Japan. J. Ichthyol.
42(2): 121–130, 1995

魚類学雑誌
42(2): 121–130, 1995

Aspects of Reproduction and Sexuality in the Black-spot Tuskfish, *Choerodon schoenleinii*

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(*Received March 5, 1993; in revised form March 10, 1995; accepted May 31, 1995*)

Abstract The annual reproductive cycle and sexuality of *Choerodon schoenleinii* were studied histologically. The major spawning period persisted from February until May, spawning of individuals occurring almost every day during the most active period, being March and April. Relationships between TL and both Fecundity and batch fecundity were obtained. *C. schoenleinii* mature as females at about 24 cm TL and exhibit protogynous hermaphroditism with monandric sexuality. Sex transition occurred from 40–64 cm TL, all fish larger than 65 cm TL being males. *C. schoenleinii* is closely sexually dichromatic, the body color changing from an initial greenish-yellow phase (female) to a terminal blue phase (male), in almost complete accordance with the sex transition.

Most labrid species are known to be protogynous hermaphrodites with monandoric or diandric sexuality. In addition, sexual dichromatism and dimorphism is common among labrid species (Yogo, 1987). Much research on labrid fishes has been focused on sexuality, dichromatism or the mating system (Warner and Robertson, 1978; Nakazono, 1979; Jones, 1981; Tribble, 1982; Nemtzov, 1985) rather than on general biology, such as growth, reproduction and feeding behavior (Warner, 1975; Dipper et al., 1977; Hoffman and Grau, 1989). Descriptions of gametogenesis in labrid fishes are very few (McPherson, 1977; Dipper and Pullin, 1979; Bruslé, 1987).

Studies of *Choerodon* species are relatively scarce. Protogynous hermaphroditic species with monandric (*C. transversalis*) and diandric (*C. albigena*) sexuality were studied by Choat (1969), and Nakazono and Kusen (1991) reported protogynous hermaphroditism and both sexual dichromatism and dimorphism in *C. azurio*. *C. schoenleinii*, one of the larger labrids, is a very important commercial species in Okinawa, southern Japan. Preliminary information reported by Kanashiro et al. (1990) indicated the species to be caught mainly by so called "dentou moguri" (spire fishing at night), accounting for 70% to 90% of the total catch, with gill net and longline accounting for the remained. The body lengths (TL) of fish caught commercially ranged from 17 cm to 76 cm, individuals ranging from 20 to 35 cm in TL constituting approximately 70% of the total catch by number. Such figures indicate overexploitation of the Okinawa populations, resulting in increasing requests for stock management and mariculture. This report describes the annual reproductive cycle, fecundity and sexuality of *C. schoenleinii*, so to provide fundamental information for stock management and mariculture.

Materials and Methods

Specimens were purchased from Katsuren Fishery Cooperative and Nago Fishery Cooperative between April 1986 and June 1990. The major fishing ground from which the specimens were taken, fell between 26°10′N and 26°25′N, 127°50′E and 128°00′E. Almost all of the specimens were caught at night by "dentou moguri," being kept fresh on ice until measurements could be taken. After total length (TL),

standard length (SL) and body weight (BW) were recorded, the gonads were dissected for sexing and measuring to the nearest 0.01 g. The gonads were fixed in Bouin's solution, embedded in paraffin, sectioned at 6μm, and stained with Mayer's haematoxylin and eosin. The stage of oocyte development was determined following Yamamoto (1956) and Mayer et al.(1988). The maturity stage of each ovary was determined according to the most advanced stage of oocytes present in the gonad. The hydrated oocyte stage included the migratory nucleus to ripe egg stages, since the overall development of these stages is considered to occur within a day, being the maturation phase (Hourigan and Kelley, 1985; Matsuyama et al., 1988). The gonadosomatic index (GSI) was expressed as the percentage of gonad weight against body weight.

Maturity stages of the ovary, later than the tertiary yolk globule stage, were employed for fecundity estimates. Preliminary observations indicated that tertiary yolk globule oocytes were always found in successive later stages of ovarian development. Thus, ovaries at the tertiary yolk globule stage were considered to be fully mature. Yolked oocytes were counted using both tertiary yolk globules and hydrated oocyte ovaries, except ripe egg ovaries, because a uniform distribution of oocytes at each stage in the ovary could not be expected due to the accumulation of ripe egg oocytes in the ovarian lumen. Batch fecundity, which corresponded to the number of oocytes at the hydrated oocyte stage, was estimated when the ovary was at either the pre-maturation or maturation stage. Batch fecundity of the remaining two hydrated oocyte stages may have been underestimated owing to possible new recruitment in the migratory nucleus stage ovary and loss of eggs by spawning in the ripe egg stage ovary. Therefore, ovarian stages were excluded from batch fecundity estimates. In the case of migratory nucleus oocytes being detected in the pre-maturation ovary during the histological observations, fecundity only was estimated due to the difficulty in identifying migratory nucleus oocytes from their external appearance alone. The basic procedure for fecundity estimates and oocyte isolation followed Ebisawa (1990). Fecundity was calculated using the following equation.

