

Lek-Like Courtship by Males, and Multiple Spawns by Females of *Synodus dermatogenys* (Synodontidae)

Terry J. Donaldson

Section of Ichthyology, Museum of Natural Science and Department of Zoology and Physiology,
119 Foster Hall, Louisiana State University, Baton Rouge, Louisiana 70803, U.S.A.,
and the Tatsuo Tanaka Memorial Biological Station, Ako, Miyake-jima,
Izu Islands, Tokyo 100-12, Japan

Present address: Division of Fish and Wildlife, Commonwealth of the Northern Mariana Islands,
Saipan, MP 96950, U.S.A.

Abstract Courtship and spawning behavior of the lizardfish *Synodus dermatogenys* (Synodontidae) was observed at Wing Beach, Saipan, Mariana Islands. This species displayed lek-like behavior in that males aggregated for courtship at a definite site just before sunset and engaged in male-male aggressive interactions prior to and after the arrival of females for courtship. Male-male interactions continued at the site during courtship bouts with females and after spawning had been completed. Females made multiple (1-3) spawnings each night that lek-like behavior was observed. These spawnings began as a paired pelagic ascent but became multi-male group spawnings as additional males (2-7) joined the pair in the water column. Paired spawning occurred only when two individuals, a male and female, were present at the courtship site. Females spawned only once a night when paired spawnings occurred.

The reproductive behavior of lizardfishes is poorly known (Thresher, 1984). Courtship and spawning have been described for only one species, *Synodus ulae*, which engaged in paired courtship and pelagic spawning just after sunset at Miyake-jima, Izu Islands, Japan (Zaiser and Moyer, 1981). Here I describe the social organization, courtship and spawning behavior of a congener, *S. dermatogenys*, at Saipan, Mariana Islands.

Lizardfishes of the genus *Synodus* are distributed in tropical and warm temperate waters worldwide, showing greatest diversity in the Indo-Pacific region (Cressey, 1981; Waples and Randall, 1988). Hawaiian Islands species of this genus, many of which are found in the tropical Pacific Ocean, have been revised recently (Waples and Randall, 1988). *Synodus dermatogenys*, formerly known as *S. variegatus*, is commonly encountered in shallow water throughout the Indo-Pacific (Waples and Randall, 1988). At Saipan, it is observed on shallow reef flats supporting habitats of rubble, sand and coral-encrusted pavement. There, individuals may be found lying motionless on the substratum or buried just beneath the sand. This species is a cryptic ambush predator, taking small fishes on the substratum and in the water column (Hobson, 1974; Myers, 1989).

Study site and methods

Observations of social organization, courtship and spawning of *S. dermatogenys* were made at Wing Beach, Saipan, Mariana Islands. This locality is a narrow reef flat, located on a northwest exposure of the island. The site consisted of a shallow (0.4-1.9 m) area of rubble, boulders and sand in a moat adjacent to a raised seaward platform supporting coral, coralline algae and various epibenthic algae on a pavement of solid coral rock. The site was frequently swept by a strong longshore current, flowing N to S, generated by surf activity at the northern end of the beach. Surge activity from waves breaking 40 m west of the site was also present, and shifting sand was often observed.

Observations were limited to a few days between 2-4, and 6 August, 1987, because of a passing storm. Generally, there were two study periods each day. The first occurred sometime between 1000-1400H, when observations of habitat use, feeding and social interaction were made. Courtship and spawning behavior were studied during the second time period, 1630-1900H. Supplementary observations were made in September, 1988, and December 1988-July, 1989, commencing one hour prior to sunset. Over 25



Fig. 1. Resting *Synodus dermatogenys* during courtship; the male is positioned parallel to the female, which is buried in the sand (arrow).

