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Seasonal Occurrence of Milkfish Fry at Tanegashima and Yakushima in Southern Japan

Tetsushi Senta and Akio Hirai

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Abstract Milkfish fry, ranging from 10 to 16 mm TL, commonly occur at Tanegashima and Yakushima Islands from late June to early November. They are especially abundant in July and August. While no clear relationship was observed between lunar and tidal phases and the abundance of fry occurring along the beaches, the fry were much more abundant on days with the wind blowing towards the coast than on days with the wind of other directions. The fry occurred much more abundantly at Kumano, which is located on the east coast of Tanegashima and faces the Kuroshio than at Shimama on the west coast of the island and Miyanoura of Yakushima.

Recent systematic surveys on the geographical occurrence of milkfish *Chanos chanos* (Forsskål) fry in southern Japan by the present authors and their colleagues showed that the fry occur in a considerable abundance in Tanegashima and Yakushima and southwards (Senta et al., 1980).

A study on the seasonal abundance and some other aspects of the occurrence of milkfish fry was conducted at beaches of Tanegashima and Yakushima, islands south of Kyushu, during the summer months of 1978. A total of 7391 fry, 7326 at Tanegashima and 65 at Yakushima, was collected. Supplementary data were also taken in 1979. This paper presents the results.

Materials and methods

In 1977, collections of milkfish fry were conducted at Kumano and Shimama on Tanegashima and Miyanoura on Yakushima for one day each at the end of August, yielding 14, 6 and 41 fry, respectively (Senta et al., 1980). Shimama is strategically situated midway between Kumano and Miyanoura (Fig. 1). For this reason, Shimama was first chosen as the main study site for 1978 where daily collections of milkfish fry were to be conducted during the possible fry season, June to September. Kumano and Miyanoura were allocated to reference sites where collections were to be made once every ten days or two weeks. The 1978 collection started on June 21 at Miyanoura, June 22 at Kumano and June 23 at Shimama. By the end of July, it had become evident that milkfish fry were by far more abundant at Kumano than at Shimama. Thereafter, collections were made every other day alternately at Kumano and Shimama until September 19. Altogether, 44 days of collection were made at Shimama, 25 days at Kumano, and 5 days at Miyanoura.

Two kinds of gear, a push net and a seine, were used for collecting milkfish fry. The push net was made of synthetic fibre of 1 mm mesh size and equilateral triangular in shape, the base being 1.8 m long and the lateral sides 2.3 m long, to the latter are attached two crossed bamboo poles, each about 2.7 m long. The net was made so as to have a slack of 30 cm deep at the apex which would serve as a cod-end. This net was pushed forward by an operator for a distance of about 50 m in waters of from knee-depth to breast-depth along the coast. The seine was a square net, 5 by 1.3 m, made of the same material as the push net. Two persons, each handling a pole fitted to each wing of the net, towed it in the same manner as with the push net. The push net was mainly used in the collection, while the seine was only used on 3 days at Shimama, 5 days at Kumano and 1 day at Miyanoura. In calculation of the number of fry per haul, the actual number of milkfish fry caught with the seine was divided by 2.8 so that such data be comparable with those obtained with the push net.

From the nature of the gear, the operation sites were restricted to shallow, gently sloping, sandy beaches. On a few occasions, strong winds and rough waves made the collections im-