$$F = (gw/sw) \times (wv/sv) \times sn$$

where F was fecundity; gw, ovarian wall free gonad weight; sw, sample weight; wv, water volume (200 m*l*); sv, sub-sampled water volume; and sn, sub-sampled oocyte number. Batch fecundity in pre-maturation stage ovaries was estimated from the above equation by distinguishing pre-maturation oocytes from yolk globule oocytes using external appearances such as transparency and oocyte diameter. For batch fecundity estimates of a maturation stage ovary, oocytes at that stage were collected by filtering the sample through 500μm nylon mesh. The batch fecundity was calculated using the following equation.

$$Bf = (gw/sw) \times fn$$

where Bf was batch fecundity; fn, the number of maturation stage oocytes in the sample; and gw and sw as in equation of F.

The spawning intervals were calculated by comparing the rate of occurrence of both hydrated ovaries and ovaries bearing post-ovulatory follicles (POF) against matured ovaries (Demartini and Fountain, 1981; Hunter et al., 1986). The intervals based on hydrated ovaries were calculated from the number of spawnable ovaries, being mature stage ovaries including tertiary yolk globule to ripe egg stages, divided by the number of hydrated ovaries. Intervals based on POF bearing ovaries were calculated by substituting the number of POF bearing ovaries for the number of hydrated ovaries. The group maturation rate was expressed as the number of mature females divided by the number of females sampled in each given month.

Water temperature was the average of readings taken at 30 m, at st-10 of the "Okinawa Nanbu Engan Teisen," surveyed by R/V *Kuroshio* every month from April 1986 to March 1990. That station was included in the major fishing ground, from which the present specimens were taken.

Results

Seasonal changes in the ovarian maturation

Monthly changes of GSI, water temperatures and day lengths are shown in Figure 1. The GSI of females began to increase in December, peaked in March and April, and gradually decreased in July, remaining low until November. Changes in the GSI of males showed basically the same pattern as in females, the GSI increasing from January, peaking in April, and decreasing toward July. It stayed low until September, but gradually increased from Octo-

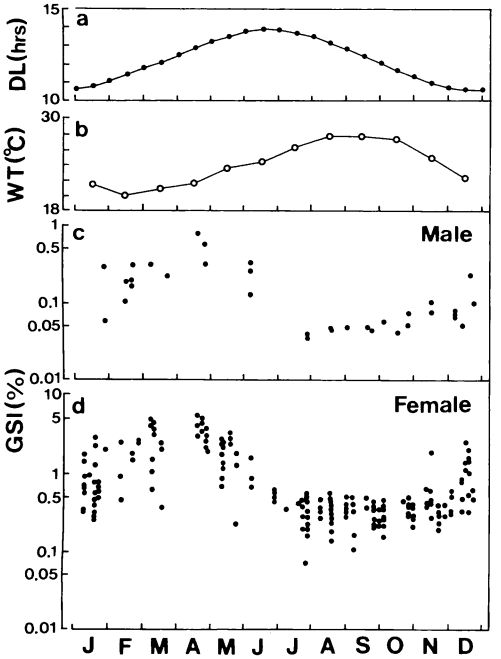

Fig. 1. Monthly changes in a) daylength; b) water temperature; c) male GSI; d) female GSI.

ber. The rapid increase in GSI observed from December to April corresponded with the increasing day length and lower water temperatures than the annual average.

The monthly changes in the stage of maturity of the ovaries are shown in Figure 2. A small ratio of early peri-nucleolus stage ovaries was initially obtained in June, at the end of the spawning period, but this suddenly increased to 67% in July. After peaking in August, it decreased toward December. Late peri-nucleolus stage ovaries appeared in June, gradually increasing to October and subsequently decreasing toward March. The primary growth phase, that is, early and late peri-nucleolus stage ovaries, predominated from June to November. Yolk vesicle stage ovaries appeared from July to January, except in October, and yolk globule stage ovaries from December to May except in April. Hydrated ovaries first appeared in November, increasing drastically from February to May. Most of the hydrated ovaries observed in this study consisted of migratory nucleus and pre-maturation stages (Table 1). Atresia was obtained in May and June. Accordingly, the reproductive cycle was taken to be as follows: resting period—July to October; yolk accumulation and early spawning—November to January, active spawning—February to May; end of spawning—June.