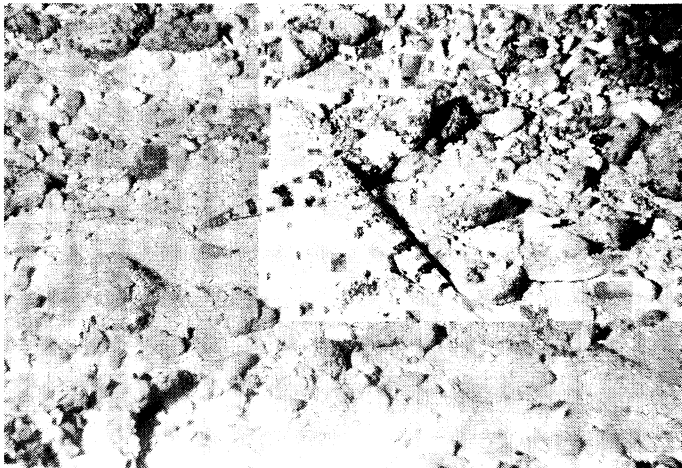


Fig. 2. Nudging of a female *Synodus dermatogenys* by a male (smaller fish) during courtship.

hrs of courtship and spawning behavior were observed.

Observations were made by snorkelling and data were recorded with pencil on plastic slates and Mylar paper, and by underwater still photography. Courtship bout durations were timed with an underwater electronic stop watch. Sunset times were determined from local meteorological tables. Fish body sizes (mm TL) were estimated by measuring the distance between two points on the substratum with a metric rule where a fish was seen. Individuals were recognized by relative body sizes and subtle differences in individual color patterns. Sexes were differentiated by noting obvious swelling of the abdomen in females prior to spawning, and by differences in body size in general.

Results

Behavioral patterns. Ten behavior patterns were observed, nine in courtship and spawning and seven in social interactions between males at the site just prior to the onset of courtship through the conclusion of spawning. Many patterns were observed in both situations and appeared to have more than one function, depending upon the circumstances in which it was displayed. The patterns are described as follows:

1) Flaring-males quickly flared their opercula and hyomandibulars, which were then held extended or puffed-out (see Zaiser and Moyer, 1981, for similar behavior in a congener, *S. ulae*). Males displayed this pattern towards one another at the

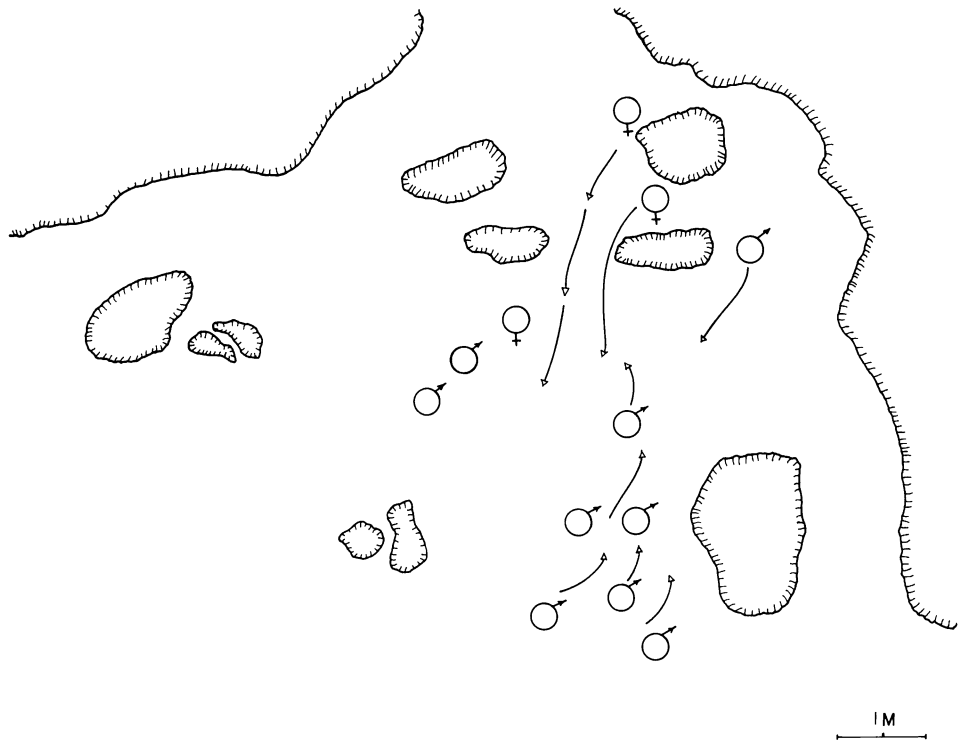


Fig. 3. Courtship and spawning site at Wing Beach, Saipan, at the onset of courtship just prior to sunset. Typically, larger males are positioned within the site, bordered by boulders of dead coral; smaller males are at the periphery. Females arrive at the periphery from the adjacent reef platform soon after. As sunset approaches, males move into the center of the site and intermale-displays begin. Females then move onto the site and intermale displays increase while males also attempt to court females. Arrows indicate paths taken by males and females entering the site from the periphery.

courtship site; males also used this behavior when courting females.

