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FIVE PROBABLE HYBRID BUTTERFLYFISHES OF THE GENUS *CHAETODON* FROM THE CENTRAL AND WESTERN PACIFIC

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ABSTRACT

The following five cases of probable hybridisation in marine butterflyfishes (genus *Chaetodon*) are reported: *C. auriga* x *C. ephippium* (Tuamotu Archipelago), *C. ephippium* x *C. semeion* (Marshall Islands), *C. kleini* x *C. unimaculatus* (Marshall Islands), *C. miliaris* x *C. tinkeri* (Hawaiian Islands), and *C. aureofasciatus* x *C. rainfordi* (Great Barrier Reef). Comparisons between the presumed hybrids and their respective parent species are presented, and each trio is illustrated. In addition, a discussion of possible conditions responsible for hybridisation in chaetodontids is included.

INTRODUCTION

Relatively few marine fishes have been reported as hybrids; of 212 fish hybrids listed by Slastenenko (1957), only 30 were inhabitants of the sea. The same preponderance of freshwater hybrids over marine is apparent in the review by Schwartz (1972) of the hybrid fishes of the world. In the present paper data are given for five presumed hybrids of the marine butterflyfish genus *Chaetodon* (family Chaetodontidae). In addition, the junior authors have observed (but not collected) probable hybrid crosses between *C. ornatissimus* — *C. meyeri* and *C. pelewensis* — *C. punctatofasciatus* at Palau, New Britain, and the northern Great Barrier Reef.

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Chaetodontids have not been reported previously as hybrids, although this phenomenon has been documented in the closely related angelfishes (Pomacanthidae). Longley (*in* Longley and Hildebrand, 1941) suspected that the angelfish, *Holacanthus townsendi* of the Caribbean Sea, is a cross between *H. ciliaris* and *H. isabelita* (now regarded as *H. bermudensis* — see Bailey *et al.* 1970: 77-78), and Feddern (1968) confirmed this. Though often classified in the Chaetodontidae by previous authors, there is now firm evidence for granting the angelfishes separate family status (see Freihofer, 1963 and Burgess, 1974a).

Hybridisation in marine fishes obviously does not lend itself to the close scrutiny offered by certain freshwater fish hybrids. Moreover, as Randall (1956) pointed out, the overwhelming majority of freshwater hybrids is reflected not only from our greater knowledge of freshwater fishes (particularly American and European species) and greater opportunity for sampling populations of freshwater habitats, but probably also from an actual lower percentage of hybrids in the sea. Unlike freshwater hybrids, which can often be either experimentally reared or collected in numbers, reports of hybrid fishes in the sea are frequently based on a single chance sighting; the investigator is very fortunate if a hybrid specimen is collected or photographed.

To those who might criticise the limited data herein in documenting hybridisation in the Chaetodontidae, we wish to point out the great amount of time and effort that was necessary to obtain the hybrid specimens and make the pertinent observations. The authors of the present work are experienced SCUBA and skin divers. It is estimated that we collectively spend over 1000 hours per year underwater. We have maintained this level of diving for the past decade, dividing our time over a vast area of the tropical Indo-Pacific and Atlantic. In the former region we have visited most of the major island groups of Polynesia, Micronesia, and Melanesia. Also we have dived at Japan, Ryukyu Islands, Taiwan, Hong Kong, Philippine Islands, Molucca Islands, Java, Australia, Sri Lanka (Ceylon), Maldive Islands, Mafia Island (off Tanzania), Mauritius, Reunion, and the Red Sea. During much of our time underwater butterflyfishes have been a focal point of interest. Randall and Allen have made a special effort to collect and observe chaetodontids at the request of W.E. Burgess who is currently preparing a taxonomic monograph of the family. Randall (1975) and Randall and Caldwell (1973) described four new species of butterflyfishes, and Allen named *Chaetodon burgessi* in conjunction with W.A. Starck (1973). Steene has been greatly involved with these fishes for the past three

years and has recently completed a manuscript dealing with chaetodontids and pomacanthids which will be published as a popular book.

In addition to our investigations of chaetodontid fishes we have drawn upon the experience and collecting ability of other divers. The butterflyfishes are among the most conspicuous families of fishes inhabiting coral reefs, and the group is well known to both laymen and scientists. Because these fishes are so colourful and their patterns so distinctive, a variant is apt to attract attention.

Comparisons were made of meristic data and selected proportional measurements of the five hybrids of which we have specimens with eight examples of each of the parent species. These data are presented in **Tables 1-5.** Many of the selected characters which appear in these tables do not specifically bear on the hybrid nature of the fishes. However, we have included them to show that the presumed hybrids generally possess meristics and morphometrics which are either identical or within the range of the presumed parental species, thus reinforcing the suspected relationship. Body depth was taken as the greatest depth from the base of the dorsal spines. Head length was measured from the front of the upper jaw to the posterior end of the opercular membrane. The interorbital width is the bony width above the centre of the eyes. The depth of the caudal peduncle is the least depth.

The *C. aureofasciatus* x *C. rainfordi* hybrid is deposited at the Western Australian Museum, Perth (WAM). The other hybrids are at the Bernice P. Bishop Museum, Honolulu (BPBM).

CHAETODON AURIGA x *CHAETODON EPHIPPIUM*

On November 17, 1956 the senior author speared a butterflyfish at a depth of 4 m on a patch reef in the lagoon of the atoll of Takaroa, Tuamotu Archipelago (14°30'S; 145°W). This specimen (**Fig. 1**) was intermediate in colour and caudal fin shape to *C. auriga* Forsskål and *C. ephippium*. We conclude that it probably represents a hybrid of these two species (shown in **Figs 2** and **3**), both of which were common at Takaroa. In most respects the colour is intermediate to the parent species. When fresh the colours of the presumed hybrid were as follows: ground colour white with large dusky area of yellowish cast on posterior portion of back; caudal peduncle and caudal fin light yellow with triangular extension of this colour onto upper and lower parts of fin; posterior portion of dorsal fin orange-yellow with a curved extension of this colour into large dusky area

of the back; trace of a black spot anteriorly on outer part of soft portion of dorsal fin (*auriga* generally has a well developed spot here; *ephippium* has none); black bar below eye (absent on adults of *ephippium*, very broad in *auriga*), and short, narrower bar above, becoming progressively diffuse and finally disappearing on nape; snout, ventral part of head, pelvic fins, and anal fin light yellowish. The hybrid lacked the two sets of diagonal dark lines which are set at right angles on the body of *auriga.* It also lacked the narrow purplish stripes found on the ventral half of the body, as well as the deep blue band along the upper edge of the gill opening, and the dark purplish line which runs from above the pectoral base to the base of the fifth dorsal spine; all these features, on the contrary, are present in *ephippium.*

The caudal fin of the hybrid is truncate and intermediate to the parent species. Adult *C. auriga* possess a slightly rounded (truncate if not fully spread) caudal fin, whereas that of *C. ephippium* is emarginate, the caudal concavity 2 to 6.5% of the standard length. Randall (1956) noted an intermediate caudal shape in the hybrid surgeonfish *Acanthurus achilles* x *A. glaucopareius.*

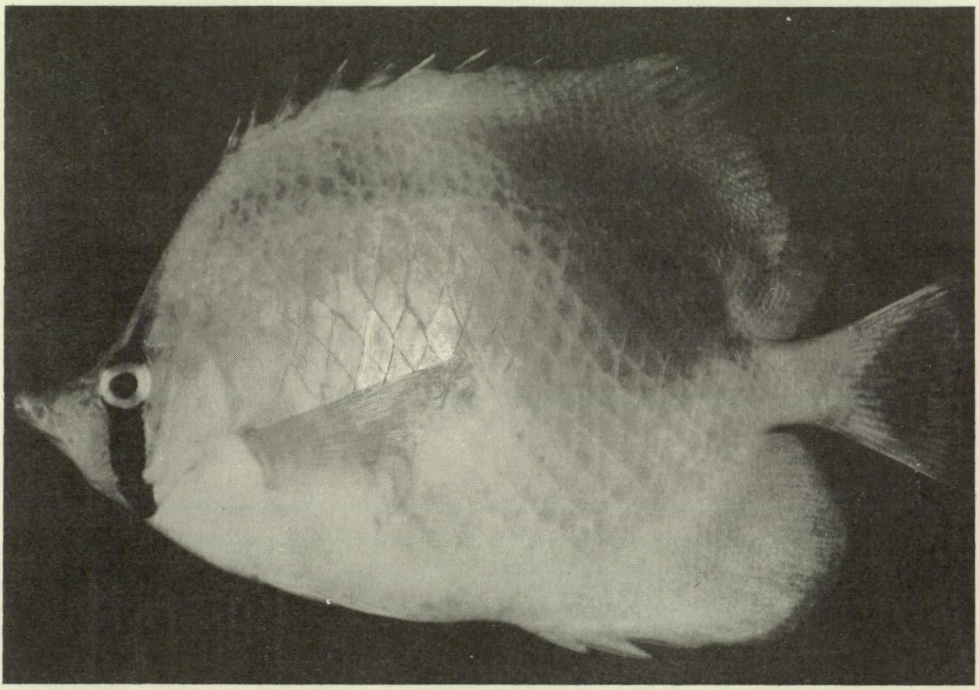

Fig. 1: *Chaetodon auriga* x *C. ephippium,* 138 mm SL, Takaroa, Tuamotu Archipelago.