Spawning interval

Spawning intervals and group maturation rates are given in Table 2. Although the estimation of spawning intervals by the POF method is biased when POF degeneration takes more than 24 hours, there were no ovaries observed which possessed completely different stages in degeneration of POF, except at the ripe egg stage. Thus it was concluded that POF degeneration was completed in around 24 hours and, consequently, estimations of the spawning intervals were not biased. Spawning intervals estimated by both hydrated ovary and POF methods in December and January differed although they were the same in November and from February to June. The intervals were calculated as one day, while the group maturation rates were very low in November and June. In March and April, all fish appearently spawned every day, according to both hydrated ovary and POF estimations. The spawning intervals and group maturation rates indicated that the active spawning period was February to May, peaking in March and April.

Body size at sexual maturation

Choerodon schoenleinii matured at 24 cm TL or slightly smaller (Table 1). Of six fish belonging to the smallest length class, from 24.0 to 25.9 cm TL, one was at the late peri-nucleolus stage, one at the primary yolk globule stage, one at the tertiary yolk globule stage and the remaining three at the migratory nucleus stage. All specimens in the larger classes possessed yolked or atretic ovaries except one late peri-nucleolus stage ovary found in the 42.0–43.9 cm TL class. Thus, although data were insufficient for a definit conclusion, the minimum length at maturation was near 24 cm TL or slightly smaller.

Fecundity

In the relationships of fecundity and batch fecundity to total length, a power function or its logarithmic transformation fitted better than any other expressions. They were expressed as follows (see also Fig. 3):

$$F = 1.579 \times 10^{-3} \times TL^{3.398}; \quad r^2 = 0.88$$
$$Bf = 3.325 \times 10^{-5} \times TL^{3.809}; \quad r^2 = 0.77$$

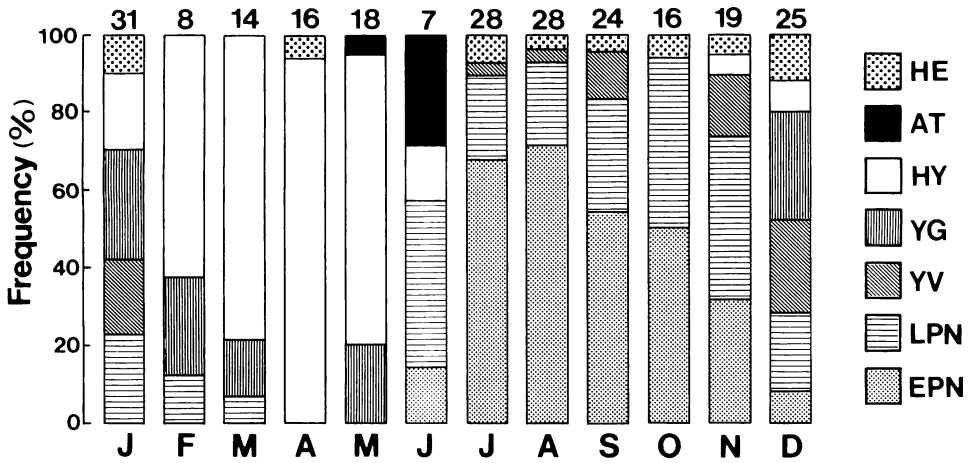

Fig. 2. Monthly changes in maturity stages of ovaries. *EPN*—early peri-nucleolus stage; *LPN*—late peri-nucleolus stage; *YV*—yolk vesicle stage; *YG*—yolk globule stages; *HY*—hydrated stages, including from migratory nucleus stage to ripe egg stage; *AT*—atresia; *HE*—hermaphrodite. Number of samples given above each column.

