, dorsal fin darkest; dark pectoral fin base distinct.

Ecology. Rare; settlement sites unknown; solitary specimens (25-70 mm) observed over areas with few live corals and extensive coralline algae, in deep water (9-25 m) on steep outer reef slopes of outer shelf reefs; single specimen observed and collected over coral rock at 5 m, in channel between Yonge and Carter Reefs.

Field identification. The restricted distribution of this species to an area where few other scarid species are found reduces the chances of confusion with other species, whilst the presence of a single pale dot on the side clearly separates this species from all other GBR *Scarus* species. As this pale dot is not always displayed, prolonged observations are often necessary for accurate identifications. The single specimen collected was uniformly brown when first observed and only displayed the pale interspaces and diagnostic pale dot when caught. Small specimens which do not display the diagnostic single pale dot can be distinguished from other species with similar colour patterns (i.e. stripes with pale spots) by the paler body and browner hue, although meristic counts are essential for confirmation.

Previous descriptions. Choat & Randall (1986) describe the late juvenile phase and give a colour plate of a 41 mm specimen from Tutuila, Samoa.

Systematic notes. The single GBR specimen examined in this study has been identified as *S. forsteni* based on its colour patterns, both in the field and when collected, and its meristic values. However, its dental plates were pale blue-green, whereas those of the IP, and of juvenile *S. forsteni* from other geographic locations, are white to off white. Additional observations of this species on the GBR are required, to ascertain if this difference occurs consistently in individuals on the GBR.

There has been some confusion over the identification of this species on the GBR. It was previously identified as *S. tricolor* Bleeker (Randall & Choat, 1980). *S. tricolor* is, however, a closely related species from the Indian Ocean and Western Pacific which has not as yet been recorded from the GBR (Choat & Randall, 1986). The colour patterns of juvenile *S. tricolor* are distinct from those of *S. forsteni* (Bellwood, 1988).

Scarus frenatus Lacepède

Pl. 5B - D

Material examined. (19 specimens 8-95 mm). AUSTRALIA - Lizard Island, AMS I.27860-001 (1:8 mm), AMS I.27863-002 (1:8 mm), AMS I.27862-001 (1:9 mm), AMS I.27862-002 (1:12 mm), AMS I.27840-002 to I.27840-005 (4:9-22 mm), AMS I. 25914-001 (1:10 mm), AMS I.25786-002 (1:19 mm), AMS I.25799-002 (1:28 mm), AMS I.27836-004 (1:31 mm), AMS I.27822-001 (1:95 mm); Yonge Reef, AMS I.27829-001 (1:20 mm), AMS I.25912-002 (2:23-27 mm), AMS I.25912-001 (1:31 mm), AMS I.27820-002 (1:43 mm); North Direction Island, AMS I.25915-001 (1:25 mm).

Diagnosis. Median predorsal scales 6 (rarely 7), scales subequal or decreasing in size anteriorly, often preceded by pair of non-laterally overlapping scales; cheek scale rows 3, 2-4 in ventral row; pectoral rays 14 (rarely 15); based on material greater than 22 mm (median predorsal scales complete at 14 mm; cheek scales complete at 22 mm).

Diagnostic colour notes. At 9-12 mm, yellow green body; 12-24 mm, 3 broad lime green stripes broken by paler dots and irregular pale interspaces; 24-40 mm, body olive green with pale interspaces visible on head, posterior part of body, caudal peduncle and caudal fin pale blue, dorsal and anal fins with red and white flecks; greater than 40 mm, body olive green to pale-red brown (especially in larger individuals), pale interspaces on head give impression of dark longitudinal stripe passing through orbit, caudal fin and caudal peduncle pale blue to off white, dorsal and anal fins with prominent red and white flecks.

Colour notes. A striking species with a series of distinctively coloured stages; changes colour patterns several times during ontogeny, but no rapid colour changes; one of the few scarid species that can be accurately identified when recently settled; 9-12 mm, body pale-yellow green with white dot on caudal fin base, fins hyaline, some specimens may display several series of pale dots (Pl. 5B, cf. Fig. 3A,B); 12-24 mm, pale dots increasingly prominent, overall appearance is of lime green body with

series of pale dots and narrow pale yellow longitudinal lines (Pl. 5C), which are interspaces between 4 broad longitudinal primary stripes, lines give head angular appearance; at approximately 24 mm, white and red flecks first appear at anterior bases of dorsal and anal fins, otherwise fins hyaline.

At 24-40 mm, body slowly changes colour, anterior two thirds of body darkens to olive green, pale interspaces become increasingly faint and restricted to head region where dark orbital stripe may be displayed, posterior third of body fades and takes on pale sky-blue hue, extending onto caudal fin and, in some specimens, onto posterior regions of dorsal and anal fins and along belly (Pl. 5D), pale dots on body become increasingly faint, white and red flecks on dorsal, anal and pelvic fins become more extensive and increasingly distinct.

At greater than 40 mm, overall colour pattern darkens, body darkens to olive brown then red brown, pale interspaces fade, in some specimens pale portions above and below orbit may emphasise a dark orbital stripe extending from snout to operculum, caudal fin and caudal peduncle darken to off white with red-brown hue of variable intensity, flecks in dorsal, anal and pelvic fins deepen before diffusing at onset of IP colouration, otherwise, fins pale red brown; dark scale bases characteristic of IP colouration become increasingly prominent greater than 100 mm; full IP colouration complete at 120 mm.

Colour in alcohol. Small specimens (9-12 mm), body off white to pale yellow, fins hyaline: 12-20 mm, body pale-yellow grey with broad grey-brown stripes, in some specimens 12-15 mm, pectoral stripe wider and darker than other stripes, giving individuals a superficial resemblance to similarly sized *S. rubroviolaceus*; greater than 20 mm, body pale grey brown, pale caudal fin and caudal peduncle indistinct, dark flecks on body and fins retained.

Ecology. Uncommon; solitary, site attached and often aggressive towards other scarids, especially conspecifics, at North Reef, Lizard Island, settled in largest numbers in areas of complex algal-covered coral rubble at base of reef slope (6-8 m); a few specimens settled in lagoon and backreef areas, in areas of structural complexity with extensive growth of turf algae in shallow water (1-3 m); at Lizard Island, small *S. frenatus* observed on numerous occasions, feeding and residing within pomacentrid territories, individuals remained within these territories until approximately 30 mm; most frequently inhabited territories were of *Plectroglyphidodon lacrymatus, Stegastes nigricans, S. apicalis* and *Pomacentrus grammorhynchus,* this relationship does not appear to be obligatory as several specimens also recorded in areas lacking pomacentrid territories; with growth, individual home ranges expanded, and extended up reef slope; at 30 mm, home ranges primarily restricted to reef crest region, including areas within *Acanthurus lineatus* territories, individuals remained in this region throughout remainder of juvenile period, before joining resident harem of adults as IP; a comparable degree of site fidelity was recorded at other locations; at Lizard Island and other midshelf reefs, juveniles recorded from all shallow (1-5 m) reef regions but most abundant in upper reef slope and reef crest; on outer shelf reefs, small specimens only recorded in shallow (1-7 m) backreef areas, few large (greater than 70 mm) specimens recorded from reef slope (5-9 m); detailed notes on biology of juvenile *S. frenatus* given in Bellwood (1986).

Field identification. This is one of the few scarid species that can be accurately identified when recently settled, by its characteristic yellow-green body. At 9-12 mm, *S. frenatus* may be confused with *S. oviceps* and *S. dimidiatus,* and at least one species of labrid (*Halichoeres gymnocephalus*), because of its pale yellow-green colour pattern. The latter can be distinguished in the field by its angular snout and swimming mode, and by meristics if collected. The two other *Scarus* species have not been observed at very small sizes but the smallest specimens examined had a canary-yellow colour rather than the lime-yellow colour of *S. frenatus.* The colour patterns of larger juvenile *S. frenatus* are not shared by any other GBR species. The identification of these later stages is therefore, relatively easy.

Previous descriptions. The colour patterns of moderately large juveniles were described and figured by Schultz (1958), as paratypes of *S. randalli* Schultz. The species description of *S. randalli* was based on the juvenile and IP of *S. frenatus.* A colour plate of a small specimen of *S. frenatus* from the Maldive Islands is given in Randall & Bruce (1983), with a brief colour description. It is interesting to note that this specimen from the Indian Ocean is virtually identical to juveniles of a similar size from the Pacific. The specimen identified as a juvenile *S. frenatus* in Masuda *et al.* (1984; pl. 214H) is probably *S. prasiognathos* (cf. Bellwood,1988). Choat & Randall (1986) give a brief description of the late juvenile phase of *S. frenatus* and a colour plate of a 100 mm specimen from Lizard Island.

Scarus ghobban Forsskål

Pl. 4H

Material examined. (4 specimens: 42-54 mm). AUSTRALIA - Lizard Island, AMS I.27819-001 (1:42 mm), AMS I.25903-003 (1:52 mm), AMS I.27819-002 (1:53 mm), AMS I.27819-003 (1:54 mm).

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

Diagnostic colour notes. Body pale with yellow hue

and 5 narrow pale blue-white vertical bands, caudal fin dark orange yellow, especially in specimens less than 35mm.

Colour notes. May display several colour patterns, able to change colour patterns rapidly, predominant colour patterns being (a) striped and (b) uniformly pale. Striped pattern: usually displayed by individuals less than 50 mm, dorsal, orbital and pectoral stripes present, stripes tan with orange hue, interspaces similarly coloured but paler, belly off white, vertical bands indistinct, vertical fins with deep orange-yellow hue. Uniformly pale pattern: predominates in individuals greater than 40 mm, body pale tan with orange hue, vertical fins with deep orange-yellow hue, especially caudal fin, 5 narrow vertical bands which correspond with pale interspaces of 'typical' scarid banding pattern (Fig. 4) often distinct; 30-40 mm, bands off white and may vary greatly in intensity, occasionally appearing as 2 rows of pale dots rather than discrete bands; greater than 50 mm, bands clearly visible with blue-white hue.