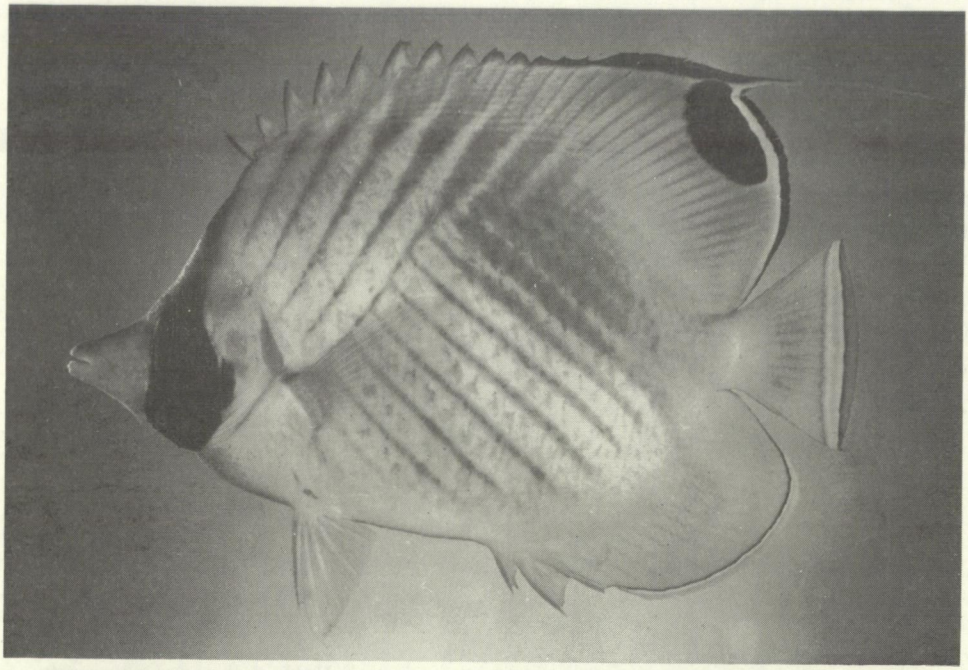

Fig. 2: *Chaetodon auriga*, 145 mm SL, Tahiti, Society Islands.

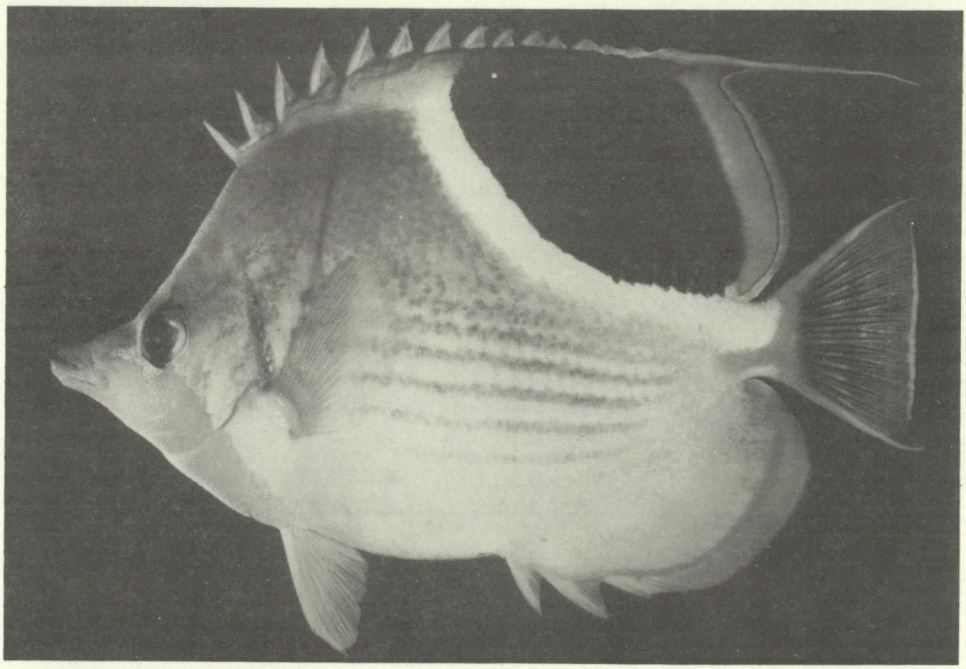

Fig. 3: *Chaetodon ephippium*, 146 mm SL, Oahu, Hawaiian Islands.

Selected counts and measurements of the presumed hybrid are compared with the parent species in Table 1. All the attributes of the hybrid which appear in this table are within the ranges of *auriga* and *ephippium*. The parent species are closely related, as indicated by the data of Table 1. Both have the same general body shape with a moderately produced snout and a filament extending from the anterior soft portion of the dorsal fin. Also sharing the same body and fin configuration are *C. semeion* Bleeker and *C. xanthocephalus* Bennett. Previous authors have grouped these species in the subgenus *Rhabdophorus* Swainson. Hybrid crosses between any of these could be expected. Burgess (1974b) described and illustrated a potential cross between *C. ephippium* and *C. xanthocephalus* from Sri Lanka.

The register number of the hybrid is BPBM 19065.

TABLE 1

Comparison of counts and measurements of *Chaetodon auriga*, *C. auriga* x *C. ephippium* (indicated as hybrid), and *C. ephippium*. Measurements expressed as percentage of the standard length.

	Chaetodon auriga	Hybrid	*Chaetodon ephippium*
Dorsal rays	XIII,23-25	XIII,24	XIII,23-25
Anal rays	III,20-22	III,21	III,21-23
Pectoral rays	16	16	16
Lateral-line scales	33-36	34	33-36
Gill rakers	17-20	16	15-17
Standard length (mm)	117-168	139	108-169
Depth of body	57.2-62.7	59.8	58.0-62.6
Head length	30.9-34.8	33.7	29.6-32.5
Snout length	12.2-15.0	13.8	10.7-13.1
Orbit diameter	7.3-8.7	8.0	7.4-8.2
Interorbital width	9.3-10.0	9.2	9.1-10.1
Depth of caudal peduncle	10.4-11.6	10.6	10.4-11.8
First dorsal spine	7.9-9.1	8.8	7.3-10.3
Pectoral fin length	24.6-26.9	24.4	23.1-25.7
Pelvic fin length	23.1-25.3	23.7	21.7-23.7

CHAETODON EPHIPPIUM x *CHAETODON SEMEION*

On March 15, 1972 Mr and Mrs Nathan A. Bartlett of Kwajalein, Marshall Islands observed a strange butterflyfish on a patch reef in the

southern part of the lagoon (8°43'52.1"N; 167°43'30.5"E) which they did not recognise. Mr Bartlett took an excellent underwater colour photograph of the fish, which he brought to the Bishop Museum for identification nearly two years later. It is reproduced herein as **Fig. 4.** The live coloration of the fish was as follows: ground colour of body and fins yellowish; snout, lower part of head, thorax, and base of pectoral fins yellow-orange; caudal fin yellow-orange basally and on upper and lower edges, remainder of fin primarily hyaline; conspicuous, large comma-shaped area of black on upper part of posterior portion of back, extending onto dorsal fin; this marking preceded by an area of pale yellow grading to white centrally; prominent black ocular bar, becoming bright blue on upper part of head; forehead and interorbital largely bright blue. The large black posterior spot is suggestive of *C. ephippium* and the blue on the head indicates a relationship to *C. semeion.* Both of these species occur at Kwajalein, though the latter is relatively rare. On the basis of the photograph we suspected the fish represented a cross between these two species, in spite of the absence of the purplish or blue bands on the ventral half of *ephippium* (**Fig. 3**) and dark dots on the body of *semeion* (**Fig. 5**). Mr Bartlett was asked if he would try to collect the fish and on April 21, 1974 he succeeded in spearing it at a depth of 5 m, approximately 25 m from the location where it was originally sighted and photographed. On a previous occasion, after the fish was first sighted in 1972, the Bartletts observed it about 55 m from the location of the first sighting, at which time it was paired with *C. semeion.* The Bartletts and other divers alerted by them have not seen any other butterflyfishes of this colour form at Kwajalein in spite of numerous hours of underwater observation and photography.