Both fecundity and batch fecundity were highly correlated with total length. Batch fecundity was 10.8% of the average total fecundity. Since spawning apparently occurred every day during the most active spawning months, the average interval for yolk accumulation required $1/0.108 = 9.3$ days. The spawning frequencies, calculated from the spawning intervals given in Table 2, were as follows: January $31/1.83 = 16.9$ times; February 20 times; March 31 times; Apri 30 times; May 25.8 times. Thus, total spawnings throughout the active spawning period from February to May exceeded 100, indicating the expected number of oocytes released in one spawning period to be approximately 10 times greater than the

Table 1. Numbers of individuals at each maturity stage during the spawning period from February to May

Size class	Maturity stage*											
TL (cm)	EPN	LPN	YV	PYG	SYG	TYG	MN	PM	MT	RP	AT	HE
24.0–25.9	—	1	—	1	—	1	3	—	—	—	—	—
26.0–27.9	—	—	—	—	—	1	3	—	—	—	—	—
28.0–29.9	—	—	—	—	—	1	2	—	—	—	—	—
30.0–31.9	—	—	—	—	—	—	1	—	—	—	—	—
32.0–33.9	—	—	—	—	—	1	1	2	—	—	—	—
34.0–35.9	—	—	—	—	—	—	2	1	—	—	—	—
36.0–37.9	—	—	—	—	—	—	3	1	—	—	1	—
38.0–39.9	—	—	—	—	—	2	4	1	—	1	—	—
40.0–41.9	—	—	—	—	—	—	2	1	—	—	—	—
42.0–43.9	—	1	—	—	—	1	—	—	—	—	—	—
44.0–45.9	—	—	—	—	—	—	2	2	—	1	—	—
46.0–47.9	—	—	—	—	—	—	3	—	1	—	—	—
48.0–49.9	—	—	—	—	—	—	2	1	—	—	—	—
50.0–51.9	—	—	—	—	—	—	1	—	—	—	—	—
52.0–53.9	—	—	—	—	—	—	—	—	—	—	—	—
54.0–55.9	—	—	—	—	—	—	1	—	—	—	—	1
56.0–57.9	—	—	—	—	—	—	1	1	—	—	—	—
58.0–59.9	—	—	—	—	—	—	1	1	—	—	—	—

* EPN, early peri-nucleolus stage; LPN, late peri-nucleolus stage; YV, yolk vesicle stage; PYG, primary yolk globule stage; SYG, secondary yolk globule stage; TYG, tertiary yolk globule stage; MN, migratory nucleus stage; PM, pre-maturation stage; MT, maturation stage; RP, ripe egg stage; AT, atresia; HE, hermaphrodites.

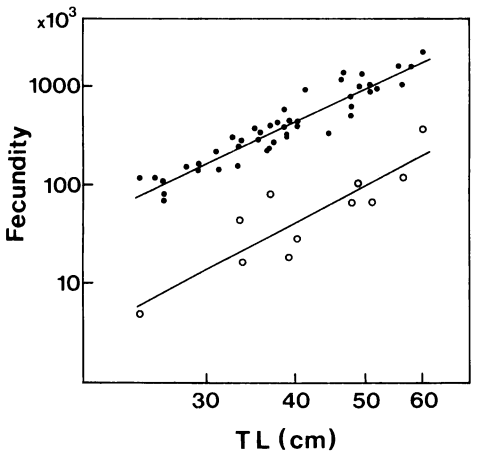

Fig. 3. Fecundity (●) and batch fecundity (○) against total length. Fecundity represents oocytes from yolk vesicle stage to maturation stage. Batch fecundity represents both oocytes in prematuration and maturation stages.

fecundity value.

Sexuality

C. schoenleinii exhibited protogynous hermaphroditism with monandric sexuality (Table 3). Among 289 specimens in total, males, hermaphrodites and females numbered 34, 13 and 242, respectively. Primary males were at no time observed. The smallest male and largest female observed were 40 cm and 62 cm TL, respectively. Hermaphrodites ranged between 48 cm and 64 cm TL. Thus, all sexual transitions observed were at post-maturational stages. Most of the hermaphrodites were obtained continuously from July to January, which corresponded to the non spawning period.

The sexual transition of *C. schoenleinii* was categorized as "undelimited type 2," following Sadovy and Shapiro (1987), i.e., during the transition from ovary (Fig. 4a) to testis (Fig. 4b), oocytes and testicular tissue were intermixed (Fig. 4c). In this type of sexual transition the central cavity formed in the testis is derived from the ovarian lumen. The basic pattern of sexual transition in *C. schoenleinii* is summarized as follows, although some exceptions were observed. The transition started with the entire degeneration of the pre-vitellogenetic oocytes. Accordingly, the ovarian lamellae atrophied, the ovary becaming very thin and wrinkled, with a surplus ovarian wall (Fig. 5a). Independent cells of equal size to primary spermatogonia appeared (Fig. 5b) at about the same time as the degeneration of the oocytes. Being about 10μm in diameter, the cells were similar also in characteristics and structure to primary spermatogonia. The nucleus and cytoplasm of the cells were less basophilic. A nucleolus located centrally in the former. The cytoplasm was narrower than in primary spermatogonia, although the minute structure could not be determined from the light microscopic observations. The cells were probably primordial germ cells (PGC), *sensu* Bruslé (1987). Among the residual oocytes and scattered debris of decaying oocytes (brown bodies) in the atrophying lamellae, spermatogonia and later spermatocytes appeared. As active spermatogenesis progressed, the former ovarian lamellae again hypertrophied, the compressed form of the gonad changing into dense, opaque testis. PGC were also found