At greater than 50 mm colour pattern increasingly resembles that of IP, body orange tan to grey yellow, paler ventrally. Freshly collected specimens: belly and pelvic fins with pink hue, pale blue-white vertical bands retained, pectoral fins hyaline, yellow dorsally, medial fins yellow tan, in larger specimens blue markings around mouth and orbit and on cheek become increasingly distinct, blue distal margin of dorsal and anal fins, dorsal and ventral margins of caudal fin and anterior edge of pelvic fins also increasingly distinct; at 80 mm, pale blue dots present along base of dorsal and anal fins, first pectoral spine blue; IP colouration fully developed at about 90 mm.

Colour in alcohol. Body pale brown grey, pale bands visible but faint, some specimens with dark patches corresponding with intersections of 'typical' scarid stripes and bands.

Ecology. Uncommon; most frequently observed in small multispecies schools; settlement sites unknown; at Lizard Island, juveniles (30-90 mm) recorded along edges of extensive reef patches bordered by sand, in shallow (1-3 m) areas of lagoon; on Magnetic Island, an inshore island with fringing reefs, occasionally observed among reef flat sargassum beds, schooling with *S. rivulatus*.

Field identification. When schooling, this species may be initially confused with other schooling species e.g. *S. chameleon, S. psittacus* and *S. rivulatus*. However, it may be distinguished by its narrow pale blue-white vertical bands, and by its distinctive deep yellow-orange or golden hue, especially on the fins, which is a deeper colour than that of other schooling species. This is the only GBR scarid with pale vertical bands on a pale body in the field.

Previous descriptions. The late juvenile phase has been described by Choat & Randall (1986) and briefly by Randall & Bruce (1983). Burgess & Axelrod (1974) give a colour plate of an 83.6 mm specimen from Taiwan.

Scarus gibbus Rüppell

Pl. 1E,F

Material examined. (8 specimens: 12-40 mm). AUSTRALIA - Lizard Island, AMS I.25913-001 (2:20-26 mm), AMS I.25909-002 (1:21 mm), AMS I.27836-003 (1:25 mm), AMS I.27825-001 (1:33 mm), AMS I.25782-003 (1:34 mm), AMS I.25905-001 (1:40 mm), AMS I.27843-001 (1:40 mm).

Diagnosis. Median predorsal scales 4, no anterior pair, anterior 2 scales largest; cheek scale rows 3, 3-7 in ventral row; pectoral rays 15-17 (usually 16); based on material greater than 20 mm; dental plates exposed in large specimens.

Diagnostic colour notes. Four black primary stripes, thin in small individuals, relatively wide in large individuals; interspaces white in small individuals, creamy white to yellowish in larger individuals; greater than 20 mm dorsal, anal and caudal fins black.

Colour notes. Dashed phase, 11-13mm (cf. Fig. 3C,D), body bright white with 4 primary rows of black dashes, fins hyaline, dashed orbital and pectoral stripes fuse at about 13-14 mm, followed by fusion of dorsal and anal stripes; with growth, black stripes increase in width and black bases of dorsal, anal and caudal fins slowly expand; at 20 mm, stripes and pale interspaces of approximately equal size (Pl. 1E), black stripes more intense and interspaces whiter than other dark striped juvenile scarids, a series of white dots may be distinct in pale interspaces; greater than 20 mm (Pl. 1F), dark stripes continue to expand and overall appearance is of pale stripes on black background, interspaces creamy yellow to off white, dark fin bases also expand, only edges remain hyaline, pectoral fin yellow proximally, hyaline distally; greater than 40 mm, pale interspaces darken, resulting in uniformly black pattern, although faint pale interspaces may be displayed occasionally, yellow hue of pectoral fins distinct; uniformly dark pattern maintained to approximately 80 mm when pale crescent may be displayed on caudal fin; greater than 80 mm, body and fins slowly fade and take on green hue, blue-green markings increasingly prominent around mouth, on distal borders of median fins and on caudal fin, especially along longest dorsal and ventral rays, diagnostic pale green bar across cheek develops subsequently; IP colour pattern complete at about 150 mm; deep body and blunt profile with sloping forehead noticeable at this size.

Colour in alcohol. Patterns as in live specimens, but black stripes and fins become dark grey, pale interspaces become pale grey. Uniformly dark specimens remain uniformly dark grey.

Ecology. Moderately common; site attached; recently settled individuals most frequently observed amongst large algal covered arborescent coral fragments at reef slope base (7-10 m); no specimens observed in pomacentrid

territories; juveniles recorded most often over coral rock or large coral rubble fragments, in deep water (4-12 m), most frequently on, or at base of, reef slope, in exposed and semi-exposed locations of mid shelf reefs and backreef bommies of outer shelf reefs; 1 or 2 individuals observed in lagoon and on reef crest at Lizard Island; small individuals may join small multispecies groups comprising 3-5 individuals, but greater than 30 mm invariably solitary.

Field identification. Small *S. gibbus* are easily distinguished from other dark juvenile scarids (Table 1) by the intense black and white stripes and black caudal fin base. In the uniformly dark black phase, it may be separated from *S. spinus* and *S. schlegeli* by its head shape, but cannot be distinguished from *S. bleekeri* or *S. sordidus* until the latter display their diagnostic colour patterns, or if the pale caudal crescent and pale yellow pectoral fins of *S. gibbus* are visible. Small *S. gibbus* (less than 30 mm) may initially be confused with juvenile *Labropsis australis* which have a similar colour pattern (described by Randall, 1981). *L. australis* may, however, be distinguished from *S. gibbus* by its more angular profile, elongate body, and distinctive exaggerated sinuous swimming motion. *S. gibbus* does not undergo rapid colour changes. The most variable stage is towards the end of the uniformly black phase, when it may display no pale markings, faint longitudinal stripes, or the pale crescent in the caudal fin. These changes are relatively slow and do not follow any distinct behavioural patterns.

The juvenile colour patterns of the red phase of *S. gibbus* (*sensu* Randall & Choat, 1980) are unknown. No juvenile specimens attributable to this colour morph were observed, although it is likely that the two GBR phases of *S. gibbus* share a common juvenile colour pattern.

Previous descriptions. The late juvenile stage of *S. gibbus* has been described briefly by Schultz (1958; as *S. microrhinos* Bleeker), Randall & Choat (1980), Randall & Bruce (1983; with a colour plate of a 59 mm specimen), and Choat & Randall (1986; with colour plates of a 59 mm and a 65 mm specimen). Burgess & Axelrod (1973b, p. 631, pl. 89) provide a colour plate of a juvenile scarid from the Maldives (as *Scarus* sp.). This specimen is indistinguishable from juvenile *S. gibbus* from the Pacific.

Scarus globiceps Valenciennes

Material examined. (5 specimens: 25-59 mm). AUSTRALIA - Lizard Island, provisional identifications, AMS I.27852-001 (1:22 mm), AMS I.27839-004 (1:25 mm), AMS I.25910-002 (1:25 mm), AMS I.27847-001 (1:29 mm), AMS I.25797-001 (1:59 mm).

Diagnosis. Median predorsal scales 5-6, often laterally overlapping anterior pair, scale size reduced anteriorly; cheek scale rows 3, 3 in ventral row; pectoral rays 14; based on selected specimens, see below.

Diagnostic colour notes. A variable species, extremely similar to *S. rivulatus*. *S. globiceps* has no discernable unique or diagnostic colour patterns.

Colour notes. Specimens provisionally identified as *S. globiceps* displayed 2 basic colour patterns: striped or uniformly pale. Striped phase: body pale tan with 4 dark tan-brown primary stripes; in small specimens (less than 25 mm), caudal extremities of medial stripes may be darkened, similar to, but not as intense as in *S. sordidus* and *S. spinus*. Uniformly pale colour pattern: body pale tan grey, fins pale grey, most often seen in large individuals, appear slightly darker grey brown than *S. rivulatus;* overall, colour patterns closely resemble those of *S. rivulatus*.

Colour in alcohol. Specimens provisionally identified as *S. globiceps* were uniformly grey brown, with darker dorsal surface; one specimen had faint body stripes, and dashes at base of dorsal and anal fins.

Ecology. Individuals tentatively identified as *S. globiceps* observed in small multispecies schools, over sand and coral rubble, in shallow water (1-4 m), in reef flat, backreef and lagoonal areas of Lizard Island; adults abundant on mid- and outer shelf reefs but rare or absent from inshore reefs (Russ, 1984; Williams, 1982), juveniles therefore most likely to be observed in first two localities.

Field identification. Juvenile *S. globiceps* are extremely difficult to identify both in the field and in preserved collections because of their similarity to juvenile *S. rivulatus*. Mature IP specimens of both species often have extremely similar colour patterns but can be separated, when collected, by their meristic values and

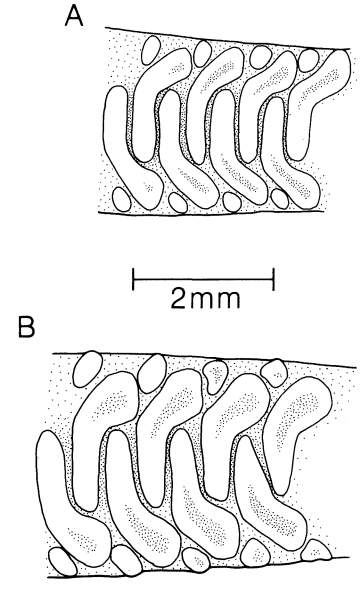


Fig.6. A ventral view of the upper pharyngeal tooth rows of (A) *S. globiceps* and (B) *S. rivulatus*. Both figures are of the midregion of the upper pharyngeal bones, posterior to the first worn tooth. Both specimens were 128 mm SL.