2) Gliding-males swiftly launched themselves into the water column, a few centimeters above the substratum, then swam quickly in a straight line for 2-4 meters before coming to rest in front of a male, or adjacent to a female. Males used this pattern while maneuvering around the site when confronting other males, or when following females.

3) Lateral display-males positioned their bodies parallel or perpendicular to other males or females. During aggressive interactions, males often raised their dorsal fins. During courtship, males remained motionless, although shaking of the body was evident as courtship progressed.

4) Rushing-males rapidly swam at other resting males close by, often chasing them to the edges of the site.

5) Circling-males swam in a circular pattern

around resting females, usually coming to rest adjacent to them.

6) Resting-males rested on the substratum, adjacent to males or females, while females usually rested by themselves. Females often buried themselves in the sand, with only their eyes and mouths protruding, even when attended by a courting male (Fig. 1). This pattern was frequently observed during lulls in aggressive and courtship displays, and just prior to the onset of spawning.

7) Nudging-during courtship, males pressed their snouts against the female's flank, head, and caudal peduncle, while resting parallel or perpendicular to them (Fig. 2). Males also nudged other males during aggressive interactions.

8) Mounting-males rested their heads on top of other males, usually at right angles, during social interaction, or on the head, flank or caudal peduncle of resting females, during courtship.



Fig. 4. Male (right) and female (left) in pre-ascension position prior to spawning. The female's swollen abdomen is clearly visible.

9) Dipping-prior to the spawning ascent, females raised and lowered themselves briefly by flexing their pelvic fins repeatedly against the substratum.

10) Spawning ascent-females rapidly "jumped" above the substratum from a pre-ascension resting position and then rose 0.5–1.5 m up into the water column, followed closely by a male, before turning at the apex of the rise. Gametes were expelled at the turn, while both contorted their bodies there for up to two seconds; males held their mouths open during the contortions.

Social interaction and sexual dimorphism. *Synodus dermatogenys* was observed singly on the raised platform during daylight hours, either sitting motionless on coral pavement and rubble, partially buried in the sand, or moving in short glides of 1–3 m between two points. Feeding was observed during this time, principally upon small wrasses (Labridae), damselfishes (Pomacentridae), and hovering juvenile gobies, *Valenciennesa strigatus* (Gobiidae).

Approximately one hour before sunset, males began to move down off the platform to a large hole or depression in the pavement at the edge of the moat (Fig. 3). The substratum there consisted of sand and rubble, as well as rocks and boulders of various sizes. Depths in this hole ranged from 1–1.9 m, depending upon the tide. Males would arrive at this site one or two at a time until about 10 minutes before sunset.

As many as nine males were observed on the site. Their bodies were relatively slender compared to females, and body sizes ranged from 125–200 mm

TL. Only three females were present at the site each evening. Their body sizes were larger, 180–220 mm TL, and their abdomens quite swollen.

Once on the site males waited there, some buried in the sand and others resting upon rocks. Social interactions between males began almost immediately. Larger males rested in the center of the site and engaged in lateral displays, flaring, and chasing of smaller males who entered the center of the site from the edges. Exceptions to these positions occurred when females were present on the fringes of the site; larger males often established themselves adjacent to females then and defended their position against other males. Smaller males often glided between points at the site, rested perpendicular to larger males in lateral displays, and flared, nudged or, less frequently, mounted them. Two or more males were engaged in these interactions when they occurred.

Male-male social interactions occurred prior to courtship, when females were both absent and present on the site, during courtship, when males competed for access to a female, and after spawning.