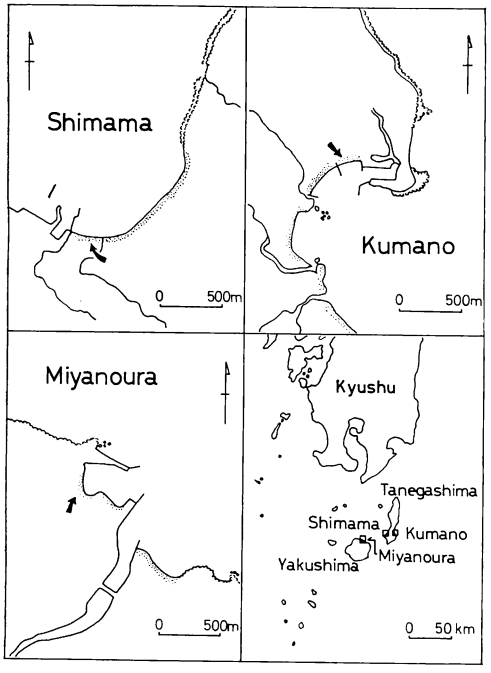

Fig. 1. Chart showing the shorelines at Shimama and Kumano of Tanegashima and Miyanoura of Yakushima. Thick arrows show the sites where collections of milkfish fry were made.

possible. As a rule, operations were repeated eight times each day at around high tide. On August 11, 13, 15 and 21, four operations were made every hour for 10 hours at Kumano in order to establish the tidal periodicity in fry occurrence.

The samples collected were immediately preserved in 10% seawater formalin, and later sorted for milkfish fry in the laboratory. The total length of about a half of the specimens collected was measured to the nearest 0.1 mm. A part of the specimens was dyed with alizarin-red for counting the vertebral number in the same way as Senta and Kumagai (1977).

In 1979, the senior author and/or some of his students visited Kumano several times and operated the seine to collect the fry for the purpose of rearing experiments. The data thus obtained were also utilized to supplement the 1978 data.

Results

Seasonal abundance. Fig. 2 illustrates the daily catch per haul of milkfish fry at Shimama, Kumano and Miyanoura in 1978. One fry each (not per haul but in total) was collected on the first day of collection, June 21 ~ 23, at all the three places.

The number of milkfish fry occurring at Shimama was very few until July 1. From July 3, the fry increased in number, reaching the maximum number, 20.4 per haul, on July 5, and were rather abundant until July 10. Then the fry decreased in number. Although occurrence of the fry was thereafter observed through the whole study period, until September 19, the number of fry per haul was mostly smaller than one, except for a small peak around August 20.

No collection was made at Kumano during the first half of July. On July 17, the number of fry per haul was as large as 76.6, and a better catch, 78.8, was obtained on July 27. After poor catches during August 3 to 6, the number of fry per haul increased again, and fluctuated between 9.9 and 35.6 until September 1. Then the fry became very few, but continued to occur until the last day of operation, September 17. The actual maximum number of fry collected by a single haul at Kumano during the study period was 224 with the push net on July 17 and 701 with the seine on July 27.

At Miyanoura, operations were made only on five days, and the data are too poor to know the seasonal abundance of fry. The number of fry per haul was almost at the same level as that at Shimama on comparative days.

Table 1 shows the collection record of milkfish fry at Kumano in 1979. This year, the main purpose was to collect fry alive to use for a rearing experiment and experimental studies on larval ecology. Each haul covering a distance of about 50 m took on the average 10 to 15 minutes, including the time to sort out the fry alive. The number of fry was small in early July, and considerably larger in late July and early September. A fry was even caught as late as on November 8, when the water temperature was 21.6°C.

Lunar and tidal periodicities. Good catches were generally obtained at spring tides at Shimama, but at neap tides at Kumano. No clear relationship between the fry abundance and the lunar phase was seen (Fig. 2).