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

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

Morphological notes. The form of the upper pharyngeal tooth plates of mature IP *S. globiceps* and *S. rivulatus* are consistently different. In *S. globiceps,* the dental plate is relatively small and elongate, with strongly interdigitating medial tooth rows, forming a rhabdom-like central region (Fig. 6A). In contrast, *S. rivulatus* has a more robust dental plate, larger, rounded teeth and less strongly interdigitating medial tooth rows (Fig. 6B). These differences were consistent in specimens greater than 114 mm and may assist in the identification of *S. globiceps* and *S. rivulatus* as juveniles.

Scarus longipinnis Randall & Choat

Pl. 3D,E

Material examined. (2 specimens: 39-75 mm). AUSTRALIA - Lizard Island, AMS I.25789-001 (1:39 mm); Carter Reef, AMS I.25784-001 (1:75 mm).

Diagnosis. Median predorsal scales 4, no anterior pair, anterior scale largest; cheek scale rows 3, 1-3 (usually 2) in ventral row; pectoral rays 14; relatively long dorsal spines and rays distinguishable at 75 mm.

Diagnostic colour notes. Small individual (39 mm), body pale tan with 7 dark brown vertical bands; larger individual (75 mm), body uniformly pale mahogany brown (banding variable); both sizes with distinct dark spot on dorsal fin base between first 2 spines and dark crescent-shaped patch on middle of caudal fin.

Colour notes. Rapid colour pattern changes not observed; at 39 mm (Pl. 3D), body off white, with 7 dark brown bands extending onto dorsal and anal fin bases, dorsal fin pale brown, with distinct dark basal spot between first 2 spines, pectoral fins and distal ends of pelvic and anal fins hyaline, caudal fin pale brown with dark medial patch (indistinct in Pl. 3D); pale body and dark brown bands particularly distinctive in field; at 75 mm (Pl. 3E), body deep mahogany brown, 2 pale blue stripes extend from mouth to orbit, 1 across cheek, 3 along belly, dorsal and anal fins olive brown, anal edged with broad blue band, dark spot between first 2 dorsal spines still distinct, pelvic fins red brown at base, pale blue hue distally, caudal fin with orange dorsal and anal margin and distinct dark medial patch, characteristic elevated dorsal fin apparent at this size.

Colour in alcohol. At 39 mm, body pale brown grey, dark bands visible but faded except where orbital and pectoral stripes would pass, giving the appearance of 2 diffused dashed lines, fins brown hyaline; pattern similar to preserved colour pattern of some specimens of *S. chameleon* and *S. ghobban;* at 75 mm, body uniformly dark grey brown, fins slightly paler; in both specimens, small dorsal spot and dark caudal patch retained.

Ecology. Rare in Lizard Island and central GBR regions; 39 mm specimen collected over algal-covered coral rubble at 4 m, Mermaid Cove, Lizard Island, in multispecies school including *S. chameleon, S. psittacus* and/or *S. schlegeli;* 75 mm specimen collected between large coral boulders on sand, 9 m, at base of backreef coral bommie on Carter Reef, with small group of juvenile scarids when first observed but subsequently remained solitary. Adults rare in northern GBR where it is typically found in deeper portions (20-30 m) of outer reef fronts; more abundant in shallower water (10-15 m) in southern GBR and is reported to be most abundant scarid species on Coral Sea reefs (Choat & Randall, 1986).

Field identification. Although large juveniles may be confused with other dark bodied species, the banded phase is easily distinguished as no other GBR *Scarus* species displays dark bands on a pale body. The most distinctive characteristic of larger specimens is the dark caudal patch combined with the dark body. Once collected, the dark spot on the dorsal fin is also diagnostic, although this spot is present (but faint) in several other *Scarus* species, including *S. chameleon* and *S. globiceps.*

Previous descriptions. Randall & Choat (1980) describe a 35 mm paratype as "...pale with exceedingly faint bars as in adults".

Scarus niger Forsskål

Pl. 5E-G

Material examined. (32 specimens: 8-57 mm). AUSTRALIA - Lizard Island, AMS I.27863-001 (1:8 mm), AMS I.25914-002 (2:8-9 mm), AMS I.27862-003 to I.27862-005 (3:8-10 mm), AMS I.27863-003 (1:9 mm), AMS I.27860-002 (1:9 mm), AMS I.27857-001 (1:12 mm), AMS I.27836-005 to I.27836-009 (5:17-31 mm), AMS I.25909-004 (4:19-22 mm), AMS I.27828-002 (1:20 mm); Yonge Reef, AMS I.27829-002 to I.27829-006 (5:15-24 mm), AMS I.25912-004 (2:20-23 mm), AMS I.25907-001 (1:57 mm); PHILIPPINES - Apo Island, AMS I. 27808-001 to I.27808-004 (3:17-45 mm); Sumilon Island, AMS I. 27809-001 (1:55 mm), AMS I.27460-001 (1:55 mm).

Diagnosis. Median predorsal scales 7 (occasionally 6), usually no anterior pair (occasionally non-laterally overlapping pair), scales subequal or reduced anteriorly; cheek scale rows 3, 3-4 in ventral row; pectoral rays 14; based on specimens greater than 20 mm, smaller specimens have lower cheek scale counts; median predorsal scales complete at 13 mm; large individuals with pale blue-green dental plates.

Diagnostic colour notes. At less than 10 mm, lower half of body dark, upper half translucent, body with series of white pupil-sized dots; 10-40 mm, lower portion of body dark with numerous small pale dots, upper part mottled olive green, white patch on caudal fin base preceded by 2 dark spots; 25-40 mm, caudal peduncle burgundy red; greater than 40 mm, body dark brown black, darkest ventrally, small pale dots on body faded, caudal peduncle pale red brown to brown, white patch at caudal fin base diffused and dark dots faded.

Colour notes. No rapid colour changes; at less than 9 mm, recently settled individuals with characteristic row of dark patches along ventral surface, dorsum remains transparent; 9-10 mm (Pl. 5E), lower half of body dark, upper half translucent, distinctive white dot present on caudal fin base, series of white pupil-sized dots on body correspond to 'typical' juvenile scarid pattern (Fig. 3A,B), fins hyaline.

At greater than 10 mm (Pl. 5F), dorsum mottled olive green, in progressively larger specimens, dark colouration in ventral part of body extends dorsally onto flank, and ventrally onto ventral and pelvic fins, olive colouration on dorsum extends onto dorsal fin, pale dots on body decrease in relative size, although increasing in number, dots may be white or pale blue and may be arranged in horizontal rows corresponding with scale rows (Pl. 5F), not with pale interspaces of 'typical' scarid pattern (Figs 3E, 4), caudal fin hyaline with bright white hemispherical patch at base, preceded by 2 black dots at bases of most dorsal and ventral caudal fin rays, ventral dot first visible at approximately 15 mm, dorsal dot at 20 mm, both dots increase in relative size in progressively larger specimens, pectoral fins hyaline to pale yellow; 25-40 mm caudal peduncle often deep burgundy (Pl. 5F), slowly fading to red then red brown at about 50 mm.

At greater than 50 mm (Pl. 5G), body gradually darkens to deep brown black, fins to dark brown, pale dots on body gradually lost, white patch on caudal fin base diffuses, then darkens, 2 dark caudal dots fade, pale yellow pectoral fin conspicuous from 50-65 mm but loses intensity and darkens in larger specimens; greater than 80 mm, green lines around mouth and under orbit, and blue-green margins on dorsal, anal and caudal fins become increasingly distinct; IP colouration first displayed at about 90 mm.

Colour in alcohol. Distinctive colour pattern retained and closely resembles that of live specimens, body remains dark-brown black ventrally, olive green to pale brown dorsally; this contrast decreases in larger specimens, which often have an overall dark grey-brown body; 2 dark spots on caudal fin base remain distinct, white caudal patch usually indistinct, pale body spots visible in small specimens but extremely faint in larger specimens.

Ecology. Moderately common; solitary, site attached, occasionally joining small multispecies schools; settlement sites in areas of complex algal covered coral rock or rubble, in deep water 4-10 m, typically at base of semi-exposed reef slopes or backreef bommies; with growth, home ranges of individuals expand and occupy most of reef slope region from 1-12 m, with exception of precipitous dropoffs which are often devoid of juvenile scarids; all individuals remain close to cover, although larger individuals may occasionally feed in areas of open rock or rubble; juveniles most abundant in deeper water (4-8 m) in relatively sheltered areas, typically over coral rock or rubble, on and at base of reef slopes, from 2-12 m; recorded from reef slope, lagoon and backreef areas of Lizard Island and other midshelf reefs, and backreef areas of outer shelf reefs; although usually solitary, may join small multispecies schools when small; larger specimens often aggressive to similar-sized conspecifics; such antagonism ceases at dusk, some large juveniles gather in small conspecific groups at base of reef slope, near to nocturnal resting sites, in or amongst large coral rubble fragments.

Field identification. *S. niger* is one of the few species that can be accurately identified shortly after settlement. It is easily distinguished throughout its juvenile phase from all other GBR scarid species by its unique colour patterns. Individuals are often difficult to locate in the field because of their cryptic colouration. From above, the mottled olive dorsum blends with the algal covered substratum, whilst from the side, the dark body matches the numerous small holes or overhangs in the areas in which this species is typically found.

Previous descriptions. The colour pattern of late juvenile phase *S. niger* has been described briefly by Schultz (1958), Randall & Bruce (1983) and Choat & Randall (1986). Randall & Bruce (1983) included a colour plate of a 45 mm specimen from the Society Islands. Choat & Randall (1986) provide a colour plate of a 45 mm specimen from Tahiti and a 50 mm specimen from Lizard Island.