Courtship and spawning. Females singly entered the site up to a few minutes before sunset. They did not go towards displaying males, but rather occupied individual places on the site and rested, often burying themselves in the sand. As the evening progressed, females at the edges of the site moved towards the center.

Males approached females by gliding, coming to rest parallel or perpendicular to them and resting



Fig. 5. Spawning ascent, with a single female and four males, just prior to the release of gametes.

(Fig. 1). Males would then circle resting females, and nudge (Fig. 2) or mount them. If the female moved to another part of the site, the male would follow by gliding after her. Usually, males had to display, often flaring, towards others attempting to approach the female while he courted her. Courting males often drove off other males attempting courtship with the same female. Alternately, males broke off courtship when females rested motionless and another male would approach and begin displaying.

Table 1. Mean number of *Synodus dermatogenys* males per group spawn at the spawning site at Wing Beach, Saipan.

Date	Number of males		No. of spawns
	Mean	SD	
2-VIII-87	4.6	1.6	8
3-VIII-87	4.8	0.5	4
4-VIII-87	6.5	1.2	8
6-VIII-87	6.0	1.1	6

Table 2. Total number of spawns and attempted spawns (indicated in parentheses) by three female *Synodus dermatogenys* at the spawning site.

Female	Size (mm TL)	Date			
		2-VIII-87	3-VIII-87	4-VIII-87	6-VIII-87
1	220	1	2	3	3
2	200	?	1 (1)	2 (2)	1 (1)
3	180	?	1 (1)	3	2 (1)

Just prior to spawning a single male would come to rest adjacent to a female (Fig. 4). Occasionally, rapid shaking or quivering of his body was observed. The female raised her snout upward off the substratum and began dipping. Suddenly, she began her ascent, closely followed by the male. As the pair rose upward they were joined by up to seven males (Fig. 5). Spawning occurred with the release of a relatively large amount of gametes at the apex of the rise, with all males ascending appearing to participate (Table 1). Males quickly dropped to the substratum, one at a time, leaving only the female and original male in the water column. Once the female's gametes were exuded, the two dropped to the substratum.

Males resumed courtship of both the other females present and the one that had just spawned. Females spawned more than once in a given night (Table 2). The order of spawning among females seemed to favor larger females (Table 3), but more data are needed.

While females initiated the spawning ascent, not all ascents led to spawning (Table 4). In a few instances females would rise quickly into the water column in the presence of males and not under courtship from any single one. She would either be joined by one or more males, and break off the ascent, or she would not be joined at all (Table 5). Spawning success, the ratio of spawns to total attempts (including false spawns), for all females is given in Table 4.

Courtship began between 4–29 minutes before sunset and continued until 23–32 minutes past sunset

during the four nights when multi-male spawning was observed (Table 6); tides were flooding during these periods. Courtship bouts leading to successful spawning ranged from 4–8 each evening (Table 4). The first spawn occurred between 1–14 minutes past sunset; the last 16–19 minutes past sunset (Table 6).

Females left the site within 10 minutes after the last spawning. Males continued to court females after the last spawning until then. Social interactions between males on the site continued until dark.

Supplemental observations. Since the four evenings in which *Synodus dermatogenys* courtship and spawning were observed the study site at Wing Beach suffered heavy wave damage as a consequence of a passing storm. Strong longshore currents effectively scoured the site, removing sand and rubble from much of the area and leaving only coral pavement and boulders. Subsequent observations after the storm failed to detect any members of the lizardfish group that used the site; either the group had dispersed or moved to another suitable site. However, on return visits to Saipan (September and December, 1988; January–July, 1989) 2–3 individuals (males; 140–150 mm TL, female; 170 mm TL) were observed using the original site for courtship. Usually, only a male-female pair was present, and paired spawnings occurred 6–11 minutes past sunset. Occasionally, two males courted the same female but only pair spawnings with the larger of the two were observed.

Discussion

Results indicated that *Synodus dermatogenys* at Wing Beach, Saipan: 1) appeared to be sexually dimorphic for body size; 2) migrated to a specific temporary courtship and spawning site away from their feeding areas; 3) had males which competed for a fewer number of females by social interaction on the site, but did not defend discrete territories; 4) possessed a number of behavioral patterns that had two functions, aggression and courtship, depending upon the situation in which they were used; 5) had males which initiated courtship upon the arrival of females on the site, but females initiated spawning and made multiple spawns; 6) had spawning which was pelagic, began in pairs, but pairs were joined by additional males.