Table 2. Spawning intervals based on hydrated oocytes and POF methods, and group maturation rate in each spawning month

Month	Spawning interval (day)		Group maturation rate (%)
	Hydrated oocytes	POF	
November	1.00	1.00	6
December	2.50	5.00	23
January	1.83	1.38	38
February	1.40	1.40	88
March	1.00	1.00	79
April	1.00	1.00	100
May	1.20	1.20	85
June	1.00	1.00	14

Table 3. Number of sexual types in each 5 cm size class

TL (cm)	Female	Hermaphrodite	Male
15.0–19.9	2	—	—
20.0–24.9	17	—	—
25.0–29.9	40	—	—
30.0–34.9	53	—	—
35.0–39.9	46	—	—
40.0–44.9	32	—	1
45.0–49.9	25	2	3
50.0–54.9	18	6	5
55.0–59.9	8	4	10
60.0–64.9	1	1	8
65.0–69.9	—	—	4
70.0–74.9	—	—	2
75.0–79.9	—	—	1
Total	242	13	34

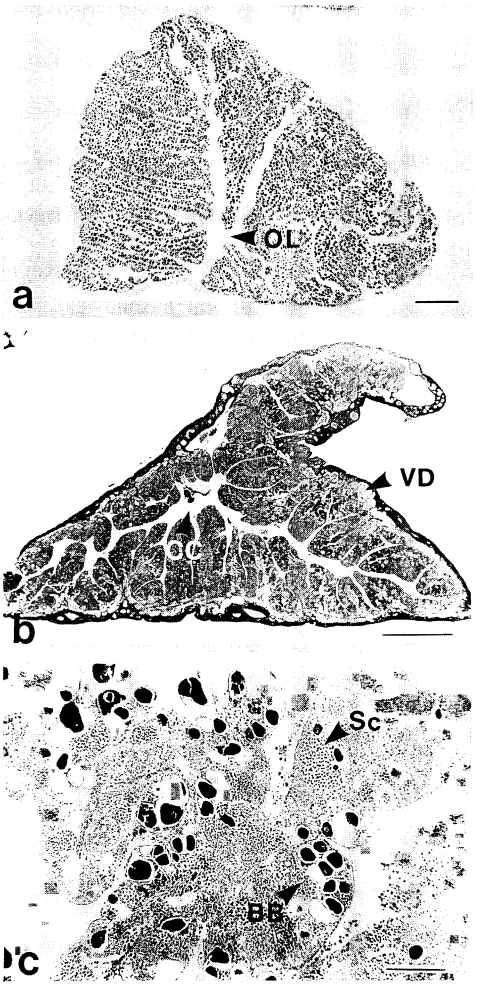

Fig. 4. Histological appearance of gonads. a) Transverse section of pre-vitellogenetic ovary, scale bar = 1 mm, 37.9 cm TL, July 25, 1989; b) transverse section of testis, scale bar = 1 mm, 59.7 cm TL, October 16, 1989; c) hermaphrodite gonad with both numerous residual oocytes and spermatogenetic cells. Scale bar = 100 μm, 45.7 cm TL, December 12, 1987. *OL*—ovarian lumen; *CC*—central cavity; *VD*—vas deferens; *Sc*—spermatocyte; *BB*—brown body.

in functional testes (Fig. 5c). The following exceptions to the basic pattern of gonad transition were found: a thread-like gonad with all ovarian lamellae completely atrophied, but no spermatogenetic activity (Fig. 5d); a gonad with an almost entire breakdown of oocytes, but with little testicular tissue (Fig. 5e).

Sexual dichromatism

C. schoenleinii showed sexual dichromatism, individuals changing their body color from an initial greenish-yellow to blue, the latter initiating anterodorsally, during sexual transition, and fully covering the entire body. The correspondence of body color and sex is shown in Table 4. Neither initial phase males nor terminal phase females were obtained. Two exceptions, a transitional color phase female and an initial color phase hermaphrodite, were obtained. In the gonads of the former, the somewhat abnormal early peri-nucleolus stage oocytes with distinctly large, irregular nucleoli, and irregular vesicles appearing in the cytoplasm, indicated that the gonad was in an early stage of pre-vitellogenetic oocyte atresia (Nakamura et al., 1989). In addition, a cyst of a spermatocyte observed among the earlier stage of decaying oocytes, suggested that the gonad was at the very beginning stage of sexual transition (Fig. 5f). The initial phase hermaphrodite had a thread-like gonad with completely atrophied ovarian lamellae. Thus sexual transition and the changes in body color proceed almost simultaneously. No obvious sexual dimorphism was observed.