Remarks. An aquarium specimen (approximately 60 mm) of unknown origin photographed by R. Kuiter was superficially similar to the *S. niger* examined but differed in several important aspects. As in the *S. niger* examined from the GBR (and the Philippines): body black, olive dorsally; cheek, anterior belly and caudal fin reddish, the latter preceded by a pair of dark dots; mouth bordered by two green lines. This specimen differed from GBR specimens in that it possessed: blue vermiculations on the rear of the head; red-brown dorsal and anal fins with a blue basal stripe; a series of seven longitudinal rows of small blue dashes on the body, and lacked a white patch at the base of the caudal fin. This specimen bears a strong resemblance to the IP of the Indian Ocean colour morph of *S. niger*,

previously known as *S. madagascarensis* (Steindachner) described by Smith (1956), Schultz (1958, 1969) and Randall & Bruce (1983). As the geographic source of the specimen is unknown, it remains to be established whether the specimen represents the Indian Ocean morph of *S. niger,* an anomalous GBR form, or the undescribed juvenile phase of another species.

A colour plate of juvenile scarid from Mombassa provided by Burgess & Axelrod (1973b, p. 630, pl. 87) probably represents the late juvenile stage of the Indian Ocean morph of *S. niger.* As in the specimen described above, it possesses a series of blue dashes on the body. Two characteristic features of juvenile *S. niger,* i.e. dark dots at the base of the caudal fin and dark bands around the mouth, are visible but exceedingly faint.

Juvenile *S. niger* observed and collected in the Central Visayas, Philippines were indistinguishable from GBR specimens.

Scarus oviceps Valenciennes

Pl. 4B,C

Material examined. (4 specimens: 32-73 mm). AUSTRALIA - Lizard Island, AMS I.25794-002 (1: 32 mm), AMS I.25794-001 (1:73 mm); PHILIPPINES - Sumilon Island, AMS I.27459-001 (2:54-55 mm).

Diagnosis. Median predorsal scales 6, no anterior pair, scales subequal; cheek scale rows 3, 2-3 (usually 3) in ventral row; pectoral rays 14.

Diagnostic colour notes. Body yellow, whitish ventrally, with dark orbital stripe from snout to opercular edge, a dark area dorsal to this stripe extends to anterior rays of dorsal fin, four slightly diagonal dark bands on dorsum often indistinct, bands wider than interspaces.

Colour notes. Body pale to bright yellow, whitish ventrally, short dark grey orbital stripe extending from snout, through orbit, to slightly beyond posterior edge of operculum, grey region dorsal to orbital stripe extending to anterior rays of dorsal fin and include upper half of band 1 of 'typical' scarid pattern (Fig. 4B); 4 short dark grey diagonal bands may be present on dorsum, corresponding to bands 2-5 of 'typical' scarid pattern, dark bands wider than pale interspaces, often indistinct, especially bands 4 and 5, and may extend onto dorsal fin base, fins hyaline yellow at 25 mm, yellow in larger specimens, short orbital stripe and dark dorsal region present in all specimens observed (all greater than 25 mm) but faint in newly caught small specimens; colour pattern of individuals greater than 50 mm closely resembles that of IP.

Colour in alcohol. Body yellow green to brown, paler ventrally, with distinct dark brown bands; bands extend onto belly at 32 mm, but restricted to dorsum greater than 54 mm; distinctive short dark orbital stripe retained in all specimens.

Ecology. Uncommon; solitary; site attached; settlement sites unknown; juveniles only recorded amongst live corals, in areas with abundant live coral, particularly arborescent *Acropora* species, in shallow water (1-5 m), from reef flat, backreef and lagoon of mid- and outer shelf reefs; often recorded in same location as *S. dimidiatus;* several large juvenile *S. oviceps* recorded in lagoon at Lizard Island, but no specimens greater than 85 mm observed during 25 month study period; absence of larger individuals may indicate migratory movement during late juvenile stage as in *S. sordidus.*

Field identification. The short dark orbital stripe and the dark area dorsal to this stripe distinguish this species from the closely related *S. dimidiatus.* The dark bands of *S. oviceps* are broader and more oblique than those of *S. dimidiatus.*

Previous descriptions. A description of the late juvenile phase and a colour plate of a 95 mm specimen from Tongtapu, Tonga are given in Choat & Randall (1986).

Scarus psittacus Forsskål

Pl. 2F

Material examined. (20 specimens: 23-49 mm). AUSTRALIA - Lizard Island, AMS I.27834-001 (1: 23 mm), AMS I.27859-001 to I.27859-0011 (11: 25-44 mm), AMS I.27823-005 to I.27823-007 (3: 26-49 mm), AMS I.25917-001 (1:28 mm), AMS I.27824-001 (1:32 mm), AMS I.25782-005 (1:34 mm), AMS I.27817-003 (1:37 mm), AMS I.27835-001 (1: 38 mm).

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

Diagnostic colour notes. Extremely variable, typically uniformly pale grey-tan or striped, belly pale; body often with distinct dark dots (cysts). Striped pattern with 4 pale grey-brown primary stripes; orbital stripe relatively wide, ventral stripe indistinct, interspaces pale grey-tan; some small specimens with pale brown stripes and bronze interspaces.

Colour notes. Extremely variable, capable of rapid colour pattern changes; recently settled individuals (9-15 mm) follow 'typical' sequence of colour pattern changes outlined in Fig. 3, body off white, 'dark' stripes pale brown; as in other species, rapid colour pattern changes only observed in individuals with complete striped colour pattern, i.e. greater than 15 mm.

At greater than 15 mm, 2 dominant colour patterns displayed, striped or uniformly pale. Striped pattern: body pale tan-grey with grey-brown dorsal, orbital and pectoral stripes, ventral stripe usually indistinct, orbital stripe relatively broad and may fuse with pectoral stripe on caudal peduncle; in some small individuals less than 25 mm, dark

stripes grey brown, interspaces metallic bronze, row of 4-6 small bronze dots within dark stripes. Overall hue may vary from dark grey-tan to extremely pale grey or tan; larger individuals (25-50 mm), stripes dark-grey brown, interspaces pale brown, a relatively dark grey orbital stripe is characteristic of this species at 25-50 mm (indistinctly visible in Pl. 2F).

Uniformly pale pattern: displayed by individuals greater than 20 mm, but most frequently greater than 40 mm; characterised by uniformly pale body and fins, colour may vary from extremely pale grey or tan to pale brown, darker specimens typically with pale snout, most common colour is pale grey-tan; greater than 40 mm, pelvic fins with pale red hue; greater than 60 mm, body and medial fins pale grey-tan to pale brown, snout slightly paler than body, pelvic fins pale red; colour pattern at 60 mm closely resembles that of IP.

Colour in alcohol. Body uniformly pale brown, occasionally with darker patches where 'typical' scarid bands and stripes intersect, fins pale brown to off white, occasionally with exceedingly faint dashes at base of dorsal and anal fins; because of overlap in colour patterns of preserved specimens of *S. psittacus* and *S. schlegeli,* and apparent lack of meristic differences, some preserved specimens can only be identified as *S. psittacus/schlegeli.*

Ecology. Common; schooling; may be site attached up to 40 mm; recently settled individuals recorded from algal-covered coral rock and rubble, in shallow (1-3 m) sandy coral rubble areas, in lagoon and backreef areas of Lizard Island; juveniles most frequently recorded over sand and coral rubble or rock, in shallow (1-5 m) sheltered areas, including reef flat, backreef and lagoon; one of most abundant species in shallow water on mid-shelf reefs, usually in small (approximately 5 individuals) to large (greater than 25 individuals) conspecific or multispecies schools.

Field identification. *S. psittacus* often schools with other pale juvenile *Scarus* species, including *S. rivulatus* and *S. chameleon.* When uniformly pale, *S. psittacus* can most easily be distinguished from these species by its paler colour, the lack of an abruptly pale belly, and frequently by the possession of small (1-1.5 mm) dark round cysts on the body and fins. Similar cysts were only occasionally observed on other species, primarily on *S. chameleon.* In the striped phase, *S. psittacus* may be distinguished by its relatively broad, dark orbital stripe. However, collection and meristic analyses are recommended to check field identifications. Recently settled and other small specimens cannot be distinguished from similar pale species with any degree of accuracy.

Uniformly dark specimens of *S. psittacus* are difficult to distinguish from *S. schlegeli.* The differences between these species in the field are discussed under the 'Field Identification' section of *S. schlegeli.*

Positive identifications of *S. psittacus* were restricted to specimens exhibiting diagnostic colour patterns in the field. Small specimens were maintained in aquaria until greater than 25 mm when meristic values could be taken.

Previous descriptions. Choat & Randall (1986) briefly describe the late juvenile phase and provide colour plates of two specimens, 43 mm and 50 mm, from Enewetak, Marshall Islands.

Scarus rivulatus Valenciennes

Pl. 5A

Material examined. (8 specimens: 36-54 mm). AUSTRALIA - Lizard Island, AMS I.27823-009 (1: 36 mm), AMS I.27823-008 (1:41 mm), AMS I.27819-002 (1:42 mm), AMS I.27817-001 (1:47 mm), AMS I.25788-001 (1:49 mm), AMS I.25796-001 (1:50 mm), AMS I.27819-001 (1:50 mm), AMS I.27817-002 (1:54 mm).

Diagnosis. Median predorsal scales 5-6 (usually 6), occasionally with laterally overlapping anterior pair, scales subequal or smaller anteriorly; cheek scale rows 3, 2 (rarely 3) in ventral row; pectoral rays 14.

Diagnostic colour notes. A variable species, body typically pale tan or olive tan; caudal fin and caudal peduncle with yellow hue which may extend onto midbody.