The specimen was presented to the Bishop Museum (BPBM 17363). Counts and measurements were taken and compared with equivalent data for eight specimens of *C. ephippium* and *C. semeion* (**Table 2**). All the counts and measurements for this fish fall within the range of these two species. As in the previous case, the colour is not exactly intermediate in all respects. However, the overall yellowish colour is intermediate to the light grey of *ephippium* and the orange of *semeion.* In addition, the large black zone on the upper back is intermediate in size to the black dorsal band of *semeion* and the huge black area on the upper back of *ephippium*; it is not rimmed on the ventral margin with a pale band as in *ephippium* except for the anterior patch of pale yellow. There is no trace of the black band at the base of the soft portion of the anal fin of *semeion.* The narrow black bar below the eye is intermediate to the broad black bar of *semeion* and

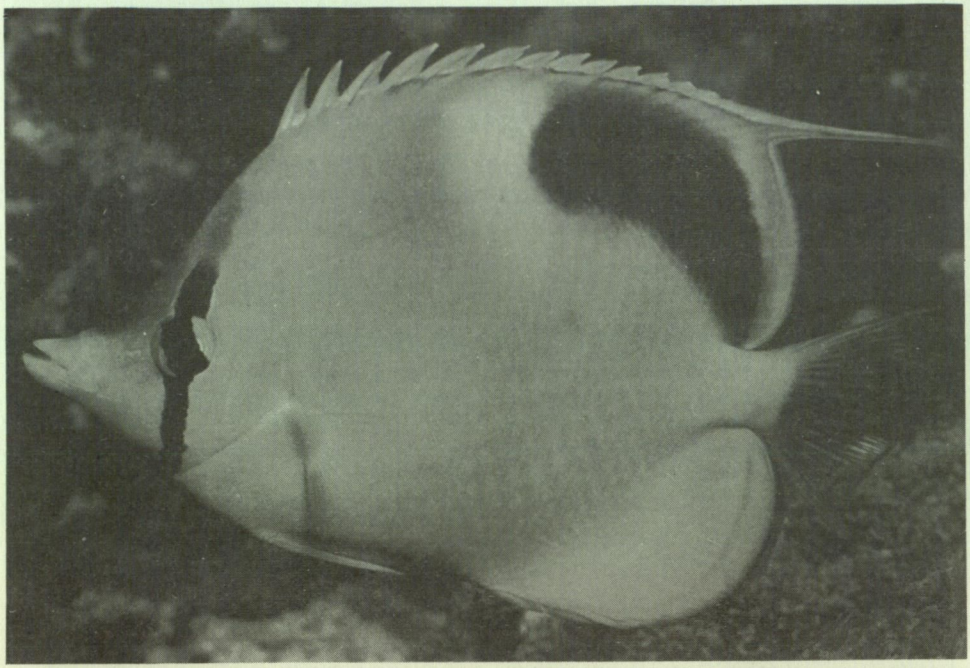

Fig. 4: *Chaetodon ephippium* x *C. semeion*, 124 mm SL, Kwajalein, Marshall Islands.

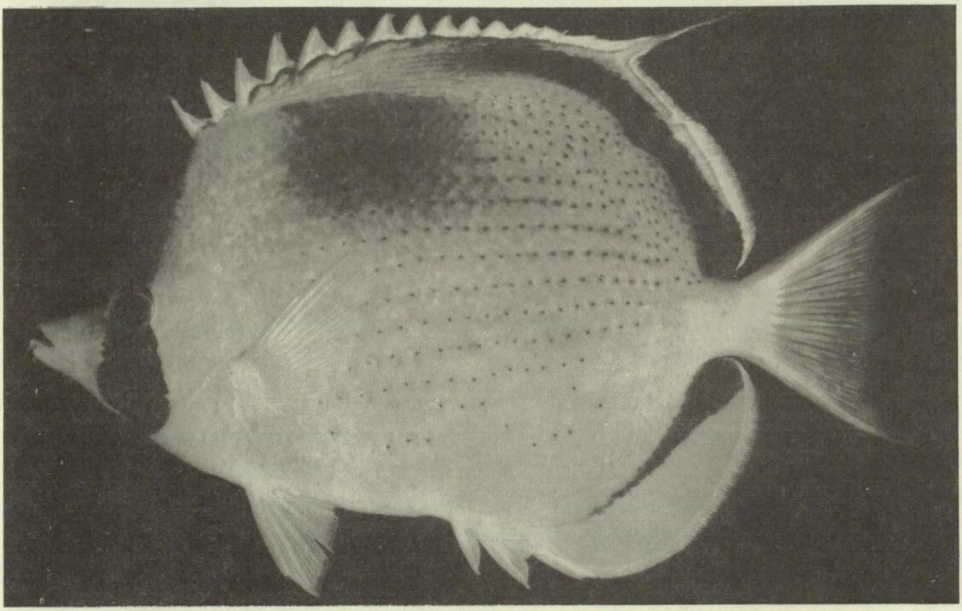

Fig. 5: *Chaetodon semeion*, 151 mm SL, Tetiaroa, Society Islands.

the absence of this marking on adult *ephippium*; above the eye the black bar is also intermediate to that of the probable parents. The blue of the upper part of the bar and on the forehead is, as previously mentioned, typical of *semeion.*

A possibility exists that this fish represents an undescribed species closely allied to both *ephippium* and *semeion.* It seems far more likely, however, that it is a hybrid of the two.

TABLE 2

Comparison of counts and measurements of *Chaetodon ephippium, C. ephippium* x *C. semeion* (indicated as hybrid), and *C. semeion.* Measurements expressed as percentage of the standard length.

	Chaetodon ephippium	Hybrid	*Chaetodon semeion*
Dorsal rays	XIII,23-25	XIII,25	XIV,25-26
Anal rays	III,21-23	III,21	III,21.23
Pectoral rays	16	16	16
Lateral-line scales	33-36	34	32.34
Gill rakers	15-17	17	15-17
Standard length (mm)	108-169	124	116-165
Depth of body	58.0-62.6	59.5	56.3-60.5
Head length	29.6-32.5	33.6	29.8-34.5
Snout length	10.7-13.1	13.7	10.6-14.4
Orbit diameter	7.4-8.2	8.1	6.7-8.7
Interorbital width	9.1-10.1	9.3	9.3-10.3
Depth of caudal peduncle	10.4-11.8	10.3	9.8-10.9
First dorsal spine	7.3-10.3	9.4	8.5-10.3
Pectoral fin length	23.1-25.7	24.6	23.0-24.6
Pelvic fin length	21.7-23.7	22.5	21.6-23.4

CHAETODON KLEINI x *CHAETODON UNIMACULATUS*

During the northern summer of 1970 one of us (GRA) observed an unusual butterflyfish near the wreck of a cement ship at the edge of the deep passage of Enewetak Atoll to the west of Bogen Islet (11°26'N; 162°22'E). This individual was clearly intermediate to *C. kleini* Bloch and *C. unimaculatus* (Bloch). Illustrations of these two species are presented as Figs 7 and 8 respectively. At Enewetak *C. kleini* usually occurs in water greater than 20 m, whereas *unimaculatus* tends to prefer shallower depths (usually less than 10 m). The intermediate fish was a member of an

aggregation of about 12 *kleini* which roamed over a steep reef slope at depths ranging from about 14 to 25 m. It was seen on several dives over a period of 1½ months, always within 50 m of the same location. It was finally speared on August 3, 1970 and photographed (**Fig. 6**). The specimen is now deposited at the Bishop Museum (BPBM 11377).