Discussion

The spawning period expected from natural occurrences of juvenile *Choerodon schoenleinii* basically agrees with the results obtained here. Kanashiro (1993) conducted seine sampling on and around the sea grass zone every month from 1986 to 1992. A number of juvenile *C. schoenleinii* were obtained from May with a peak in June and July. However, specimens were rare between October and April, inclusive. The total lengths of the specimens obtained in May ranged from 10 mm to 55 mm. Since there is little information on initial growth of *C. schoenleinii*, data obtained from other reef fishes under captive rearing was used for comparison. The daily growth rate from hatching to 10 mm TL is 0.42 mm/day and to 25.1 mm TL, 0.46 mm/day in *Plectoropomus leopardus* (Masuma et al., 1993). Growth rates are 0.37 mm/day to 11 mm TL and 0.74 mm/day to 50 mm TL in *Lethrinus nebulosus* (Tawada, 1988), 0.47 mm/day to 7.15 mm TL and 0.62 mm/day to 24.8 mm TL in *Siganus guttatus*

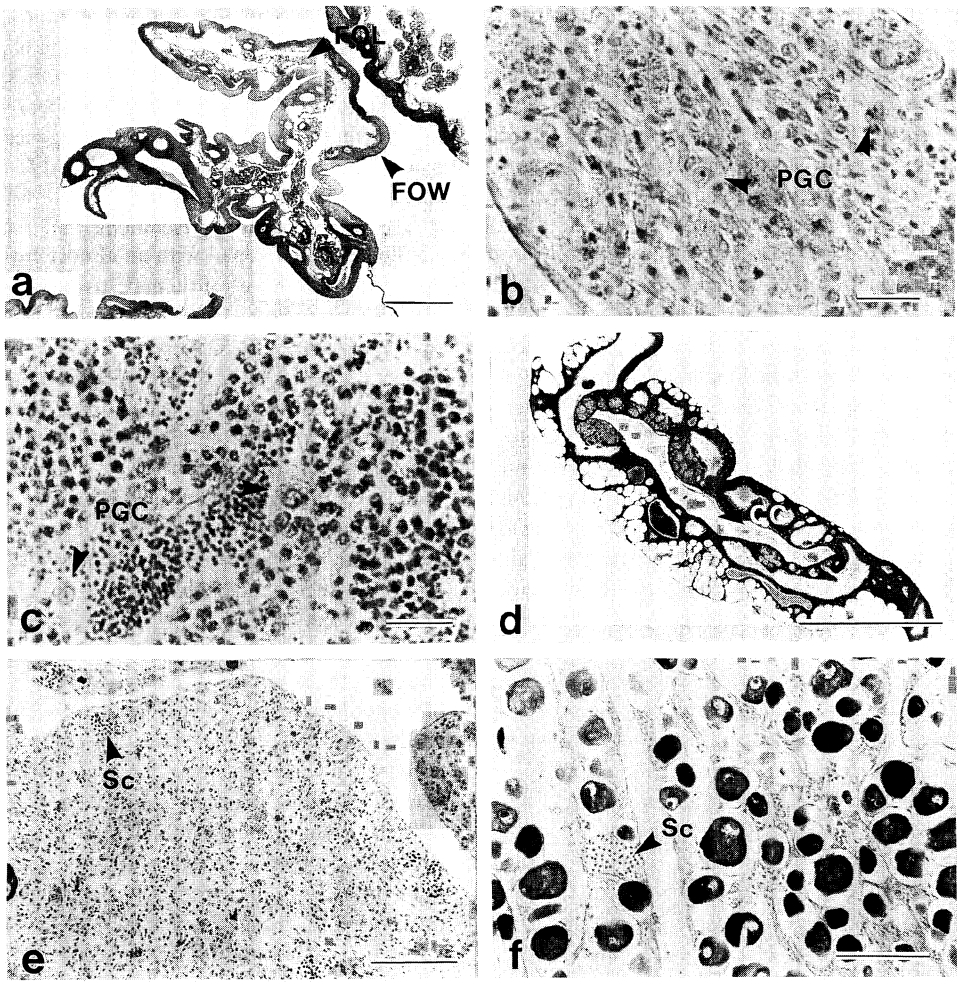

Fig. 5. a) Transitional gonad, scale bar = 1 mm, 54.5 cm TL, July 18, 1988; b) *PGC* observed in transitional gonad, scale bar = 10 μm, 54.0 cm TL, January 8, 1988; c) *PGC* observed in functional testis, scale bar = 10 μm, 53.7 cm TL, March 20, 1989; d) transitional gonad with completely atrophied ovarian lamellae, scale bar = 1 mm, 54.2 cm TL, April 24, 1989; e) transitional ovary with some testicular tissue and residual oocytes, scale bar = 100 μm, 54.0 cm TL, January 8, 1988; f) early stage of transitional ovary, scale bar = 50 μm, 52.7 cm TL, January 13, 1989. *FOW*—former ovarian wall; *FOL*—former ovarian lamellae; *PGC*—primordial germ cell; *CC*—central cavity; *Sc*—spermatocyte; *CNO*—chromatin nucleolus oocyte.

(Tawada, 1986a), and 0.28 mm/day to 8 mm TL and 0.32 mm/day to 19.4 mm TL in *Acanthopagrus sivicolus* (Tawada, 1986b). On the basis of growth rates up to 10 mm TL and 55 mm TL in *C. schoenleinii* being 0.4 mm/day and 0.5 mm/day, respectively, 25 days and 110 days would be necessary for growth to those given lengths. Consequently, individuals of 55 mm TL in May are likey to have spawned in January.

Table 4. Correspondance of sexual type and body color

Body color	Female	Hermaphrodite	Male
Initial	81	1	—
Transitional	1	4	4
Terminal	—	1	13