Colour notes. Small juveniles (less than 17 mm), body off white with grey to grey-tan dorsal, orbital and pectoral stripes, belly off white. Striped pattern, with grey-tan stripes and pale grey-tan interspaces, often displayed less than 25 mm, but may be displayed to 60 mm, most often by solitary individuals or individuals in conspecific schools on inshore reefs, predominating in captivity (to 55 mm). In field, most juveniles (greater than 20 mm) body, dorsal and anal fins uniformly pale olive-tan, pectoral fins hyaline, caudal fin and caudal peduncle usually with pale yellow hue which may extend onto posterior flank; occasionally body may have overall pale yellow or golden-yellow hue, usually in individuals among sargassum beds on inshore reefs; greater than 55 mm, body may assume darker shade, with dark scale edges, losing yellow hue on body and caudal fin (as in Pl. 5A), dorsal margin of sclera often distinctly pale blue, this colour pattern characteristic of recently collected specimens as yellow hue quickly lost upon capture, also recorded in larger specimens in schools, especially near dusk.

Colour in alcohol. Body tan, grey or grey brown, darker dorsally; some specimens with faint dashes at base of dorsal and anal fins and on body where 'typical' scarid pattern of bands and stripes intersect; other specimens, with dark patch on middle of each scale.

Ecology. Common; occasionally solitary, usually in small (approx. 5 individuals) to large (greater than 25 individuals) conspecific or multispecies schools; site attached when small; at Lizard Island, recently settled individuals observed on few occasions in areas of live hard

and soft coral and coral rubble, in shallow water (2-3 m), along edges of large lagoon patch reefs; at Lizard Island and other midshelf reefs, juveniles recorded over all substratum types except open sand, in shallow water (1-6 m), including reef flat, lagoon and other sheltered areas; some small individuals (less than 45 mm) in regions of high coral cover may be solitary with small home ranges and may be aggressive to other *Scarus* species; greater than 45 mm, most individuals join schools and move off over open areas to feed, these individuals are highly mobile, having either large home ranges or seminomadic behaviour; on inshore reefs, juveniles most abundant on reef flat, especially in sargassum beds; in most inshore localities, it is the only *Scarus* species present, often forming relatively large conspecific schools.

Field identification. This is a variable species capable of rapid colour pattern changes. It shares several colour patterns with other species, including *S. chameleon, S. globiceps* and *S. psittacus. S. rivulatus* often schools with *S. psittacus, S. chameleon* and probably *S. globiceps.* It can be easily distinguished from the first two species which are typically paler, especially ventrally, and have more elongate bodies. At Lizard Island, *S. rivulatus* has two predominant colour patterns: (a) a pale olive-tan body with darker scale edges (as in Pl. 5A), and (b) a pale olive-tan body with a pale yellow or golden-yellow caudal fin and caudal peduncle. The first pattern distinguishes *S. rivulatus* from all other GBR species with the exception of *S. globiceps.* The second pattern distinguishes it from all GBR scarid species including *S. globiceps.* At Lizard Island, this unique pattern is retained in the IP and aids in the identification of IP *S. rivulatus.* However, this pattern may not be retained or possessed by *S. rivulatus* in other GBR localities (Randall & Choat, 1980). See the species description of *S. globiceps* for notes on its similarity to *S. rivulatus,* and a possible means of separating the two species.

Scarus rubroviolaceus Bleeker

Pl. 3F-H

Material examined. (7 specimens: 12-38 mm). AUSTRALIA - Lizard Island, AMS I.25790-001 (4: 12-18 mm), AMS I.27845-001 (1:17 mm), AMS I.25909-003 (1:22 mm), AMS I.25902-001 (1:38 mm).

Diagnosis. Median predorsal scales 6, no anterior pair, 2 anterior scales smallest, remainder subequal; cheek scale rows 3, 2 in ventral row; pectoral rays 15.

Diagnostic colour notes. At less than 25 mm, body off white, 3 brown stripes, orbital and dorsal stripes faint, pectoral stripe broad and dark, especially posteriorly; greater than 25 mm, stripes olive green, dorsal and orbital stripes increasingly visible, pale dots clearly visible in orbital and pectoral stripes, single broad dark vertical band extending from dorsal spines 3-8 distinct in small individuals but fades in progressively larger specimens; greater than 40 mm, body pale brown, scales with dark posterior margins, pale dots and interspaces become increasingly faint.

Colour notes. A relatively distinctive species, no rapid colour changes, can be identified when recently settled; recently settled individuals (less than 10 mm), body off white, with 3 dashed brown lines, fins hyaline, pectoral line notably wider than dorsal and orbital lines, and fuses first; 10-12 mm, pectoral line appears as a broad stripe with pale dots interspersed along its length.

At 14-25 mm (Pl. 3F,G), body off white, some scales with darker red-brown patches, dorsal, orbital and pectoral stripes olive green, orbital and dorsal lines fuse to form stripes at about 25 mm, dorsal stripe lies close to base of dorsal fin, but leaves short, pale interspace along midline anterior to dorsal fin, snout may have pale green hue, 2 series of pale white dots on body and pale patch at caudal fin base, as in 'typical' juvenile scarid pattern (Fig. 3), retained, iris pale olive green, brown and white flecks on base of dorsal, anal and pelvic fins, otherwise fins hyaline; dark brown-olive green vertical band corresponding to band 2 of 'typical' scarid pattern (Fig. 4) first displayed at about 14 mm, band extends from dorsal spine 3-8 and is darker dorsally (Pl. 3G), band may be faint in specimens less than 25 mm, if so, dashes or part of stripes in region of band darker than remaining dashes or striped regions (Pl. 3F).

At 25-40 mm (Pl. 3H), dorsal, orbital and pectoral stripes clearly visible, brown and white flecks still restricted to fin bases, iris olive brown, pale dots on body retained and clearly visible in orbital and pectoral stripes, particularly posteriorly, dark vertical band fades in progressively larger specimens and lost at about 40 mm, scale edges start to darken at about 38 mm, dark pectoral base visible in Pl. 3H not visible in live specimens; greater than 40 mm, stripes fade, starting with pectoral stripe anterior to pectoral fin base, pale dots of variable intensity, body takes on more uniform brown hue and dark scale edges become increasingly prominent.

At 80 mm, body pale brown-grey with dark scale edges, pale interspaces and pale dots faintly visible or lost; IP colouration almost complete by 150 mm, although typical IP colour pattern, ie. with abruptly darker anterior half, not displayed by specimens less than 200 mm at Lizard Island or on nearby outershelf reefs.

Colour in alcohol. Colour pattern closely resembles live specimens: body pale grey with distinct dark grey brown dashes, with or without stripes, pale dots in orbital and pectoral stripes retained, pectoral fin base dark but not as intense as in *S. forsteni;* smaller specimens (14-22 mm), dark vertical bar retained but faint.

Ecology. Uncommon; solitary, occasionally joining small multispecies schools; site attached; settlement sites variable; several recently settled juveniles collected from algal 'lawns' within pomacentrid (*Dischistodus* spp.)

territories at reef slope base, North Reef, Lizard Island, other specimens from patches of algal-covered coral rubble near reef slope base (6-9 m); small juveniles (12-15 mm), recorded from upper reef slope regions on several occasions although recently settled individuals only observed below 6 m; larger juveniles (20-50 mm), observed over open coral rock or rubble, occasionally among stands of arborescent live corals, in areas extending from reef crest (1-2 m) to reef slope base (8-12 m); individuals greater than 50 mm most often observed in shallower water (2-5 m); recorded from exposed and moderately exposed sites at Lizard Island and other midshelf reefs.

Field identification. This species is easily distinguished when small by the unique combination of a single band and three stripes, and at larger sizes, by dark scale edges and distinct pale dots which lie in the region of the dark stripes.

Previous descriptions. The late juvenile phase has been described by Choat & Randall (1986). Burgess & Axelrod (1973b, p. 628, pl. 85) give a colour plate of a small scarid from the Maldives. This specimen is probably a juvenile *S. rubroviolaceus*.

Scarus schlegeli (Bleeker)

Pl. 2G,H

Material examined. (5 specimens: 16-38 mm). AUSTRALIA - Lizard Island, AMS I.25906-001 (1: 37 mm), AMS I.25782-001 (1:38 mm). Provisional identifications: AMS I.27849-010 (1:16 mm), AMS I.27816-003 (1:24 mm), AMS I.27818-001 (1:36 mm).

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

Diagnostic colour notes. Small specimens uniformly black or dark grey-brown with pale snout; 4-5 thin pale vertical lines displayed most frequently by specimens greater than 50 mm.

Colour notes. At less than 20 mm, body and fins black to dark grey-brown; some small specimens (25-35 mm) provisionally identified as *S. schlegeli* displayed 3 indistinct stripes, but only briefly; typical colour at all sizes dark grey-brown, with pale grey snout; all specimens observed displayed 4-5 thin pale vertical lines which correspond with pale interspaces of 'typical' banded scarid pattern (Fig.4); intensity and duration of lines varies and may change rapidly, lines more distinct and more frequently displayed by individuals greater than 50 mm; large juveniles displaying thin pale vertical lines extremely similar to small IP specimens; IP colouration appears at approximately 110 mm, in IP vertical lines more distinct and body and fins often have browner hue; live colour patterns often fade shortly after collection (freshly collected specimen shown in Pl. 2G; Pl. 2H shows stressed pattern of captive specimen).