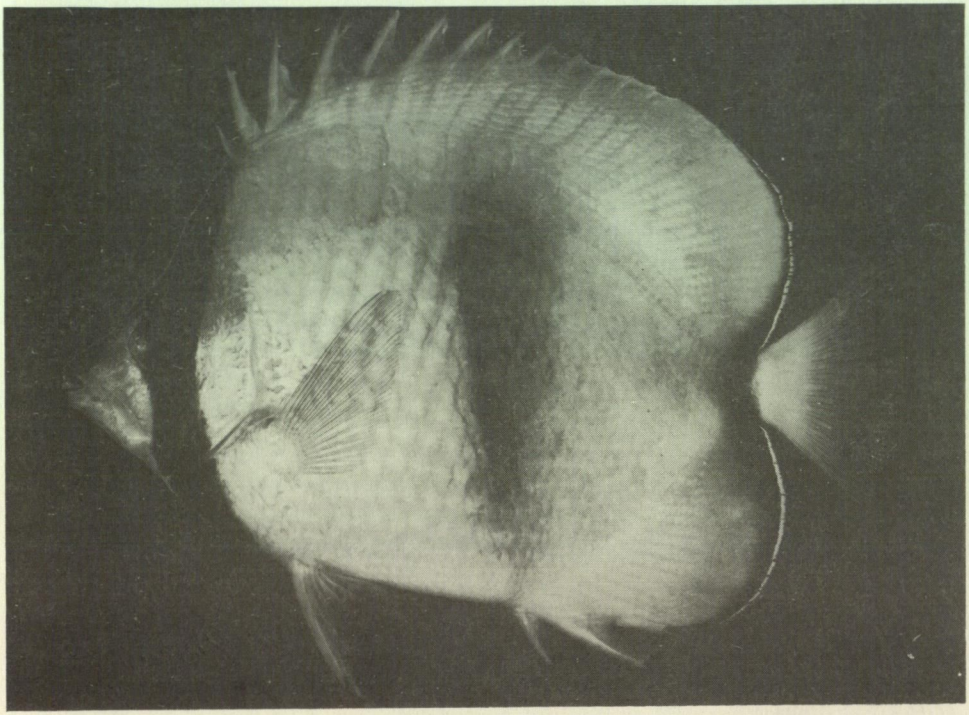

Fig. 6: *Chaetodon kleini* x *C. unimaculatus*, 92 mm SL, Enewetak, Marshall Islands.

The counts and measurements of the presumed hybrid are compared with those of eight specimens of *kleini* and *unimaculatus* (three of each collected in the same area as the hybrid) in **Table 3.** The data for the hybrid are either within the ranges or intermediate to those of *kleini* and *unimaculatus.*

The colour pattern of the probable hybrid is essentially a compromise between those of the suspected parents. Some characters are intermediate, and others favour one species or the other. If we ignore the dark markings, the overall colour is very similar to *kleini*: generally brownish-yellow, the centres of the scales pale tan, thus forming spots (which are larger anteriorly on the body). The diffuse blackish bar in the middle of the body

is more suggestive of *kleini*, but its darker colour probably represents an effect from the black spot of *unimaculatus*. The black bar across the caudal peduncle, which is continuous into the dorsal fin above and anal fin below, is derived from *unimaculatus* but its restriction in the fins and diffuse nature seem to be of *kleini* origin. The broad bold eye bar and blackish pelvic fins typify *unimaculatus*. There is no broad, diffuse dusky bar anteriorly on the body which is characteristic of *kleini*. On the upper anterior body there are narrow, near-vertical dark bands due to dusky posterior edges on the scales, a pattern which is suggestive of *unimaculatus*; however, these bands are more conspicuous on the latter species and continue ventrally where they are abruptly deflected posteriorly, forming a chevron-like pattern.

C. kleini and *C. unimaculatus* do not appear to be as similar morphologically as the parent species of the potential hybrids previously discussed. Nevertheless, Weber and de Beaufort (1936) grouped them in the same subgenus, *Lepidochaetodon* Bleeker.

TABLE 3

Comparison of counts and measurements of *Chaetodon kleini*, *C. kleini* x *C. unimaculatus* (indicated as hybrid), and *C. unimaculatus*. Measurements expressed as percentage of the standard length.

	Chaetodon kleini	Hybrid	*Chaetodon unimaculatus*
Dorsal rays	XIII,21-22	XIII,22	XIII,22-24
Anal rays	III,18-19	III,19	III,19-20
Pectoral rays	15-16	15	15-16
Lateral-line scales	34-40	40	40-43
Gill rakers	21-23	22	17-21
Standard length (mm)	82-105	92	89-101
Depth of body	54.0-62.2	61.8	58.5-64.0
Head length	27.5-29.9	29.0	31.3-34.2
Snout length	8.2-9.4	10.9	11.1-12.6
Orbit diameter	8.0-10.4	9.5	9.2-12.2
Interorbital width	9.0-10.6	10.4	11.0-12.2
Depth of caudal peduncle	8.8-10.3	9.7	9.8-10.6
First dorsal spine	6.4-8.1	6.8	7.5-8.6
Last dorsal spine	19.9-22.6	22.3	20.8-22.7
Third anal spine	20.3-23.3	22.8	20.5-24.0
Pectoral fin length	24.0-26.9	26.2	26.0-28.2
Pelvic fin length	23.7-26.7	25.8	23.8-27.0

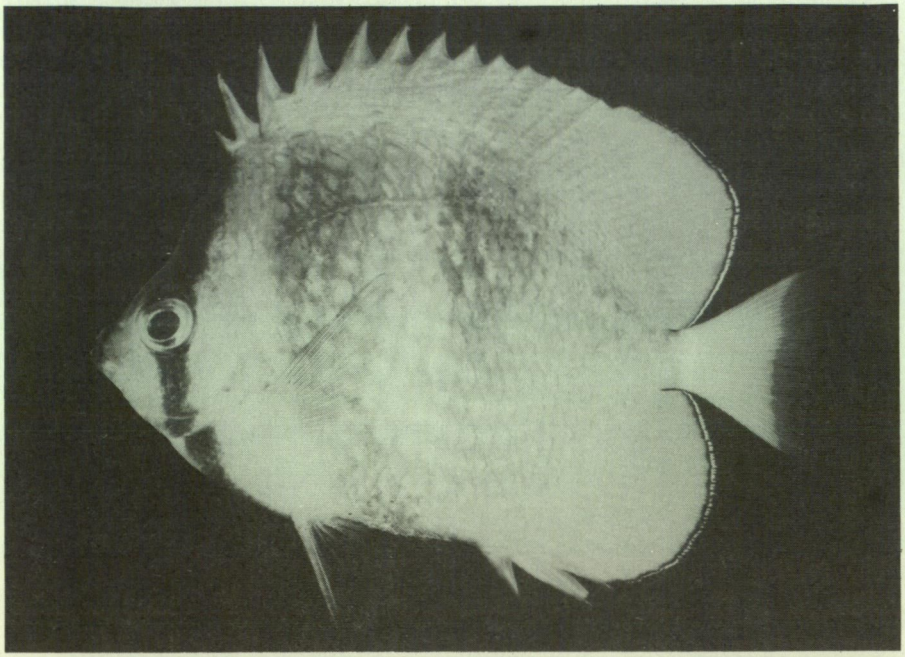

Fig. 7: *Chaetodon kleini*, 75 mm SL, Palau Islands.

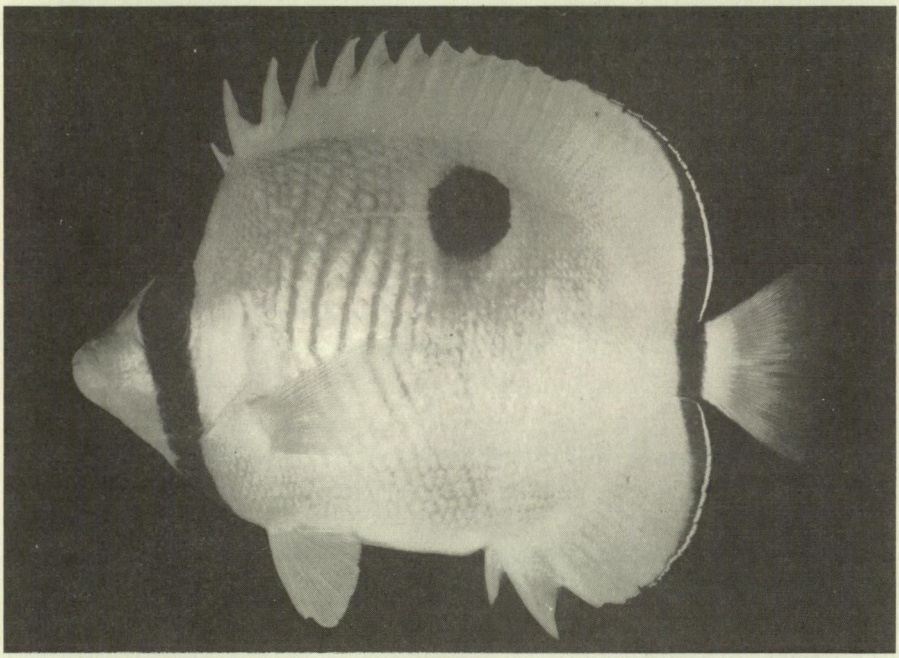

Fig. 8: *Chaetodon unimaculatus*, 103 mm SL, Bora Bora, Society Islands.