Fig. 3 illustrates the results of hourly collec-

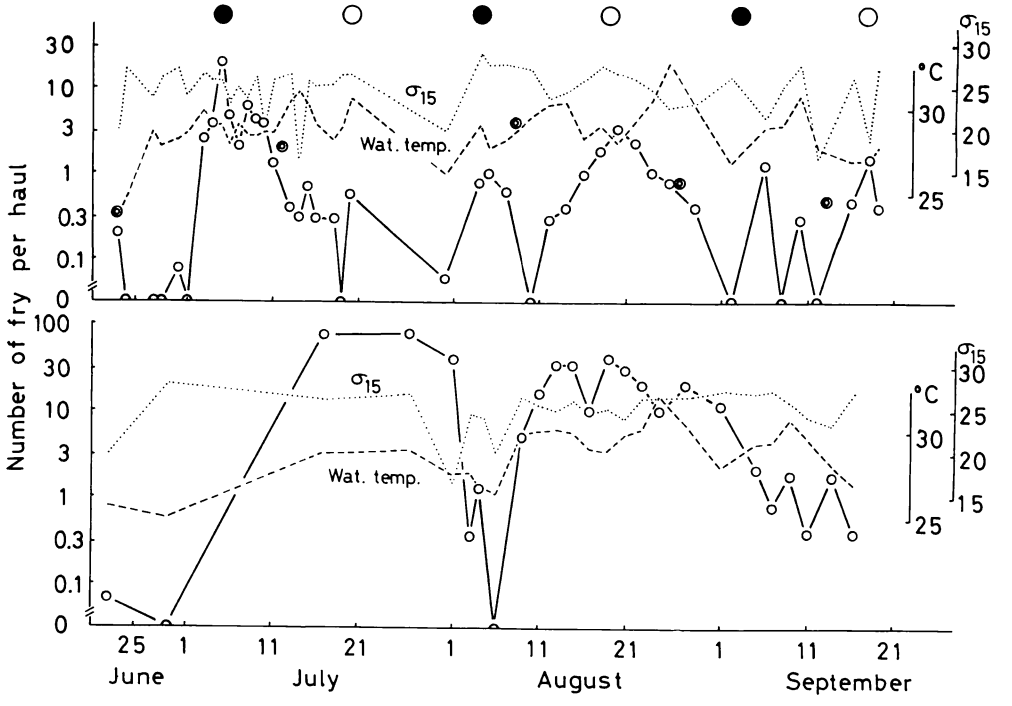

Fig. 2. Daily catches of milkfish fry at Shimama (top), Kumano (bottom) and Miyanoura (top, double circles) in 1978. Most collections were made by pushing forward a triangular net, 1.8 m long along anterior edge, for a distance of 50 m along the coast line. A few collections were made with a seine, 5 m long, when the catch was divided by 2.8. Solid and open circles at the top represent new and full moons, respectively.

Table 1. Collection record of milkfish fry with a seine, 1.3 by 5.0 m, at Kumano, Tanegashima in 1979.

Date	Total hours operated	Number of fry collected	Number of fry per hour	Range of w. t. (°C)
July 4~ 6	9.1	54	5.9	24.0~24.5
July 26~30	15.8	677	42.8	28.8~31.9
Sept. 4~ 6	8.8	259	29.4	25.2~28.2
Nov. 8	1.0	1	1.0	21.6

tions on four days in August 1978 at Kumano. On two days, the maximum catch was obtained at high tide, but the opposite was the case on the remaining two days.

Effect of wind. Wind direction was recorded using eight points of the compass on every operation day at Shimama and Kumano. The number of fry per haul by direction of wind is shown in Table 2. The best catch of fry at Shimama was observed when the wind blew from the northwest, while the catch was poor when the wind came from other directions. A marked contrast to this is that at Kumano good catches accompanied easterly, southeasterly and southerly winds, and poor catches with winds of the opposite directions. In short, milkfish fry at both Shimama and Kumano were more abundant on days when the wind blew from the sea, and vice versa (Fig. 1).