Although some overlap in body sizes existed between sexes, spawning female *S. dermatogenys* were generally larger than males and sexual dimorphism

for body size is indicated. More data are clearly needed. Sexual dimorphism for body size occurs in *S. ulae* and females are generally larger than males (pers. obs.).

Both male and female *S. dermatogenys* spent daylight hours foraging and feeding alone on the outer reef flat, moving down to the courtship and spawning site as sunset approached. Males engaged in aggressive displays with other males, without defending discrete fixed territories (though a “territory” might be mobile, its position determined by the position of a male relative to that of a female), and the intensity of these displays increased as fe-

Table 3. Order of female *Synodus dermatogenys* in spawning and spawning attempts (A) during four days of courtship at the spawning site. Female numbers and sizes (mm TL) are: (1) 220, (2) 200, and (3) 180. ?, order not recorded through spawning observed.

Spawning number	Date			
	2-VIII-87	3-VIII-87	4-VIII-87	6-VIII-87
1	1	1	1	1
2	?	2 (A)	1	1
3	?	2	3	3
4	?	3 (A)	2	2
5	?	1	2	1
6	?	3	1	3 (A)
7	?	—	3	3
8	?	—	3	2 (A)
9	? (A)	—	2 (A)	—
10	? (A)	—	2 (A)	—

Table 4. Spawning success of three female *Synodus dermatogenys* with multi-male participation.

Date	No. attempts	No. spawns	Success rate (%)
2-VIII-87	10	8	80
3-VIII-87	6	4	67
4-VIII-87	10	8	80
6-VIII-87	8	6	75

Table 5. Mean number of male *Synodus dermatogenys* participating in each unsuccessful female spawning attempt. *Female-only attempt.

Date	Number of males		Number of attempts
	Mean	SD	
2-VIII-87	1.0	1.4	2
3-VIII-87	4.5	0.7	2
4-VIII-87	1.0	0.0	2
6-VIII-87	0.0	0.0	2*

males migrated to the site and courtship attempts began. In contrast, *S. ulae* engaged in male-male aggression, though without any apparent territoriality, which appeared to increase in the presence of a female, and courtship during daylight hours through sunset (Zaiser and Moyer, 1981). No migration by *S. ulae* to a specific site from feeding grounds was noted; males and females appeared to interact in the same area where they normally occurred. Subsequent observations of this species at Miyake-jima, Japan indicated that courtship occurs within the same, relatively small, area each night, although at different locations within this area (pers. obs., September–October, 1989).

The mating system of sedentary reef fishes such as *S. dermatogenys* may have evolved from the influence of access to food, potential mates or courtship and spawning sites. This is true of numerous other reef fish species (Robertson and Hoffman, 1977, Moyer and Nakazono, 1978, Moyer and Yogo, 1982; Thresher, 1984; Baird, 1988; etc.). One such system, lekking or lek-like mating behavior, has been identified in certain reef fish species (Loiselle and Barlow, 1978; Sale, 1978; Moyer and Yogo, 1982; Thresher, 1984). Males may realize greater reproductive success by defending temporary territories at favorable spawning sites which allow access to females that migrate their from their feeding areas (Warner, 1984; Hoffman, 1985; Baird, 1988).

Loiselle and Barlow (1978: 32) defined the term lekking as “the temporary aggregation of sexually active males for reproduction.” This definition, and others which utilize the words “lek” and “lek-like” (Moyer and Yogo, 1982; Thresher, 1984) is applied, with some uncertainty, towards fishes and is distinct from the original use of the term in describing an avian mating system (see review in Loiselle and Barlow, 1978). The complexity of lekking behavior among fishes may vary. This behavior can be “highly evolved” for some teleosts (Loiselle and Barlow, 1978: table 2.5), or merely less so for others. The

extent of this evolution may have a phylogenetic basis, or it may simply result from different levels of convergence among various fish groups. The term “lek-like” is used here to describe behavior in *S. dermatogenys* that is at least partially consistent with that behavior described for other fishes where this phenomenon occurs. However, conditions that lead to the evolution of this behavior can vary, as can the components that define it.