Colour in alcohol. Body and fins dark brown, occasionally indistinct body stripes, smaller specimens with dark dashes at base of dorsal and anal fins and occasionally at base of most dorsal and ventral caudal fin rays; as in live specimens, some patterns are indistinguishable from those of *S. psittacus,* precluding any identification further than *S. psittacus/schlegeli.*

Ecology. Uncommon, occasionally solitary, usually in small (approx. 5 individuals) to medium sized (greater than 15 individuals) conspecific or multispecies schools; settlement sites unknown; recorded only from relatively deep water (5-15 m), typically over low coral rubble on sand; most frequently observed at base of reef slope, in both exposed and sheltered locations, occasionally schooling with *S. sordidus* and *S. chameleon.*

Field identification. This species is often difficult to identify in the field, as it rarely displays the diagnostic pale vertical lines, especially individuals less than 40 mm. The two main species with which it may be confused are *S. sordidus* and *S. chameleon,* both of which often display uniformly dark colour patterns, especially in deep water and when in multispecies schools. *S. chameleon* may also have a pale snout, as in *S. schlegeli.* The three species can only be separated in the field when they display diagnostic colour patterns which may require extended observations. Provisional identifications may be checked using meristics, as these three species are readily separated by scale counts. Other dark coloured species including *S. gibbus, S. bleekeri* and *S. spinus* can be distinguished from *S. schlegeli* by their diagnostic colour patterns, and their more rounded profile. *S. spinus* and *S. schlegeli* also differ in their depth preferences, being restricted to shallow and deep areas respectively.

The main problem when identifying juvenile *S. schlegeli* is distinguishing them from juvenile *S. psittacus.* These two species have indistinguishable meristic values and although they differ greatly in their typical colour patterns and depth distributions there is some overlap in these parameters. The differences between the two species which will enable most specimens to be distinguished in the field are summarised below:

S. psittacus: often pale or striped, does not display vertical bands nor a uniformly black colouration. If the overall colour is brown (as in some larger specimens) the pelvic fins and, to a lesser extent, the anal fin have a red hue. Abundant in shallow water (1-5 m).

S. schlegeli: usually has a uniformly dark grey-brown or black body and fins; displays indistinct stripes extremely rarely. Occasionally displays narrow pale vertical lines (more often when greater than 50 mm). If the overall colour is brown, anal fin remains brown, and red hue in the pelvic fins is either indistinct or absent. Only abundant in deeper water (below 5 m).

The greatest difficulty was experienced in separating small uniformly brown specimens which have meristic counts corresponding to both *S. psittacus* and *S. schlegeli.* These specimens cannot, at present, be identified further and must remain as *S. psittacus/schlegeli.*

As in *S. psittacus*, positive identifications of *S. schlegeli* were restricted to individuals displaying diagnostic colour patterns in the field.

Previous descriptions. Choat & Randall (1986) describe the late juvenile phase and give a colour plate of a 110 mm specimen from Heron Island.

Scarus sordidus Forsskål

Pl. 2A,B

Material examined. (19 specimens: 9-66 mm). AUSTRALIA - Lizard Island, AMS I.27853-001 (1: 14 mm), AMS I.27854-001 (1:18 mm), AMS I.27816-001 (1:20 mm), AMS I.27816-002 (1:21 mm), AMS I.27854-002 (1:27 mm), AMS I.25798-002 (1:28 mm), AMS I.25793-002 (1:29 mm), AMS I.27823-001 to I.27823-004 (4:30-66 mm), AMS I.27825-001 (1:30 mm), AMS I.25786-001 (1:40 mm), AMS I.27819-004 (1: 43 mm), AMS I.27819-005 (1:51 mm), AMS I.25785-001 (1:56 mm), AMS I.27824-001 (1:60 mm). Provisional identifications: AMS I.27864-001 (1:9 mm), AMS I.27863-005 (1:10 mm).

Diagnosis. Median predorsal scales 4, no anterior pair, anterior scale largest; cheek scale rows 2; pectoral rays 14-16 (usually 15); dental plates exposed in larger specimens.

Diagnostic colour notes. Body uniformly dark-brown black or bearing 5 dark stripes; caudal fin base and caudal peduncle often pale with exception of dark caudal extremities of orbital and pectoral stripes which may be fused; larger specimens typically uniformly dark, caudal peduncle and caudal fin base often pale with a dark central dot.

Colour notes. Although colour patterns change greatly during ontogeny, basic colours are consistent; body or pale interspaces remain off white, dark stripes black, brown or green brown; sequence of colour patterns follows 'typical' scarid pattern outlined in Fig. 3, dashes in orbital and pectoral stripes start to fuse at about 12 mm, with complete fusion of all stripes by 21 mm, dorsal division of dorsal stripe fuses last; at 21 mm, caudal extremities of orbital and pectoral stripes may darken in some individuals but intensity varies markedly (Fig. 7A,B).

In progressively larger specimens, body and fins darken, and greater than 32 mm, may be uniformly black; caudal extremities of orbital and pectoral stripes expand and eventually fuse at about 40 mm, surrounding area is pale and gives characteristic appearance of pale patch on caudal peduncle and caudal base, with dark central dot (Fig. 7C,D; indistinctly visible in Pl. 2B).

Wide range of colour patterns may be displayed greater than 30 mm, from uniformly black to striped, with or without dark dot on caudal peduncle (Table 1); colour pattern may change rapidly, often in less than two seconds; greater than 50 mm, range of patterns may occasionally include 2 series of 3-4 white dots on posterior region of uniformly dark body; colour patterns of specimens greater than 60 mm essentially same as those of IP, with predominant colour pattern being uniformly dark brown-black; pale patch on caudal fin and caudal peduncle with dark central dot and series of pale dots on body often displayed by stressed individuals, especially if solitary, and often become increasingly distinct upon collection or shortly after death.

Colour in alcohol. Small specimens retain dashes or stripes, body off white to grey, stripes dark grey, dark caudal extremities of orbital and pectoral stripes retained and often prominent; larger specimens (greater than 40 mm), body and fins dark-grey brown, caudal fin base usually paler with dark central dot.

Ecology. Common; in small (comprising 5-15 individuals) conspecific or multispecies schools, occasionally solitary or in large (greater than 25 individuals) schools; site attached when small; settlement sites include live arborescent coral (primarily *Acropora*) and algal covered dead coral or coral rubble; recently settled specimens and small individuals in dashed or early striped phase (9-15 mm) often found in pomacentrid territories, particularly those with rich algal 'lawns', including *Plectroglyphidodon lacrymatus, Pomacentrus grammorhynchus, Stegastes nigricans* and *S. apicalis;* juveniles recorded over all substratum types, except open sand, in all reef habitats from 1-14 m; present on inner shelf reefs, abundant on mid- and outer shelf reefs; at Lizard Island, juveniles particularly abundant in lagoon, remaining within small home ranges until approximately 90 mm, before joining large mobile schools; despite large numbers of juveniles in lagoon, no IPs, TPs or juveniles greater than 92 mm recorded from this area during 25 month study period; Bellwood (1986) suggested that *S. sordidus* migrate from lagoon during late juvenile phase; detailed notes on biology of juvenile *S. sordidus* given in Bellwood (1986).

Field identification. An easily identified species when displaying the diagnostic pale caudal peduncle and caudal fin base with a dark central dot (Fig. 7C,D). However, two common colour patterns of *S. sordidus* are also displayed by other species (Table 1). When uniformly black, *S. sordidus* may be mistaken for *S. schlegeli* at sizes less than 30 mm, or *S. spinus, S. bleekeri* and *S. gibbus* at sizes greater than 30 mm. *Scarus schlegeli, S. spinus* and *S. gibbus* can be separated from *S. sordidus* using meristics but they can also be separated in the field. *Scarus sordidus* has a more rounded snout and deeper body than *S. schlegeli* and *S. spinus,* although this may be difficult to assess in solitary specimens. For a positive identification of a uniformly dark specimen, prolonged observations are usually necessary. *Scarus schlegeli, S. bleekeri* and *S. gibbus* all possess unique colour patterns, whilst *S. sordidus* (greater than 30 mm) frequently exhibits the unique pale caudal peduncle and caudal fin with a dark central dot, especially if disturbed. If a

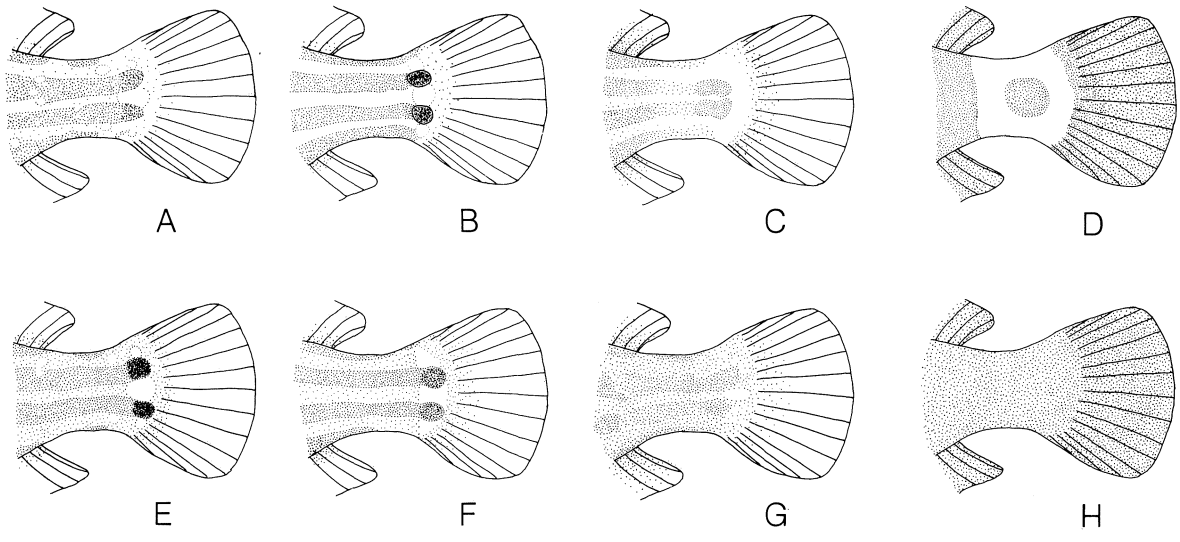


Fig.7. Ontogenetic changes in the colour pattern of the caudal region of *S. sordidus* and *S. spinus*. *S. sordidus:* A, 19 mm; B, 23 mm; C, 40 mm; D, 50 mm. *S. spinus:* E, 18 mm; F, 22 mm; G, 27 mm; H, 40 mm. See text for details of colour pattern changes.

uniformly black pattern is maintained by a large specimen (greater than 50 mm) for a prolonged period (hours or days) and the pectoral fins do not have a yellow hue (= *S. gibbus*), then the specimen is likely to be *S. spinus,* although meristic analyses are required before a positive identification can be made.