Comparison of fry abundance between three locations. From Fig. 2 and Table 2, it is obvious that the fry were much more abundant at

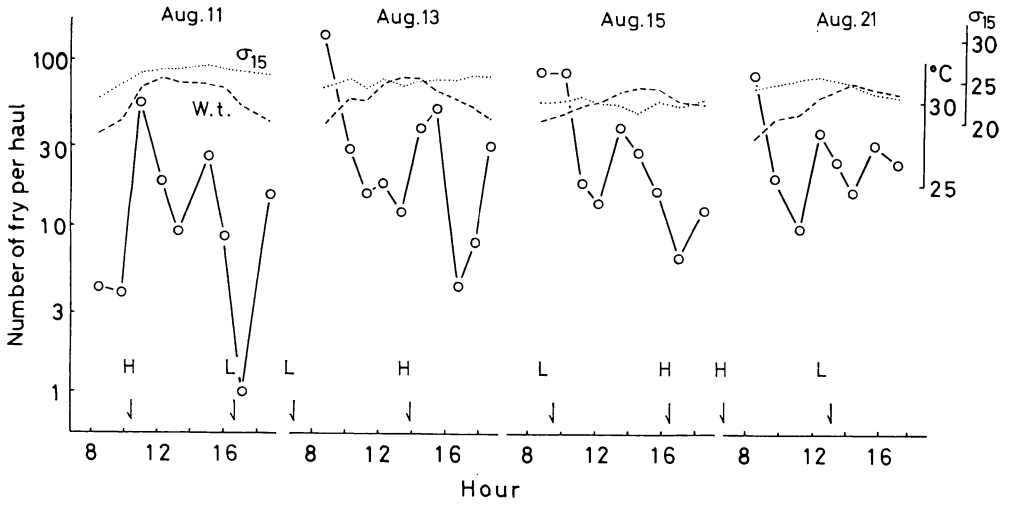

Fig. 3. Hourly catches of milkfish fry with a push net at Kumano on four days in August 1978. H and L indicate high and low tides, respectively.

Table 2. Occurrence of milkfish fry in relation to wind directions at Shimama and Kumano, June 22 to September 19, 1978.

A. Shimama

Direction of wind	N	NE	E	SE	S	SW	W	NW	No wind
Number of days operated	1	3	8	10	6	6	0	8	2
Number of hauls*	8	18	60	86	70	52	0	63	15
Number of fry caught	10	3	82	65	23	55	0	313	5
Number of fry per haul	1.25	0.17	1.37	0.76	0.33	1.06	—	4.97	0.33

B. Kumano

Directions of wind	N	NE	E	SE	S	SW	W	NW	No wind
Number of days operated	0	0	3	12	4	2	2	1	1
Number of hauls*	0	0	24	188	47	24	42	8	8
Number of fry caught	0	0	724	5223	742	18	54	6	3
Number of fry per haul	—	—	30.17	27.78	15.79	0.75	1.29	0.75	0.38

* Number of hauls with the seine was multiplied by 2.8, and the fishing effort in this table is shown in terms of the number of hauls with the push net.

Kumano than at the other two locations. The overall average number of fry per haul was 19.85 at Kumano, 1.49 at Shimama, and 1.48 at Miyanoura.

Temperature and salinity where the fry occurred. The water temperatures and salinities (in terms of σ_{15}) at any positive operation are added to Figs. 2 and 3 and Table 1. Almost no relation was seen between the abundance of fry and either temperatures or salinities, so far as observed.

Size of the specimens. Size frequencies of the specimens collected during each ten-day unit of the months, June to September 1978, are illustratedin Fig. 4. Total length of the fry ranged from 10.3 to 16.2 mm. The mode in total length almost always occurred either at 13.5～14.0 mm or 13.0～13.5 mm, at both Shimama and Kumano and regardless of season.

Vertebral number. The vertebral number was determined for a total of 1810 fry. The counts ranged from 42 to 45, and fish with 43 and 44 vertebrae accounted for 55.8% and 41.5%, respectively. The mean vertebral count