Loiselle and Barlow (1978) described certain prerequisites for lek formation and behavior in teleosts. These included reproductive synchrony, existence of a lekking ground, species mobility to travel to the lekking ground, little or no feeding on the lekking ground, and little or no parental care if parental care exists. *Synodus dermatogenys* at Wing Beach appeared to satisfy these minimum prerequisites. Males and females congregated for courtship just prior to sunset at a specific site, having migrated to that site from adjacent feeding grounds, did not appear to feed at the site, and, being pelagic spawning fishes, did not practice parental care.

Characteristics of highly evolved teleost leks described by Loiselle and Barlow (1978) and their applicability to *S. dermatogenys*, based upon the limited observations contained herein, are given in Table 7. While there is agreement between observed *S. dermatogenys* behaviors and some of these characteristics, there are also notable exceptions. One was a lack of clear dominance relationships between central (larger) and non-central (smaller) males. Larger males did appear to congregate and interact in the center of the site while smaller males held to the edges, at least during the formation of the lek and the onset of aggressive and courtship activities. However, as females entered the site, male positions appeared to depend upon the location of females, and smaller males also had access to females. Dominance by larger males, even if successfully courting females, was circumvented by multi-male spawning participation (analogous to “sneaking” or

Table 6. Temporal pattern of *Synodus dermatogenys* courtship and spawning in minutes before (–) or after (+) sunset at the spawning site.

Date	Courtship onset	Spawn no. and time								Courtship end
		1st	2nd	3rd	4th	5th	6th	7th	8th	
2-VIII-87	–13	+11	+11	+12	+13	+14	+15	+18	+19	+32
3-VIII-87	–4	+14	+14	+16	+19	—	—	—	—	+30
4-VIII-87	–6	+7	+7	+12	+13	+16	+16	+17	+17	+27
6-VIII-87	–29	+1	+13	+13	+14	+15	+16	—	—	+23

“stealing”; see Thresher, 1984 for review and discussion) by smaller males. There were other exceptions as well. Cheating by subordinate males was not rare but rather frequent, in a form of group (multi-male) spawning. Larger (central) males did not appear to experience less interference while mating not did they spawn more often; again, smaller (non-central) males interfered by group spawning participation and spawned just as often, even when a larger male had managed to begin a paired ascent with a female. These exceptions are noted with caution, since they are based upon data from 26 spawns during four evenings where lek-like behavior were observed, and thus constitute a limited basis for comparisons with Loiselle and Barlow’s (1978) characteristics. Nevertheless, there are indications that lek-like behavior in *S. dermatogenys*, even if not highly evolved, functions to provide access to potential mates, but this access is not limited by large body size. The lack of discrete temporary territories and the apparent dependence upon female location, which changes as the female moves around the site, to gain access for courtship, and female initiation of spawning ascents, may promote multi-male spawning participation.

Males courted females using ritualized displays, many of which were also in aggressive male-male

interactions at the site. Although there were too little data to provide a detailed analysis of behavior pattern use, this duality may be dependent upon the situation in which a display is given. *Synodus ulae* uses behaviors that have two functions as well, depending upon the situation in which they are given (Zaiser and Moyer, 1981; pers. obs.), and indeed shares similar displays and their functions with *S. dermatogenys*.

Although males initiated courtship and participated in group spawning with single females, the initiation of the spawning ascent was made by the female being courted; I have observed this of *S. ulae* as well. Females made more than one spawning ascent each evening, and each ascent, save for those few which were aborted, resulted in the release of relatively large amounts of eggs. Multiple spawning events by a female in a single night, which effectively parcel eggs into discrete clutches, and are rarely seen in pelagic spawning reef fishes, may be a strategy that evolved to ensure fertilization of as many eggs as possible by exposing them to as many males as are present within a narrow time period, and thus increasing the genetic variability of the progeny (Burt et al., 1988). Alternately, this may be a strategy by which the female ensures that at least some of her eggs are fertilized by a desirable male during multi-

Table 7. Some characteristics of highly-evolved teleost leks (after Loiselle and Barlow, 1978) in relation to lek-like behavior of *Synodus dermatogenys*. For *S. dermatogenys*, central and non-central denote positions at onset of lek-like behavior; central males were larger than non-central males.