The reproductive cycles of many labrid species have been reported as exhibiting both lunar and tidal cycles, for example, *Thalassoma duperrey* (Ross, 1983; Hoffman and Grau, 1989), *Thalassoma cupido* (Moyer, 1974) and *Coris dorsomaculata* (Tribble, 1982), and others (Kuwamura, 1981). However,

spawning of *C. schoenleinii* bears no relationship with the lunar cycle, since the species spawns nearly every day during the spawning period. With regard to spawning time, the fact that all sampling was done at night, at which time the hydrated ovaries in the samples were mostly at the migratory nucleus and pre-maturation stage, suggests the following result. Hence, the later successive stages of maturation and breeding are expected to occur in daytime. Many labrid fishes, including *C. schoenleinii* are known to be daytime spawners (Warner and Robertson, 1978; Nakazono, 1979; Ross, 1983). However, the process of oogenesis is very much longer in *C. schoenleinii* than in the tidal spawner, *T. duperrey*. In the latter, the process from the beginning of the hydrated stages to spawning is completed in 6 hours, up to the time of high tide (Hoffman and Grau, 1989). Oogenesis in the maturation phase of *C. schoenleinii* instead resembles that of *Pagrus major* (Matsuyama et al., 1988). By comparison with *T. duperrey*, the speed of oogenesis from pre-vitellogenetic oocytes to ripe egg stage oocytes in *C. schoenleinii* appears to be extremely slow. In *T. duperrey*, pre-vitellogenetic oocytes are released within 24 hours, passing through the yolk accumulation and maturation processes (Hoffman and Grau, 1989), whereas in *C. schoenleinii* the process required approximately 10 days.

In *C. schoenleinii*, the GSI's of females were nearly ten times greater than those of male. In many labrids (Robertson and Choat, 1974; Warner and Robertson, 1978; Dipper and Pullin, 1979) and scarids (Choat and Robertson, 1975; Warner and Downs, 1977; Robertson and Warner, 1978;), the testicular mass has been closely related to the mating system. In most cases, the higher GSI, where the BW-GW relationship of the male is nearly equal to that of the female, leads to group spawning and the lower GSI to pair spawning. In the case of *C. schoenleinii*, therefore, it is likey that the species spawns in pairs.