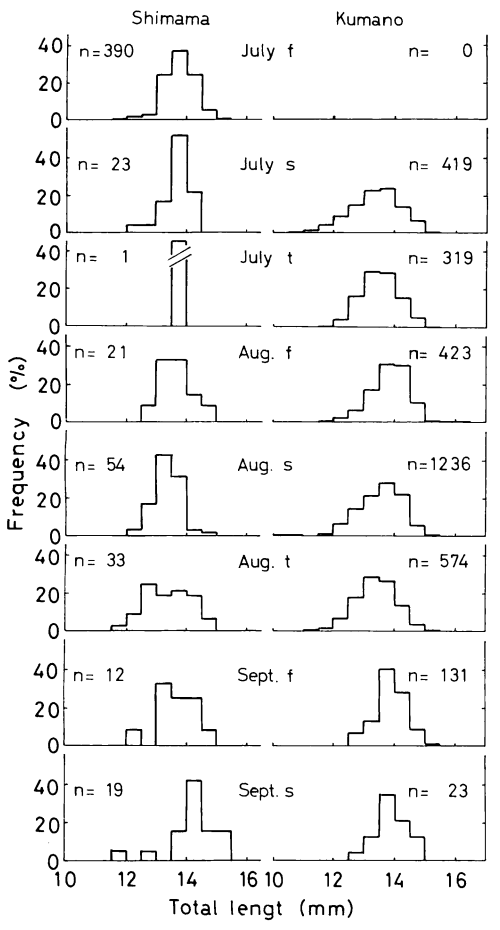

Fig. 4. Total length composition of milkfish fry collected at Shimama and Kumano in 1978. f, s, t: the first, second, and third ten-days.

and its 95% confidence limits were 43.408± 0.025.

Discussion

Before the study by the present authors (Senta et al., 1980), records of only three individuals of milkfish fry had been known from the waters of southern Japan. One of them was collected by Yoshida (1933) at a fishing port of Tomari, about 50 nautical miles northwest of Tanegashima, in June 1932. He considered that the occurrence of the fry might be an accidental incident related to a record-breaking abundance of milkfish fry in Taiwan waters in that year.

According to the Nagasaki Marine Observatory (1977～1979), the volume transport of the Kuroshio along the section between PN-1 (Lat. 27°30′N, Long. 128°15′E) and PN-4 (Lat. 28°25′N, Long. 126°54′E) in April～May and July～August was calculated as 34.9 and 25.5 Sv. (sverdrup=$10^6 m^3$/sec). in 1977, 22.3 and 21.2 Sv. in 1978, and 24.3 and 22.2 Sv. in 1979, respectively. Based on quarterly observations since 1955, Dr. Hideo Akamatsu of that observatory (personal communication) considers that the long term mean of the volume transport of the Kuroshio along the above-mentioned section is about 20 Sv. Therefore, we may say that 1978 and 1979 were average years regarding the strength of the Kuroshio, and that the occurrence of milkfish fry, often in a large number, at Tanegashima is not an extraordinary phenomenon associated with any unusual strength of the warm current.

In the present study the milkfish fry were collected in Tanegashima during the period from late June to early November, with the peak in July and August. Although no collection was made either in and before May or in December, it is least likely that milkfish fry occur in those months, because the surface water temperature is usually below 23°C in May and December even at the central part of the Straits of Osumi (Takeshita, 1958), and must be much lower along the beaches.

The fry season of milkfish in Taiwan extends from March or April to August or September with a peak falling in April to June (Miyagami, 1921; Chen, 1976), which is almost the same as that in central and northern Luzon (Librero et al., 1976). The start of the fry season and its peak in Tanegashima and possibly also in Yakushima are two or three months later than at the above-mentioned islands. It is interesting to notice that the peak of fry occurrence at Nha Trang, southeast coast of Vietnam, falls in the same months, July to September, as in Tanegashima, although at Nha Trang milkfish fry start to appear early in April (Kuronuma and Yamashita, 1962).

The association of good catches of milkfish fry with full and new moons has been observed in many countries (Miyagami, 1922; Schuster, 1952, 1960; Thiemmedh, 1955; Htin, 1969; Ramanathan, 1969; Prabhakara Rao, 1970; Schmittou, 1977), but this was not clear in the present study.

