

Geographical Occurrence of Milkfish, *Chanos chanos* (FORSSKÅL) Fry in Southern Japan

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A total of 216 milkfish fry was collected with a small seine along sandy beaches of 31 places in southern Japan ranging from Okinawa to the Goto Islands and Wakayama Prefecture in summer months of 1977-1979. They were considerably abundant in Tanegashima and Yakushima and southwards. They were also caught using a light, though few in number. Water temperature and density of water of the locations at which any milkfish larvae were found ranged from 24.0 to 33.2°C and from 1.17 to 26.96 σ_{15} , respectively. They showed the same size composition as those known for the fry collected in tropical and subtropical Asian countries. The mean vertebral count in them had no statistically significant difference from those for the fry collected in Taiwan, the Philippines and Indonesia. Problems regarding the spawning grounds for the fry occurring in Japanese waters and their fate in winter remain unknown.

Only three individuals of milkfish fry have ever been collected in the waters of southern Japan: the first specimen, 14.0 mm TL, at Koniya, Amami Oshima in July 1927 (Yoshida, 1932); the second, 14.7 mm TL, at a fishing port of Tomari, Kagoshima Prefecture in June 1932 (Yoshida, 1933); and the third, 14.0 mm TL, at Lat. 32° 38.5' N and Long. 128° 24.8' E, about 10 nautical miles west of Fukue island, in September 1956 (Senta, 1956).

Recently, occurrence of young milkfish has been observed in two fish ponds in Kagoshima Prefecture; an eel pond at Jucho, Ibusuki City and a prawn pond at Minamibeppu, Chiran Town (Senta and Hirai, 1980a). These fish were considered to have strayed into the ponds as fry in the preceding summer. A juvenile milkfish, 51.5 mm FL. was also collected in a small

tide pool at Ugui coast, Wakayama Prefecture (Senta and Hirai, op. cit.). These facts suggested that milkfish fry might occur much more commonly and abundantly in the waters of southern Japan than one might expect.

A systematic survey on geographical occurrence of milkfish fry in southern Japan was carried out in the summer months of 1977, 1978 and 1979. A total of 240 milkfish fry was collected at 31 places, ranging from Okinawa in the south to the Goto Islands and Wakayama Prefecture in the north. This paper summarizes the results of the survey.

A study on seasonal occurrence of milkfish fry in islands of Tanegashima and Yakushima was also made in the summer of 1978, yielding about 7300 fry. The result of this study will appear in a separate

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paper (Senta and Hirai, 1980b).

Materials and Methods

Sandy beaches of 55 places distributed from Okinawa to Hirado island on the East China Sea side and Kii Peninsula on the Pacific coast were visited during the study period, June to September of 1977, 1978 and 1979 (Fig. 1). Most of the places were

surveyed once, while several places were visited twice or more. Some of the locations illustrated in Fig. 1 consisted of two or three sub-locations which were several hundred meters away from each other.

Collections were mostly made with a simple, rectangular seine, 5 by 1.3 m with a mesh size of 1 mm. Two persons, each handling a pole fitted to each wing of the net, waded in the sea of from a knee-depth