Fundamental sexual transition of the gonads in the Labridae involves *in situ* replacement, spermatogenesis taking place in the ovarian lamellae and being mixed with degenerating oocytes. This type of transition was categorized as "undelimited type 2" by Sadovy and Shapiro (1987). However, some variations in cytological succession in the gonad may occure. Bruslé (1987) reported the appearance of a thread-like gonad resulting from the complete disappearance of the ovarian lamellae during sexual transition in *Coris julis*. Kobayashi and Suzuki (1990) reported the existence of an "undelimited type 1"-like gonad as a variation in *Cirrhilabrus temmincki*, most of the sexual transition being of the "undelimited type 2" form in that species. Dipper and Pullin (1979) reported chronological variations in oocyte breakdown and spermatogenesis in the ovarian lamellae in *Labrus bergylta* and *L. ossifagus*. In *C. schoenleinii*, some variations were found, such as a thread-like gonad resembling that reported by Bruslé (1987), a gonad with an almost entire breakdown of oocytes with little male tissue, and a gonad in which spermatogenesis progressed with numerous residual oocytes. Such variations might be expected to occur when one or other of either atrophication of the ovarian lamellae by degeneration of oocytes or hypertrophication of the lamellae by spermatogenesis proceeds faster than usual.

In the course of sexual transition, primordial germ cells, which proliferate by mitotic division (Bruslé, 1987), may play a particular role in cytological succession in the gonad. Accordingly, male germ cells could proliferate both in PGC and during primary spermatogonium stages. In the present study, numerous PGC were observed during the earlier stage of sexual transition, but were in low numbers in active testes. The sexual transition of *C. schoenleinii* appeared to take place as follows. At the onset of sexual transition, simultaneous processes of both atrophication of ovarian lamellae with an almost entire breakdown of oocytes, and the emergence of numerous PGC in the ovarian lamellae, occur. PGC proliferate, forming the primary spermatogonium. With the breakdown of all of the oocytes, the sexual transition is completed, and spermatogenesis begins.

Sexual dichromatism is very common among labrid and scarid fishes, although color changes of labrid species do not always coincide with their sex changes (Choat and Robertson, 1975; Roede, 1975; Robertson and Warner, 1978). In *Pseudolabrus celidotus*, the color change is slightly delayed until after the sex change, especially when the latter occurred prior to maturation (Jones, 1980). In *Pimelometopon pulchrum*, 5–13% of males occurred in the initial phase, despite being monandoric (Warner, 1975). On the other hand, Nakazono (1979) reported color change and sexual transition to be essentially simultaneous in five labrid species. In the case of *C. schoenleinii*, an intermediate color phase female and an initial phase hermaphrodite were obtained, the remaining 102 individuals examined being sexually dichromatic. However, the two exceptions represented a rather low rate in comparison with other

sexually dichromatic labrid species (Warner, 1975; Jones, 1980).

Acknowledgments

This work was supported by "Morphometric Survey of Important Fisheries Resources in Seas Adjacent to the Okinawa Islands" and "Research on Biological Characters of Dominant Species of Coral Reefs around the Okinawa Islands," both being conducted by the Japan Fisheries Agency. We acknowledge the former director, S. Kudou and staff of Pacific Coast Research Division, Nansei Regional Fisheries Research Institute, for their kind suggestions and assistance with the project. We also thank Prof. A. Nakazono, Kyushu University, and two anonymous reviewers, who kindly improved an earlier version of the manuscript. We are also gratefull to Dr. G. S. Hardy for the linguistic improvement of the manuscript.

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シロクラベラの産卵期及び性構造に関するいくつかの知見

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シロクラベラ (*Choerodon schoenleinii*) の産卵期及び性構造を調べるため，1986年4月から1990年6月までの間に沖縄島周辺海域から入手した289尾の標本の生殖腺を組織学的に観察した．

生殖腺重量指数 (GSI) は12月頃から増加を始め 3, 4 月にピークを迎えた後減少し，7月から11月まで低いレベルで推移した．卵巣の成熟段階の推移をみると11月から卵黄蓄積期が開始し，吸水期の卵巣は2月から5月にかけて非常に高い割合で出現した．吸水期の卵巣及び排卵痕を持った卵巣の出現割合から推定した産卵間隔はほぼ一致し，2月に1.4日，3月に1.0日，4月に1.0日，5月に1.2日となった．GSI及び成熟段階の推移，産卵間隔，群成熟率から推定された主産卵期は2月から5月までで，3, 4月に最も活発に産卵すると考えられた．成熟を開始する雌の全長は24cm前後であった．

本種は雌性先熟の性転換を行う．289尾の標本中で雌，性転換中の個体，雄はそれぞれ242尾，13尾，34尾得られた．全長範囲は雌が16.7–62.7cm，性転換中の個体が48.0–64.7cm，雄が40.5–76.9cmで，出現した雄はその精巣構造から全て二次雄であった．卵巣から精巣へと転換する様式は他のベラ類と同様に精細胞全域混在型であった．また本種は性転換に伴う体色変化を示した．雌の体色は緑黄色であるが雄への転換に伴って青みを帯びた体色への変化を示し，体色と性はほぼ例外なく一致した．

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