Characteristic	<i>Synodus dermatogenys</i>
No feeding on lek	Yes
The more males present, the more females attracted	Yes (limited data)
Reduced aggression and increased displays between males	Ritualized displays usually seen; few chases observed
Well-developed sexual dimorphism	Females with larger body sizes; males slimmer
Clear dominance relationships	Not observed
Largest and oldest males (central males) most dominant	Initially when males arrive at site; later, smaller males circumvent larger males and participate in courtship
Succession to central positions determined by protocol	All males move towards females after females arrive on site
“Cheating” by subordinate males rare	No
Larger males experience less interference while mating	Smaller males participate in spawnings
Central males devote more time to courtship, less to status fights, territorial defense, or in teleosts, anti-predator behavior	Not measured, but non-central males appear to court as often as central males
Females select centrally-positioned males	Not measured, but non-central males able to participate without female-selection
Centrally-positioned males spawn more often	Not measured, but non-centrally positioned males able to participate even if a central male begins the ascent initially

male spawnings. Physiological or morphological constraints, such as the physical inability to release an entire clutch in one spawning, may also lead to multiple spawnings (Bagenal, 1978). Multiple spawnings might also allow eggs to be more widely dispersed, thus potentially reducing predation (Burt et al., 1988).

Three females were present on the site each evening and alternated with each other in making ascents; no two females spawned at the same time, and males courting other females often rushed towards the female making a spawning ascent. The order of spawning each evening may be influenced by female body size. The largest female made her first spawn before the others, and completed spawning before the others as well. Larger females may realize greater reproductive success by spawning earlier, since she can obtain access to unspent males, and avoid potential predators on herself and her potential mates as darkness approaches. Larger females did not appear to spawn more often than smaller females, however, although the fecundities of larger females were expected to be greater.

Synodus dermatogenys may utilize lek-like behavior if population numbers are relatively high within a given area and sex ratios are sufficient to guarantee few females and an excess of males. If population numbers are low, as they were in subsequent observations of courtship and spawning at Wing Beach, and sex ratios are at or approaching unity, paired spawning can occur. Paired spawning occurs in the congener *S. ulae*, though lek-like courtship and group-like spawning have never been observed; lek-like courtship and group spawning behavior may not be limited just to *S. dermatogenys*, but may also occur in *S. ulae*, and other species of *Synodus* as well, providing that individuals of both sexes in a given area are relatively common and females are in excess of male numbers. Variation of spawning systems, such as shifts between pair and group spawning, within the same species, occurs in other fishes, notably the Acanthuridae (see review in Thresher, 1984). Such variability may be dependent upon population density (Barlow, 1974; Loisel and Barlow, 1978; Thresher, 1984).

Another point that must be considered is whether lek-like behavior exists to enhance male attractiveness in a communal setting or if it results merely from the aggregation of males and females at favorable spawning sites, where the site, and not the choice of an attractive male, is of paramount im-

portance (Loiselle and Barlow, 1978; Thresher, 1984). In-depth studies of the social and reproductive behavior of this important genus of reef-dwelling predators are clearly needed.

Acknowledgments

I am grateful to J. T. Moyer and R. F. Myers for useful discussions and G. C. Donaldson (Saipan) and J. T. Moyer (Miyake-jima) for help in the field. The Division of Fish and Wildlife, Commonwealth of the Northern Mariana Islands issued necessary permits. J. F. Fitzsimons kindly proofed the manuscript. D. Aldan executed Fig. 3 from my field notes. The valuable comments of an anonymous referee are greatly appreciated. This study was made possible by the generous support of the Coyupo Foundation, the LSU Museum of Natural Science, and M. C. and S. de C. Wilkins. Additional support for the supplemental portion of this study on Saipan was made possible with funding from the U.S. Fish and Wildlife Service Federal Aid in Sportfish Restoration Program (Project No. CNMI F-2-R-1). This is contribution no. 79 of the Tatsuo Tanaka Memorial Biological Station.