CHAETODON MILIARIS x *CHAETODON TINKERI*

In the summer of 1973 a butterflyfish about three inches long with a colour pattern and shape intermediate to *C. miliaris* Quoy and Gaimard and *C. tinkeri* Schultz was captured in 12 m off Nanakuli, Oahu by Daniel Coughlin, who was then working as an aquarium fish collector for Coral Fish Hawaii. Mr Coughlin took a colour photograph (reproduced in black and white as **Fig. 9**) of this specimen, but unfortunately the fish was subsequently discarded. A comparison of this photograph with **Figs 11** and **12** of *C. miliaris* and *C. tinkeri* respectively, seems to indicate that the specimen was a hybrid of these two species. The ground colour of the presumed hybrid in the photograph is white with a faint yellowish cast, shading to yellow on the dorsal and anal fins, thus intermediate to the deep yellow of *miliaris* and the white of *tinkeri.* The black area posteriorly on the body and on the soft portion of the dorsal fin is clearly intermediate in size to the corresponding black areas of the suspected parents. The faint dark spots on the body are slightly more evident on the hybrid than on *tinkeri*, but notably less so on *miliaris*; also they are not in such regular vertical rows as on *miliaris.* The ocular bar of *miliaris* is black and that of *tinkeri* is yellow; the bar of the hybrid is dusky orange.

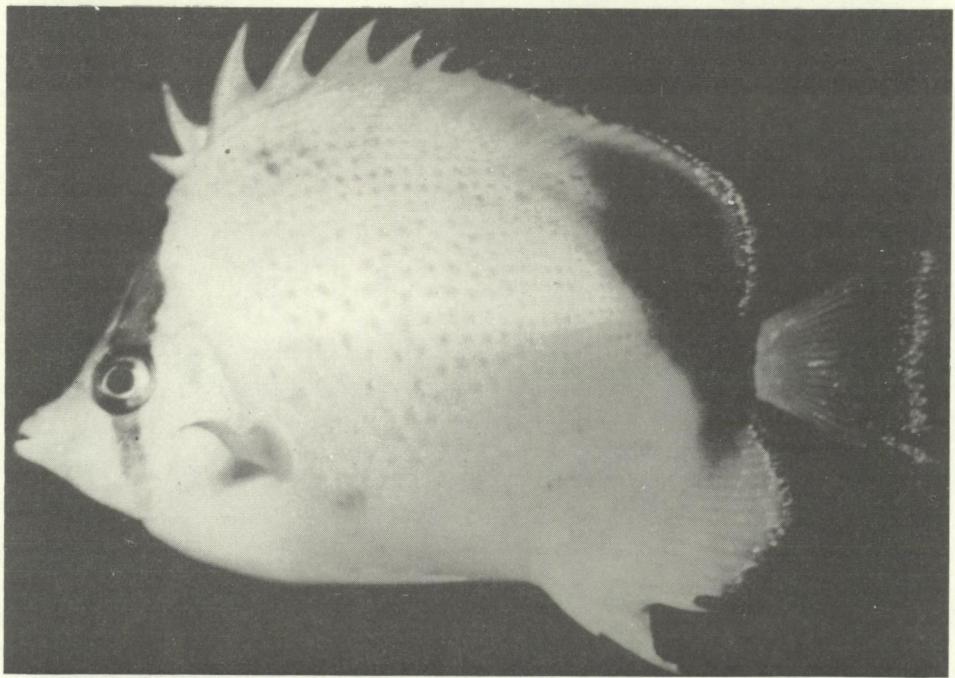

Fig. 9: *Chaetodon miliaris* x *C. tinkeri,* about 60 mm SL, Oahu, Hawaiian Islands.

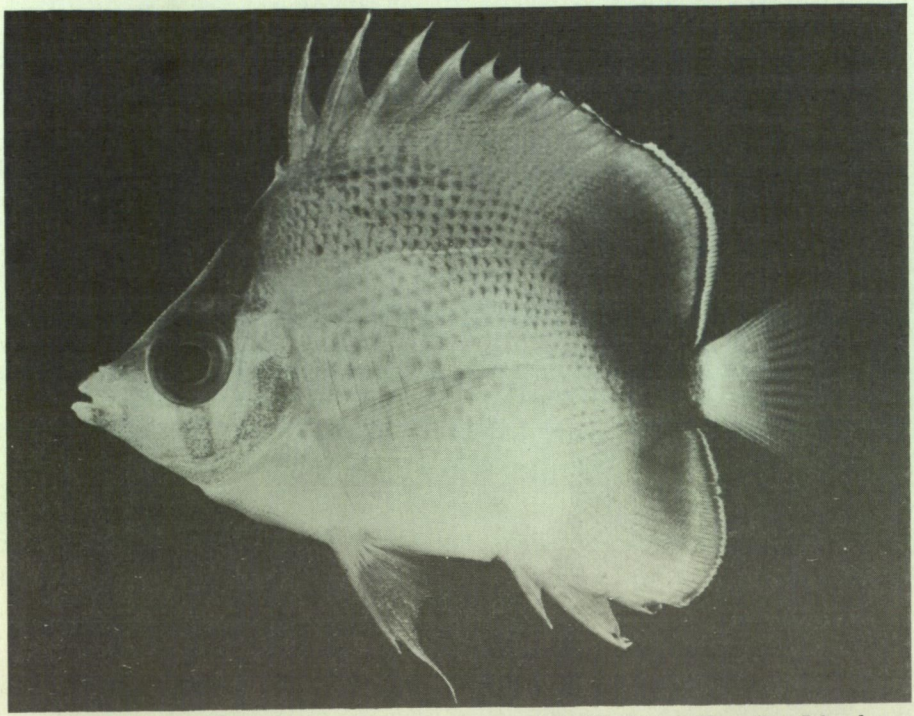

Fig. 10: *Chaetodon miliaris* x *C. tinkeri*, 40.5 mm SL, Oahu, Hawaiian Islands.

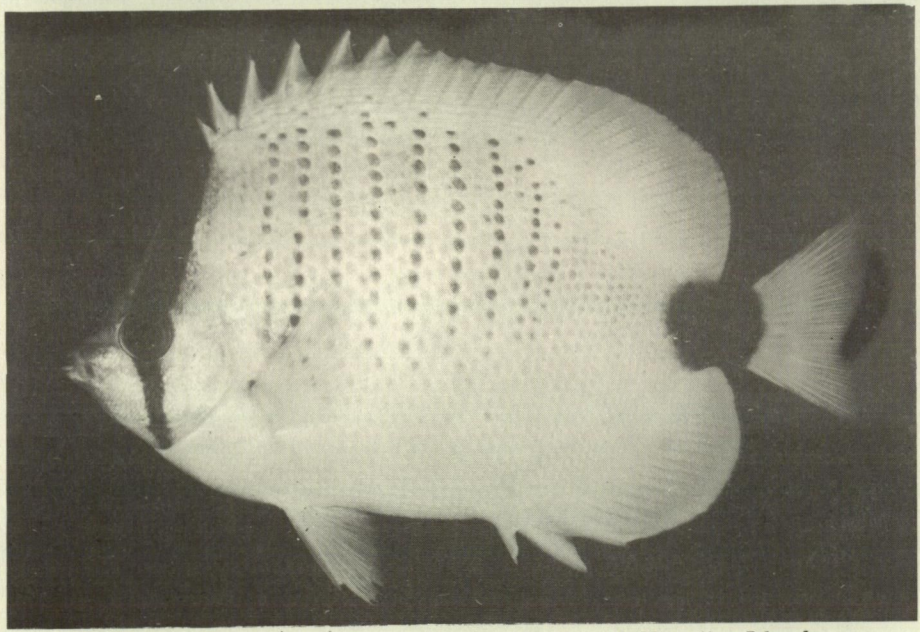

Fig. 11: *Chaetodon miliaris*, 124 mm SL, Hawaii, Hawaiian Islands.