When striped, small *S. sordidus* (less than 30 mm) are difficult to distinguish from similarly sized *S. spinus.* There are, however, several slight differences that separate the two species. In *S. sordidus,* dashes in the dorsal division of the dorsal stripe fuse at a smaller size than in *S. spinus* (i.e. at about 20 mm, cf. 27 mm in *S. spinus*); the dark stripes are often paler, the pale interspaces darker, and the dark caudal extremities of the orbital and pectoral stripes less intense than in similarly sized *S. spinus,* especially less than 20 mm. In addition, *S. sordidus* typically has a deeper body and lacks the white patch at the caudal fin base, which is present in *S. spinus* (faintly visible in Fig. 7F; Pl. 2D). The diagnostic differences in the caudal region of these two species are summarised in Fig. 7. Despite these differences, it is often necessary to collect the specimen for meristic analysis to check field identifications. Other species which may display a striped pattern with dark caudal extremities of the orbital and pectoral stripes include *S. globiceps* and *S. chameleon.* These species may be initially confused with *S. sordidus,* however, this colour pattern is only rarely displayed by these species. Both species can be easily distinguished from *S. sordidus* (and *S. spinus*) by their pale body and the lack of a dorsal division of the dorsal stripe.

As with most other *Scarus* species which follow the 'typical' scarid sequence of colour pattern changes during the early post-settlement phase (Fig. 3), recently settled *S. sordidus* cannot be accurately identified in the field. Small individuals with dark dashes or stripes are likely to be *S. sordidus,* but these individuals must be grown to a larger size before an accurate identification can be made based on both the colour pattern and meristic values. Small specimens collected prior to the development of the head scales, may be tentatively identified as *S. sordidus* if they have (a) dark body dashes or stripes, (b) 15 pectoral fin rays, and (c) 3 upper pharyngeal tooth rows. It must be noted, however, that this combination is also possessed by *S. gibbus, S. bleekeri* and *S. pyrrhurus.*

Previous descriptions. Schultz (1958) described the ontogeny of the colour patterns of juvenile *S. sordidus.* However, these descriptions were based on preserved material and are therefore of limited use for field identifications. Choat & Randall (1986) describe the late juvenile phase, and provide a colour plate of a 37 mm specimen from Jana Island, Persian Gulf and a 50 mm specimen from Lizard Island.

Morphological notes. The identification of extremely small *S. sordidus* (less than 15 mm) may be supported by an examination of the upper pharyngeal tooth rows. *S. sordidus* possesses three rows on each upper pharyngeal bone, whereas all other GBR *Scarus* species, with the exception of *S. bleekeri, S. gibbus* and *S. pyrrhurus,* typically possess only two rows.

Scarus spinus (Kner)

Pl. 2C-E

Material examined. (25 specimens: 9-50 mm). AUSTRALIA - Lizard Island, AMS I.27827-001 (1: 15 mm), AMS I.27844-004 (1:17 mm), AMS I.25910-001 (1:20 mm), AMS I.25917-002 (1:20 mm), AMS I.27844-001 (1:21 mm), AMS I.25910-004 (1:22 mm), AMS I.27828-001 (1:23 mm), AMS I.25910-003 (2: 27 mm), AMS I.27839-007 (1:27 mm); Yonge Reef, AMS I.27829-007 to I.27829-010 (4:17-28 mm), AMS

I.25912-003 (1:21 mm), AMS I.25912-005 (1:27 mm), AMS I.27820-001 (1:50 mm). Provisional identifications: Lizard Island, AMS I.27848-001 (1:9 mm), AMS I.27846-001 (1:10 mm), AMS I.27846-002 (1:11 mm), AMS I.27847-003 (1:11 mm), AMS I.27836-002 (1: 17 mm), AMS I.27847-002 (1:19 mm), AMS I.27821-001 (1:21 mm), AMS I.27821-002 (1:21 mm).

Diagnosis. Median predorsal scales 4, anterior scale relatively small, preceded by pair of laterally overlapping scales; cheek scale rows 3, 1-3 (usually 2) in ventral row; pectoral rays 14 (rarely 15); based on specimens greater than 20 mm.

Diagnostic colour notes. Body off white with 5 dark stripes; dorsal division of dorsal stripe remains dashed to 27 mm; posterior extremities of orbital and pelvic stripes form intense dark round dots in white patch at caudal fin base; greater than 35 mm, body and fins uniformly black.

Colour notes. A variable species, no rapid colour changes; small specimens invariably striped, body off white to pale grey with intense dark brown to black dashes or stripes; sequence of colour pattern changes during early postsettlement phase closely follows 'typical' scarid sequence outlined in Fig. 3; greater than 15 mm, intense dark stripes on pale body sole colour pattern to approximately 25 mm, although intensity of pale interspaces may vary; striped colour pattern characterised by 5 body stripes: 4 primary stripes, and dorsal division of dorsal stripe, stripes relatively narrow and dark, with more contrasting appearance than other striped *Scarus* species; stripes much darker in field than in Pl. 2C,D; posterior extremities of orbital and pectoral stripes intense black (Fig. 7E), with contrast enhanced at approximately 20-25 mm as caudal extremities lie in white hemispherical patch on caudal fin base (Fig. 7F), patch more intense in field than in Pl. 2D, closely resembling patch in *S. niger* (Pl. 5F); intense caudal extremities of medial body stripes first displayed at approximately 15 mm, remaining until about 25 mm when start to diffuse (Pl. 2E), these changes summarised in Fig. 7E—G; greater than 25 mm, contrast between dark stripes and pale interspaces decreases and fins darken (Pl. 2E; Fig. 7H), uniformly black body may be displayed by specimens greater than 30 mm, almost invariably displayed by specimens greater than 40 mm; this pattern continues through to IP, pale vertical lines displayed by some IP specimens (Choat & Randall, 1986) not present in juveniles or small IP specimens observed on Lizard Island.

Colour in alcohol. Live colour pattern retained, although colours fade; pale interspaces grey, stripes dark grey; less than 25 mm, dashed dorsal division of dorsal stripe and dark posterior extremities of orbital and pectoral stripes remain distinct; greater than 30 mm, colour pattern indistinct, body and fins uniformly dark grey-brown.

Ecology. Uncommon; solitary or in small multispecies schools; site attached; small and recently settled specimens most often recorded in live arborescent corals, few specimens recorded within pomacentrid territories; on Lizard Island, small juveniles recorded in shallow water (2-5 m), in areas with abundant live coral, typically in sheltered areas, occasionally in semi-exposed locations; most juveniles recorded from lagoon, but only individuals less than 50 mm, larger juveniles and adults absent from this area, absence may indicate migration as in *S. sordidus;* on outer reefs, occasionally observed over live coral or coral rubble, on slopes and bases of backreef bommies (3-9 m).

Field identifications. *Scarus spinus* closely resembles *S. sordidus,* and in the field the two species may be confused. There are, however, several slight differences in the colour patterns of the two species which enable some individuals to be identified in the field but, because of the degree of overlap, collection and diagnostic meristic analyses are recommended. When the two species are compared in the field, *S. spinus* has a more elongate body, darker, narrower stripes, and a more distinctly dashed dorsal division of the dorsal stripe (especially when viewed from above). In comparison, *S. sordidus* has a deeper body, broader, less contrasting dark body stripes, and an indistinctly dashed dorsal division of the dorsal stripe. In addition, the intense dark caudal extremities of the medial body stripes have a characteristic form in both species. In *S. spinus,* the dark extremities are intense and contrast strongly with the adjacent white patch(es), especially at 15-25 mm. In *S. sordidus,* the extremities are less intense and the contrast with surrounding pale patches less notable than in *S. spinus;* the stripes anterior to the dark extremities are often faded and the dark extremities more diffuse. These differences are summarised in Fig. 7. The differences are clearest in specimens between 15-30 mm; less than 15 mm, identifications must be verified by meristic characters (primarily pectoral ray counts). At sizes greater than 30 mm, *S. sordidus* can be distinguished by the characteristic dark dot on the caudal peduncle. A specimen with a uniformly black pattern may be one of several species, including *S. bleekeri, S. gibbus, S. schlegeli, S.sordidus* and *S. spinus* (Table 1). Larger juvenile *S. spinus* have a more rounded snout than these species, which may aid identification, but there are no diagnostic colour patterns displayed by *S. spinus* greater than 30 mm. A uniformly black specimen in shallow water (1-5 m) which retains this pattern for extended periods, even if chased, is likely to be *S. spinus* although meristic verification is essential.

Previous descriptions. The late juvenile stage of *S. spinus* was described briefly by Schultz (1958; as *S. formosus* Valenciennes), but based only on preserved material.

Discussion

Juvenile scarids on the Great Barrier Reef exhibit a wide range of colour patterns. Within this range, there are two distinct groups characterised by a strong correlation between juvenile colour patterns, range of patterns exhibited at a given size, extent of change throughout

ontogeny, speed of colour pattern changes, and social behaviour and habitat as a juvenile.