Herre and Mendoza (1929) and most of the above-named authors consider that milkfish fry come in with advancing tide and catches are good at high tidal levels, but again this kind of tidal periodicity was not observed at Kumano. This difference may be partly due to the differences in the nature of study sites and collecting methods. Collections at Kumano were made along a beach having no large rivers in the vicinity and with a seine or a push net, while the study sites of the above-named authors were often tidal creeks, estuaries or tidal lakes and, besides seines and push nets, stationary nets (called "saplad" in the Philippines; for details, see Bunag, 1957) set inside the mouth of rivers were also used to catch incoming milkfish fry.

According to Schuster (1960), most fishermen in Java consider that catches are good when the direction of wind is parallel to the coast and they are markedly low when the wind blows straight to or from the coast. On the other hand, Thiemmedh (1955), Kuronuma and Yamashita (1962) and Schmittou (1977) noted that winds blowing toward shore favor fry collecting more than winds in other directions. This agrees with the results of the present study.

The fry were much more abundant at Kumano than at Shimama and Miyanoura. A stronger influence of the Kuroshio must favor the occurrence of fry at Kumano. The Kuroshio flows northward just off the east coast of Tanegashima.

With a mode at 13.0～14.0 mm TL, milkfish fry occurring at Tanegashima and Yakushima are the same size as those occurring in tropical Indo-Pacific waters (Delsman, 1926, 1929～30; Schuster, 1952; Rabanal et al., 1953; Htin, 1969; Prabhakara Rao, 1970; Chen, 1976; Kumagai et al., 1976; Liao et al., 1977). Experiments on larval rearing by Liao et al. (1979) showed that milkfish larvae grew to the size of 13.5 mm TL by 20 days after hatching. The age of fry occurring at Tanegashima could be about three weeks.

The mean vertebral count of the fry at Tanegashima showed no statistically significant difference from counts of the fry collected in Taiwan, the Philippines and Indonesia (Senta and Kumagai, 1977).

We must look to future studies to know where the fry occurring at these islands have been spawned.

Acknowledgments

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(TS: Nagasaki University Nomo Fisheries Station, Nomozaki, Nagasaki-ken 851-05, Japan; AH: Tokyo Kyuei Technology Center, Shiba Tsurugamaru, Kawaguchi 332, Japan)

種子島・屋久島におけるサバヒー仔魚出現の季節変化

千田哲資・平井明夫

1978年6月下旬～9月中旬に種子島西岸の島間，同東岸の熊野，及び屋久島宮之浦の砂浜海岸の波打際近くで，前端の幅1.8mの三角形の押網，または幅5m，丈1.3mの長方形の曳網を使って採集を繰り返し，総計7391尾のサバヒー仔魚を得た．仔魚は全研究期間を通じて出現し，盛期は7～8月であった．海岸線に平行に50mの距離を押し，または曳いた1回の操業で得られた仔魚数の最高は，押網による224尾，曳網による701尾であった．他の目的をもった熊野における1979年の研究では，11月上旬にも1尾の仔魚が採集された．東シナ海での流量観測の結果によると，1978，1979年の黒潮流量は長年平均流量を僅かに上廻る程度で，これら両年に限ってサバヒー仔魚が種子島・屋久島に特に多く出現したと考えねばならぬ根拠はない．採集された仔魚の全長範囲は10.3～16.2mm，モード13.0～14.0mmで，熱帯各地の海岸で養殖用種苗として採捕されている仔魚と同じ大きさである．海から岸に向かって風の吹く日には，そうでない日よりも多くの仔魚が採集された．しかし，仔魚の出現と潮候・潮時との関係は明瞭でなかった．熊野における仔魚出現量は島間，宮之浦のそれに比べてかなり多く，これは熊野の海岸が黒潮の影響をより強く受けるためと思われる．

(千田：851-05　長崎県西彼杵郡野母崎町　長崎大学水産実験所；平井：332 川口市芝鶴ケ丸　東京久栄技術センター)