Another noteworthy distinction between *C. miliaris* and *C. tinkeri* which is evident from the illustrations is the high spinous in contrast to the low soft portion of the dorsal fin of the latter in comparison to the former. The dorsal fin of the hybrid is intermediate in this respect.

In August, 1976 Dan Coughlin and Dennis Yamaguchi each captured a juvenile (40.5 and 41.3 mm SL) of the same hybrid in 8 and 18 m off Makua, Oahu. These were brought frozen to the senior author by Anthony Nahacky. A colour photo was taken of the smaller of the two which is reproduced herein in black and white as **Fig. 10.** These specimens have been deposited in the Bishop Museum under number BPBM 20458.

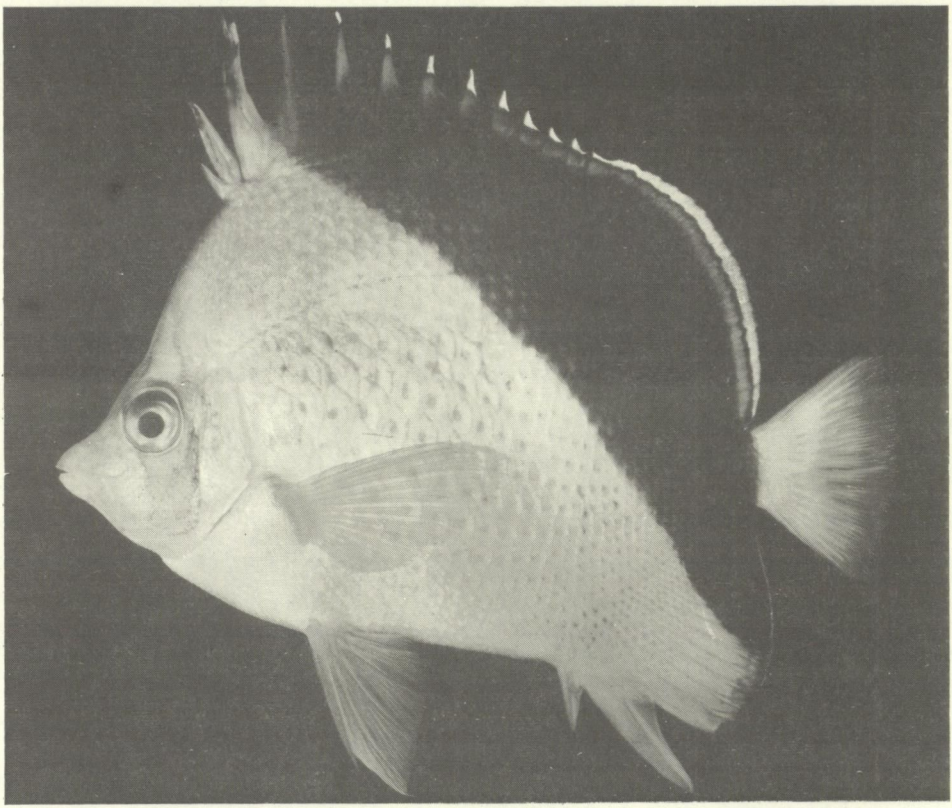

Fig. 12: *Chaetodon tinkeri,* 115 mm SL, Oahu, Hawaiian Islands.

Counts and measurements were made of the two hybrids and compared with data from the parent species (Table 4). The only count showing a clear distinction between the parent species is the number of anal soft rays. As may be noted in the table, both hybrids are exactly intermediate in

having 18 anal rays. The measurement data are not so readily compared because of the small size of the hybrids and the lack of specimens of the parent species of this size. Nevertheless, all of the measurements of the hybrid except interorbital width and orbit diameter fall within the range of the parent species; the relatively large eye of the hybrids, at least, would be expected from such diminutive specimens. The proportional measurement with the greatest difference between *miliaris* and *tinkeri* is the length of the longest dorsal spine. In this the hybrids are strikingly intermediate. In having a low soft portion of the dorsal fin they favour *tinkeri.*

TABLE 4

Comparison of counts and measurements of *Chaetodon miliaris, C. miliaris* x *C. tinkeri* (indicated as hybrids), and *C. tinkeri.* Measurements expressed as percentage of the standard length.

	Chaetodon miliaris	Hybrids	*Chaetodon tinkeri*
Dorsal rays	XIII,21-23[1]	XIII,22	XIII,20-22[1]
Anal rays	III,19-21	III,18	III,16-17
Pectoral rays	15-16	15-16	15-16
Lateral-line scales	35-40	37-38	36-40
Gill rakers	17-19	18	16-19
Standard length (mm)	45.3-98	40.5-41.3	49.6-107
Depth of body	57-62.2	58.2-61.7	61.2-66.7
Head length	28.8-35.4	34.5-35.4	29-34.9
Snout length	9.7-12.4	11.8-12.1	10.9-12.1
Orbit diameter	9.7-12.1	14.3-16	9.9-12.7
Interorbital width	9.2-11	10.3-12.1	9.6-10.1
Depth of caudal peduncle	9.8-11	10.2-10.6	10.1-11.7
First dorsal spine	7.4-9.7	10.8[2]	8.9-11.9
Longest dorsal spine	21.4-25.7	28.9-29.8	30.3-34.9
Eleventh dorsal ray	19-21.9	16.3-16.7	15.0-18.7
Pectoral fin length	24.7-29.1	27.4-29.9	27.3-31.7
Pelvic fin length	26.4-35.2	31.3-35.8	30.5-36.2

[1] One of 15 individuals of *C. miliaris* has XIV dorsal spines, and Schultz (1951) reported one of his three type specimens of *C. tinkeri* with XIV dorsal spines.

[2] First dorsal spine of one hybrid aberrant.

Both *C. miliaris* and *C. tinkeri* are endemic to Hawaii. The former is the most common butterflyfish in the islands. It occurs over a considerable

depth range which extends from shallow inshore waters to at least 200 m; submarine observations have revealed that it is one of the most abundant shorefishes penetrating deeper waters. *C. tinkeri* is strictly a deep-water form, having seldom been sighted in less than 40 m. It is often encountered in pairs, whereas *miliaris* occurs either singly or in aggregation. *C. miliaris* feeds mainly on zooplankton and has also been observed to 'clean' other fishes. *C. tinkeri* feeds on a variety of planktonic and benthic organisms, and partly for this reason does well in aquariums in contrast to species of *Chaetodon* which are more specialised in their feeding, many of which are restricted to browsing on coral polyps.

C. miliaris is also known to hybridise with *C. multicinctus* Garrett, another common species which is endemic to Hawaii. Two cases of this cross will be reported separately by Warren E. Burgess.

CHAETODON AUREOFASCIATUS x *CHAETODON RAINFORDI*

On November 20, 1973 one of us (RCS) encountered an apparent hybrid of *C. aureofasciatus* Macleay and *C. rainfordi* (McCulloch) at Decapolis Reef, about 24 km southwest of Lizard Island, Great Barrier Reef (approximately 13°51'S; 145°15'E). The fish was observed for about two hours. It was in the company of two *C. aureofasciatus*, both about twice the size of the presumed hybrid. In spite of its inferior size the hybrid seemed to dominate the trio, leading the way while foraging and acting the most aggressive towards other fishes which were encountered during this activity. This agonistic behaviour consisted of the characteristic *Chaetodon* habit of erecting the dorsal spines and tilting the head downwards, thus presenting the spines to the opposition. Both *C. aureofasciatus* and *C. rainfordi* were common on Decapolis Reef. At the end of the observation period the hybrid was photographed (**Fig. 13**) and then collected by concussion with a .303 powerhead.

Counts and measurements of the probable hybrid are compared with those of *C. aureofasciatus* and *C. rainfordi* in **Table 5.** These data for the hybrid fall within the ranges given for the parent species. *C. aureofasciatus* and *C. rainfordi* are very closely related, differing primarily in colour pattern. Their geographical distribution is confined to the northern Australia-Arafura Sea region; *C. rainfordi* has a limited distribution which is mainly restricted to the Great Barrier Reef.