The two groups represent the extremes of a spectrum of juvenile scarid types. The first group is solitary and are characterised by: (a) complex colour patterns which are often cryptic and/or camouflaged in the field, (b) an inability to change colour patterns rapidly, and (c) the presence of several different patterns throughout ontogeny, although only one at a given size. These species are typically site attached, and live in areas of high topographic complexity. As adults, species in this group are typically either solitary or haremic. This group is exemplified by *S. frenatus, S. niger* and *S. altipinnis,* and to a lesser extent *C. carolinus, S. dimidiatus* and *S. oviceps.*

The second group are typically schooling and are characterised by: (a) simple colour patterns which are either striped, barred or uniformly plain, (b) an ability to change colour patterns rapidly, with several colour patterns being displayed at a given size, and (c) only a limited number of colour pattern changes during ontogeny. These species are site attached when small, become highly mobile in the late juvenile phase, and typically live in areas of relatively low topographic complexity. These species constitute the abundant schools of small grey scarids that occur in large numbers in shallow reef areas. As adults, species in this group usually remain highly mobile, forming moderately large multispecies schools. This group is exemplified by *S. psittacus, S. rivulatus* and *S. globiceps,* and to a lesser extent *S. ghobban, S. sordidus, S. schlegeli* and *S. chameleon.*

The two groups clearly demonstrate the problems encountered when identifying juvenile scarids. Species in the first group may not initially look like scarids and their solitary behaviour and cryptic nature make them easy to overlook. Once located, however, they are readily identified. Species in the second group are ubiquitous and represent what are, for most workers, the typical small uniformly grey-brown or striped juvenile *Scarus* species. These species are easily located, but subsequent identification requires extended observation and an eye for the subtle minutiae that enable one to distinguish species in the field. In many cases field identifications must remain tentative. If collected, most species can be identified, with the notable exceptions of the *S. schlegeli/ psittacus* and *S. rivulatus/ globiceps* pairs.

In addition to the groups described above, there is a range of species in-between which have either intermediate character states or possess features associated with both groups. Such intermediate species include *S. rubroviolaceus, S. flavipectoralis, S. gibbus, S. bleekeri* and *S. forsteni.* The above grouping excludes *C. bicolor* and *H. longiceps.* These species have unusual colour patterns which show similarities to the juvenile stages of other reef species. The possibility of these colour patterns having a mimetic function requires further investigation.

The status of some species in relation to these groups appears to vary with size and geographic location, but observations and descriptions of juvenile scarids from other geographic regions suggests that the above groups are typical for the family as a whole.

There are a number of explanations that may account for the observed range of juvenile colour patterns, including phylogenetic constraints and their function as predation avoidance mechanisms. Some closely related species have extremely similar colour patterns, e.g. *S. dimidiatus* and *S. oviceps,* but so have some distantly related species, e.g. *S.sordidus* and *S. spinus.* Although phylogenetic or developmental factors may determine the possible range of colour patterns, i.e. the typical scarid arrangement of dots and stripes, the influence of these factors appears to be limited. One of the more important factors appears to be the function of the colour patterns in predation avoidance. Scarids are prey for a wide range of diurnally active visual piscivores, including scorpaenids (Hiatt & Strassburg, 1960), serranids (Choat, 1968), carangids (Popova & S'erra, 1983) and sharks (Stevens, 1984), and during the juvenile phase probably have particularly high mortality rates (Bellwood, 1986). Most colour patterns are camouflaged and/or cryptic and make the individuals hard to locate in the field. Complex colour patterns may blend with the heterogeneous reef background whilst striped, barred or plain colour patterns may facilitate protection from predators in open areas, especially when schooling. The potential advantages, in terms of predation avoidance, of a striped colour pattern and a high degree of similarity between multispecific schooling species has been noted by Barlow (1972) and Ehrlich & Ehrlich (1973).

In some species at least, it also appears that colour patterns may have a social function, influencing the response of other species within the same trophic level. The interactions between juvenile scarids possessing various colour patterns and territorial pomacentrids is an area of particular interest.

Conclusions about the functions of colour patterns await a comprehensive study of the function and development of colour patterns in the family.

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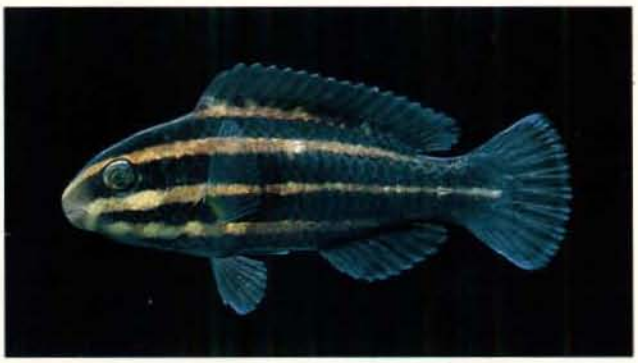
1A. *Calotomus carolinus*, 43 mm SL, AMS I.25905-002, dead, Lizard Island.

1B. *Leptoscarus vaigiensis*, approx. 50 mm SL, underwater photograph by R. Kuiter, Sydney Harbour.

1C. *Cetoscarus bicolor*, approx. 40 mm SL, underwater photograph by D.R. Robertson, Heron Island.

1D. *Hipposcarus longiceps*, 48 mm SL, AMS I.25783-001, dead, Lizard Island.

1E. *Scarus gibbus*, 25 mm SL, AMS I.25913-001, live, Lizard Island.



1F. *S. gibbus*, 40 mm SL, AMS I.25905-001, dead, Lizard Island.

1G. *S. bleekeri*, 33 mm SL, AMS I.25916-001, dead, Lizard Island.

1H. *S. bleekeri*, 46 mm SL, AMS I.25903-002, dead, Lizard Island.

2A. *Scarus sordidus*, 28 mm SL, AMS I.25798-002, dead, Lizard Island.

2B. *S. sordidus*, 40 mm SL, AMS I.25786-001, dead, Lizard Island.

2C. *S. spinus*, 20 mm SL, AMS I.25910-001, dead, Lizard Island.

2D. *S. spinus*, 22 mm SL, AMS I.25910-004, dead, Lizard Island.

2E. *S. spinus*, 27 mm SL, AMS I.25912-005, dead, Yonge Reef.

2F. *S. psittacus*, 30 mm SL, dead, Lizard Island.

2G. *S. schlegeli*, 37 mm SL, AMS I.25782-001, dead, Lizard Island.

2H. *S. schlegeli*, 37 mm SL, AMS I.25906-001, live, Lizard Island.

3A. *Scarus flavipectoralis*, 33 mm SL, AMS I.25782-004, dead, Lizard Island.

3B. *S. flavipectoralis*, 44 mm SL, AMS I.25787-001, dead, Lizard Island.

3C. *S. chameleon*, 33 mm SL, AMS I.25793-001, dead, Lizard Island.

3D. *S. longipinnis*, 39 mm SL, AMS I.25789-001, live, Lizard Island.

3E. *S. longipinnis*, 75 mm SL, AMS I.25784-001, dead, Carter Reef.

3F. *S. rubroviolaceus*, 18 mm SL, AMS I.25790-001, dead, Lizard Island.

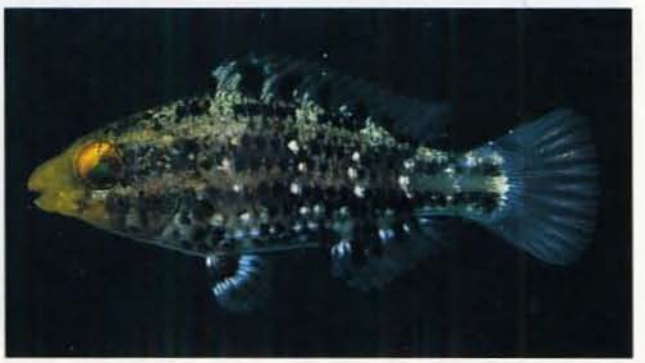
3G. *S. rubroviolaceus*, 22 mm SL, AMS I.25909-003, dead, Lizard Island.

3H. *S. rubroviolaceus*, 38 mm SL, AMS I.25902-001, dead, Lizard Island.

4A. *Scarus dimidiatus*, 30 mm SL, AMS I.25912-006, dead, Yonge Reef.

4B. *S. oviceps*, 32 mm SL, AMS I.25794-002, dead, Lizard Island.

4C. *S. oviceps*, 73 mm SL, AMS I.25794-001, dead, Lizard Island.



4D. *S. altipinnis*, 26 mm SL, AMS I.25912-007, live, Yonge Reef.

4E. *S. altipinnis*, 29 mm SL, AMS I.25909-001, dead, Lizard Island.

4F. *S. altipinnis*, 54 mm SL, AMS I.25903-001, dead, Lizard Island.

4G. *S. altipinnis*, approximately 80 mm SL, underwater photograph by D.R. Robertson, Heron Island.

4H. *S. ghobban*, 52 mm SL, AMS I.25903-003, dead, Lizard Island.

5A. *Scarus rivulatus*, 49 mm SL, AMS I.25788-001, dead, Lizard Island.

5B. *S. frenatus*, 10 mm SL, AMS I.25914-001, live, Lizard Island.

5C. *S. frenatus*, 23 mm SL, AMS I.25912-002, live, Yonge Reef.

5D. *S. frenatus*, 31 mm SL, AMS I.25912-001, live, Yonge Reef.

5E. *S. niger*, 10 mm SL, live, Lizard Island.

5F. *S. niger*, 34 mm SL, live, Lizard Island.

5G. *S. niger*, 57 mm SL, AMS I.25907-001, dead, Yonge Reef.

5H. *S. forsteni*, 61 mm SL, AMS I.25908-001, dead, Yonge Reef.