Literature cited

- Bagenal, T. B. 1978. Aspects of fish fecundity. Pages 75-101 in S. D. Gerking, ed. Ecology of freshwater fish production. Blackwell Scientific Publ., Oxford.
- Baird, T. A. 1988. Female and male territoriality and mating system of the sand tilefish, *Malacanthus plumieri*. Env. Biol. Fish., 22: 101-116.
- Barlow, G. W. 1974. Contrasts in social behavior between Central American cichlid fishes and coral-reef surgeonfishes. Amer. Zool., 14: 9-34.
- Burt, A., D. L. Kramer, K. Nakatsuru and C. Spry. 1988. The tempo of reproduction in *Hyphessobrycon pulchripinnis* (Characidae), with a discussion on the biology of 'multiple spawning' fishes. Env. Biol. Fish., 22(1): 15-27.
- Cressey, R. 1981. Revision of the Indo-West Pacific lizardfishes of the genus *Synodus* (Pisces: Synodontidae). Smithson. Contr. Zool., 342: 1-53.
- Hobson, E. S. 1974. Feeding relationships of teleostean fishes on coral reefs in Kona, Hawaii. U.S. Fish. Bull., 72: 915-1031.
- Hoffman, S. G. 1985. Effects of size and sex on the social organization of reef-associated hogfishes, *Bodianus* spp. Env. Biol. Fish., 14: 185-197.
- Loiselle, P. V. and G. W. Barlow. 1978. Do fishes lek like birds? Pages 31-75 in E. S. Reese and F. J. Lighter, eds.

- Contrasts in behavior. Wiley-Interscience, New York.
- Moyer, J. T. and A. Nakazono. 1978. Population structure, reproductive behavior and protogynous hermaphroditism in the angelfish *Centropyge interruptus* at Miyake-jima, Japan. *Japan. J. Ichthyol.*, 25(1): 25-39.
- Moyer, J. T. and Y. Yogo. 1982. The lek-like mating system of *Halichoeres melanochir* (Pisces: Labridae) at Miyake-jima, Japan. *Z. Tierpsychol.*, 60: 209-226.
- Myers, R. F. 1989. Micronesian reef fishes. Coral Graphics, Mangilao, 299 pp., 144 pls.
- Robertson, D. R. and S. G. Hoffman. 1977. The roles of female mate choice and predation in mating systems of some tropical labrid fishes. *Z. Tierpsychol.*, 45: 298-320.
- Sale, P. F. 1978. Reef fishes and other vertebrates: a comparison of social structures. Pages 313-346 in E. S. Reese and F. J. Lighter, eds. *Contrasts in behavior*. Wiley-Interscience, New York.
- Thresher, R. E. 1984. Reproduction in reef fishes. T.F.H. Publ., Neptune City, 399 pp.
- Waples, R. S. and J. E. Randall. 1988. A revision of the Hawaiian lizardfishes of the genus *Synodus*, with descriptions of four new species. *Pacif. Sci.*, 42: 178-213.
- Warner, R. R. 1984. Mating systems and hermaphroditism in coral reef fishes. *Amer. Sci.*, 72: 123-136.
- Zaiser, M. J. and J. T. Moyer. 1981. Notes on the reproductive behavior of the lizardfish *Synodus ulae* at Miyake-jima, Japan. *Japan. J. Ichthyol.*, 28(1): 95-98.

(Received November 4, 1989; accepted May 22, 1990)

ミナミアカエソにおける雄のレック的求愛行動と雌の多回産卵

Terry J. Donaldson

サイパン島においてミナミアカエソ *Synodus dermatogenys* (エソ科) の求愛・産卵行動を観察した。日没前になると、決まった場所に複数の雄が集まり、レック的な求愛行動を示した。雄同士の攻撃行動は雌の到着前から産卵終了後まで続いた。産卵は日没直後に行われ、各雌は一晩に1-3回放卵した。産卵の際には、まずペアが上昇を始め、後に2-7尾の雄が加わってグループで放卵放精した。求愛場所に2個体(雄と雌)しか現われなかった日にのみ、ペア産卵が観察され、その際には雌は一晩に1回しか放卵しなかった。