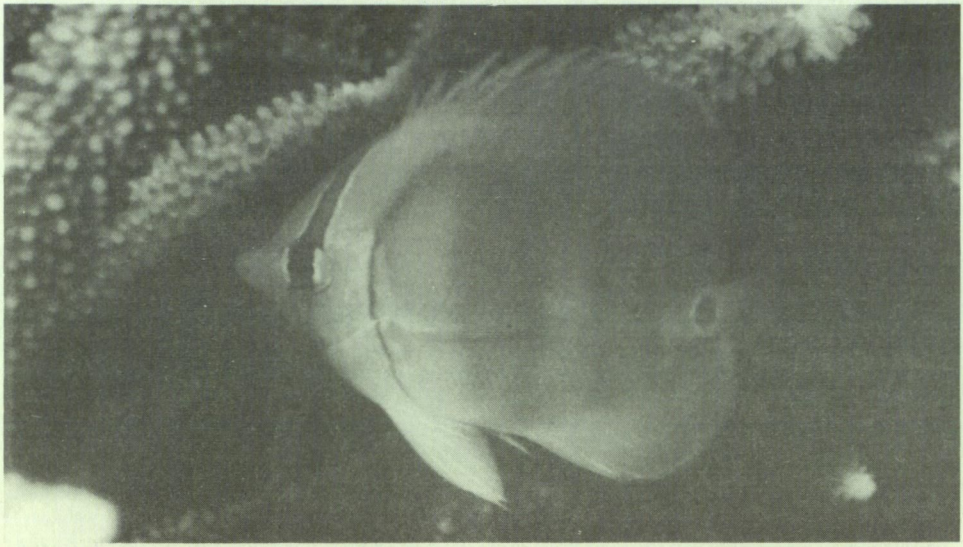

Fig. 13: *Chaetodon aureofasciatus* x *C. rainfordi*, 51 mm SL, Decapolis Reef, Great Barrier Reef.

TABLE 5

Comparison of counts and measurements of *Chaetodon aureofasciatus*, *C. aureofasciatus* x *C. rainfordi* (indicated as hybrid), and *C. rainfordi*. Measurements expressed as percentage of the standard length.

	Chaetodon aureofasciatus	Hybrid	*Chaetodon rainfordi*
Dorsal rays	XI,21-22	XI,21	XI,21-22
Anal rays	III,18-19	III,18	17-18
Pectoral rays	15-16	16	15
Lateral-line scales	31-36	36	32-37
Gill rakers*	14-21	14	15-19
Standard length (mm)	40-92	51	42-70
Depth of body	74.3-80.3	71.0	70.6-80.3
Head length	29.3-37.0	34.7	32.9-37.7
Snout length	9.2-12.5	10.3	11.1-13.0
Orbit diameter	9.8-13.3	12.8	11.8-13.2
Interorbital width	10.2-13.3	12.0	11.1-13.0
Depth of caudal peduncle	12.0-13.3	12.0	12.1-13.8
First dorsal spine	8.6-11.3	9.3	8.7-11.8
Pectoral fin length	27.8-31.1	29.2	28.7-33.6
Pelvic fin length	32.9-36.3	37.1	35.0-40.3

*Gill raker counts for the upper portion of the first branchial arch of *C. aureofasciatus* are extremely variable. There is an apparent increase in the number of elements with increasing growth.

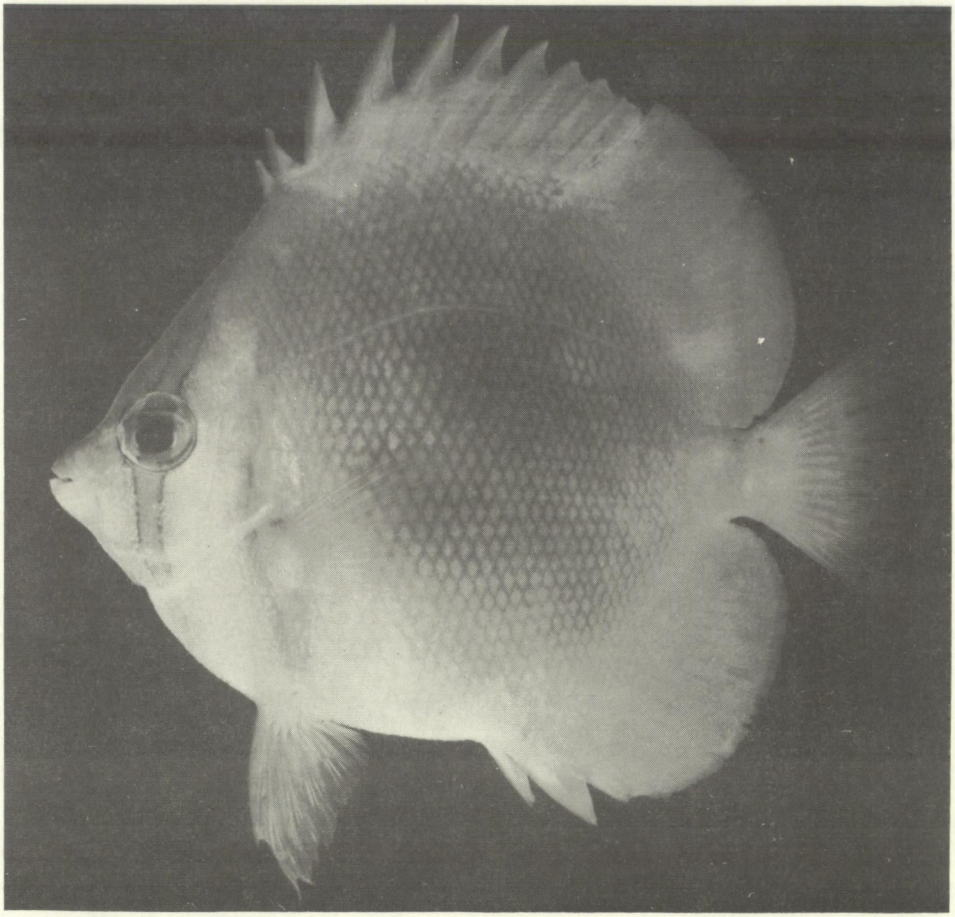

Fig. 14: *Chaetodon aureofasciatus*, 53 mm SL, Wistari Reef, Great Barrier Reef.

The live coloration of the potential hybrid was as follows: ground colour pale greyish-white with this colour extending over most of the dorsal fin; snout, distal portion of dorsal fin, caudal base, and pelvic and anal fins yellow; two faint bars on middle of sides, mostly grey but grading to yellowish on ventral half; ocular bar bright orange below eye, dusky orange above eye with pale margins; a narrow bar extending from base of about fourth or fifth dorsal spine, passing through pectoral base and extending to abdomen, this bar mainly orange, but dorsal third grey; a similar but fainter bar behind eye, extending onto thorax. This coloration, although not exactly intermediate, represents a compromise condition between *C. aureofasciatus* **(Fig. 14)** and *C. rainfordi* **(Fig. 15).** This is particularly

true with reference to the alternating white and grey bars on the middle of the sides; these are much more prominent in *C. rainfordi*, and entirely absent in *C. aureofasciatus*. However, the bars lack the dusky orange margins which are characteristic of *rainfordi*. The somewhat ovate, pale rimmed spot on the caudal peduncle of the hybrid is derived from the *rainfordi* parent, although it is far less prominent in the suspected hybrid; again it represents a compromise condition as this marking is absent in adult *aureofasciatus*. Juveniles of the latter species exhibit a dark bar across the peduncle.

The specimen is now deposited at the Western Australian Museum (WAM P25103-001). The bars have faded in preservative (70% ethanol) and it closely resembles *C. aureofasciatus*.

Fig. 15: *Chaetodon rainfordi*, approximately 110 mm SL, off Cairns, Great Barrier Reef.

DISCUSSION

One aspect regarding the hybridisation of chaetodontid fishes which merits further discussion involves the circumstances under which it might occur and its possible adaptive significance. Reese (1975) studied the social behaviour and related ecology of chaetodontid fishes. He divided various species into three groups according to social relationships: (A) those occurring as solitary individuals; (B) those occurring in conspecific pairs; and (C) those occurring in groups containing either conspecific or interspecific members. He also noted that a given species might be classed in one category at one locality and another category at a different location. He established 95% confidence limits for 19 species occurring at Enewetak Atoll (Marshall Islands), Heron Island (Great Barrier Reef), and Johnston Island (Central Pacific). As an example from his data at Enewetak, one could be 95% confident of seeing *C. auriga* in pairs approximately 73% of the times when observed.

Five of our presumed parental species (*auriga*, *ephippium*, *unimaculatus*, *aureofasciatus*, and *rainfordi*) were classed by Reese as being either solitary or occurring in pairs. *C. kleini*, *C. semeion*, and *C. tinkeri* were not studied by him, but we have frequently seen these species either alone or in conspecific pairs. The remaining parental species, *C. miliaris*, exhibits a relatively wide range of social behaviour, but is frequently seen in large aggregations. In addition, we have previously mentioned the occurrence of probable crosses involving *C. ornatissimus* (with *C. meyeri*) and *C. punctatofasciatus* (with *C. pelewensis*), which are also mentioned by Reese as pair-forming species.

On the basis of the evidence presented in the previous paragraph it is apparent that the suspected hybridisation potential is greater in chaetodontids which are normally solitary or which form pairs, in contrast to aggregating species. If suitable mates are in short supply, we would expect the solitary fish to seek an individual of a closely related species for reproduction. This seems to be the case, for example, for the hybrid surgeonfish *Acanthurus achilles* x *A. glaucopareius* on the Kona coast of the island of Hawaii where this hybrid may on rare occasions be seen. *A. achilles* is abundant at this locality whereas the closely related *glaucopareius* is uncommon. The same situation pertains to certain chaetodontids we have observed. One has to swim literally 'miles' in order to encounter an individual of *Chaetodon semeion* in the Marshall Islands or *C. adiergastos* at Northwest Cape and the Dampier Archipelago of Western Australia.

Unfortunately there is little information about the reproductive habits of chaetodontids, and it is not known whether breeding occurs in pairs or aggregations, or both, depending on species. We suspect, however, that pair-forming species spawn as pairs as we have never seen breeding aggregations. These aggregations are conspicuous for certain other common diurnal reef fishes, such as labrids, scarids, and acanthurids, during reproductive periods.

Reese differentiated between weakly and strongly pairing species. Chaetodontids such as *C. ephippium* and *C. unimaculatus*, whose 95% confidence limits for pairing ranged between 65-83% of the total individuals observed, were regarded as being strongly paired. On the contrary, *C. reticulatus* was considered as a weakly paired species with 57% of the individuals observed occurring in this condition. Reese mentioned that mixed pairs or threesomes were occasionally encountered and were usually composed of fishes belonging to a strongly paired species. Reese stated, 'apparently when a fish of a strongly paired species became separated [sometimes only temporarily] it attempted to establish a pair with another fish [different species of chaetodontid]. The second fish presumably was in the same situation and motivational state, and therefore both fish responded appropriately to one another.' It seems to us that this type of behaviour might certainly set the stage for interbreeding.

Reese found that adult pairs of chaetodontid fish were usually composed of members of the opposite sex. He did not, however, discuss the phenomenon of pairing in relation to growth. We have noted that juveniles of some species swim in pairs. It would be fruitful to conduct long-term studies of pairing to assess the degree of permanence of bonds formed at an early age. If there is some semblance of permanence in the pairing by butterflyfishes, the death of one member of the pair, as by predation, would seem to enhance the possibility of hybridisation.

In addition to certain social conditions, an obvious prerequisite for hybridisation in chaetodontids is a close phylogenetic relationship between the interbreeding species. The probable hybrid between *C. miliaris* and *C. tinkeri* is the only cross we have studied involving members of different subgenera. In nearly every case the presumed parents possess strikingly similar morphology, although colour patterns may be very different.

The psittaciform birds (parrots) might be regarded as the terrestrial counterpart of the butterflyfishes, exhibiting a multitude of dazzling colour patterns and being distributed primarily in the tropics. The species inhabiting Australia are among the most ecologically diverse and have been

well documented. Hybridisation in Australian parrots is widespread both in captivity and in the wild. Of the 52 species reported by Forshaw (1969) all but 16 are known to form hybrids. Most of the interbreeding occurs between closely related forms, but in a few cases members of different genera have been involved.

ADDENDUM

Just prior to publication a letter was received from Dr Leighton Taylor, Director of the Waikiki Aquarium (Honolulu, U.S.A.) with a photograph of a probable hybrid of *C. auriga* x *C. lunula* (Lacépède). The fish is approximately 130 mm SL and is still alive and on display at the aquarium. It was collected by G. Daigle of Pacific Tropical Fish Inc. near Kona, Hawaii in 8-10 m depth. The probable hybrid appeared to be paired off with a normal *C. lunula* and they were travelling with a mixed aggregation of 6-8 *C. lunula* and a pair of *C. auriga*. We have been aware for the past three years of an identical hybrid collected by Mr J. Braun of Perth at North West Cape, Western Australia. The fish is still alive (approximately 125 mm SL) in an aquarium and it was not until Dr Taylor's letter arrived that we became aware that *C. lunula* was involved in this cross. The general colour pattern is similar to that of *C. auriga*, but *lunula* characters include a large dusky area posteriorly on the upper back, a broad white band behind the black ocular bar, slanting dark lines most prominent on the lower sides (which cross the chevron lines inherited from the *auriga* parent at right angles), and a black margin on the dorsal fin. There is a weak spot at the middle of the tail base which represents a compromise between the prominent black spot on *lunula* and the complete absence of this mark in *auriga*.

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of the Australian Museum, Sydney kindly sent us loan specimens of *C. rainfordi.* Finally, we thank Connie Allen for preparation of the typescript.

REFERENCES

ALLEN, G.R. & STARCK, W.A. (1973)—A new species of butterflyfish (Chaetodontidae) from the Palau Islands. *Trop. Fish Hobby.* 2(March): 17-28.

BAILEY, R.M., FITCH, J.E., HERALD, E.S., LACHNER, E.A., LINDSEY, C.C., ROBINS, C.R. & SCOTT, W.B. (1970)—A list of common and scientific names of fishes from the United States and Canada. 3rd ed. *Spec. Publs Am. Fish. Soc.* no. 6: 1-149.

BURGESS, W.E. (1974a)—Evidence for the elevation to family status of the angelfishes (Pomacanthidae), previously considered to be a subfamily of the butterflyfish family, Chaetodontidae. *Pacif. Sci.* 28: 57-71.

BURGESS, W.E. (1974b)—Une forme atypique de *Chaetodon* de Ceylon. *Rev. fr. Aquariol.* 2: 37-40.

FEDDERN, H.A. (1968)—Hybridization between the Western Atlantic angelfishes, *Holacanthus isabelita* and *H. ciliaris. Bull. Mar. Sci.* 18: 351-382.

FORSHAW, J.M. (1969)—*Australian parrots.* Melbourne: Lansdowne Press.

FRIEHOFER, W.C. (1963)—Patterns of the ramus lateralis accessorius and their systematic significance in teleostean fishes. *Stanford ichthyol. Bull.* 8: 81-189.

LONGLEY, W.H. & HILDEBRAND, S.F. (1941)—Systematic catalogue of the fishes of Tortugas, Florida. *Publs Carnegie Instn* no. 535: xii + 331 pp.

RANDALL, J.E. (1956)—*Acanthurus rackliffei,* a possible hybrid surgeon fish (*A. achilles* x *A. glaucopareius*) from the Phoenix Islands. *Copeia* 1956: 21-25.

RANDALL, J.E. (1975)—Three new butterflyfishes (Chaetodontidae) from southeast Oceania. *UO* 25: 12-22.

RANDALL, J.E. & CALDWELL, D.K. (1973)—A new butterflyfish of the genus *Chaetodon* and a new angelfish of the genus *Centropyge* from Easter Island. *Contr. Sci.* no. 237: 1-11.

REESE, E.S. (1975)—A comparative field study of the social behaviour and related ecology of reef fishes of the family Chaetodontidae. *Z. Tierpsychol.* 37: 37-61.

SCHULTZ, L.P. (1951)—*Chaetodon tinkeri,* a new species of butterflyfish (Chaetodontidae) from the Hawaiian Islands. *Proc. U.S. natn. Mus.* 101: 485-488.

SCHWARTZ, F.T. (1972)—World literature to fish hybrids, with an analysis by family, species, and hybrid. *Publs Gulf Coast Res. Lab. Mus.* 3: 328 pp.

SLASTENENKO, E.P. (1957)—A list of natural fish hybrids of the world. *Hidrobiologi* (B) 4: 76-97.

WEBER, M. & de BEAUFORT, L.F. (1936)—*The fishes of the Indo-Australian Archipelago.* 7 Leiden: Brill.