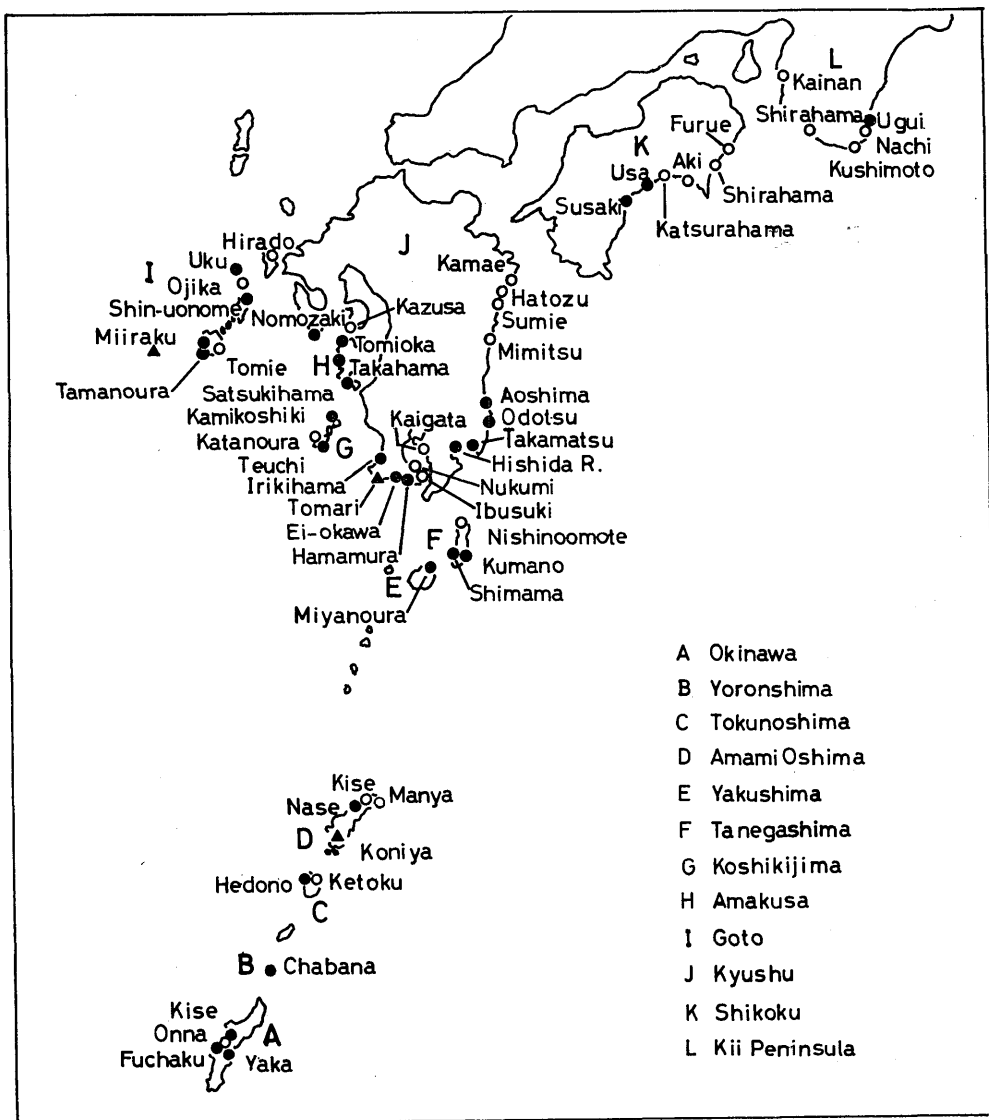


Fig. 1. A map showing the collection sites of milkfish fry in 1977, 1978 and 1979. Solid and open dots indicate the places where the fry were caught and not caught, respectively. Triangles show the three locations where the collection of the fry has been reported in the past.

to a breast-depth along the coast for a distance of about 50 m. Larval and juvenile fish sample thus collected was preserved in 5 % seawater formalin. This was repeated five times at each collection site. From the nature of the gear, the operation sites were restricted to shallow, gently sloping, sandy shores. The surface water temperature at each collection site was determined with a mercury thermometer, and the density of the water with an Akanuma type hydrometer. The number of milkfish fry collected was recorded for each haul. The total length of all the milkfish specimens except for nine which were used for rearing experiments was measured to the nearest 0.1 mm. For some specimens the vertebral number was counted after a treatment with alizalin red. On few occasions, a kerosene lamp or an underwater fish lamp was used to collect milkfish fry.

Results

Geographical occurrence. Milkfish fry were found in a wide range of locations; from Okinawa in the south to Ukujima, the northernmost island of the Goto Islands and Ugui, Wakayama Prefecture in the north (Fig. 1, Table 1). The largest number, 72 fry or 14.4 fry per haul, was obtained at Chabana, Yoron island, followed by 41 fry or 8.2 fry per haul at Miyanoura, Yakushima island. In northern half of the locations surveyed, the average number of fry per haul seldom exceeded unity.

No milkfish fry was obtained either from the Goto Islands or from the coast of Shikoku in 1977, while in 1978 they occurred at almost all the locations visited, although few in number. In these waters no survey was made in 1979.

Collection with a light. A kerosene lamp

was used to attract milkfish fry at a breakwater in Chabana, Yoron island in the evening of July 29, 1977. Seven milkfish fry were collected (Table 2). The kerosene lamp was also used on four other occasions, but yielded no fry.

During the summer months of 1978 and 1979, collections of juvenile fishes attracted to a 2000-watt underwater lamp hung at about 50 cm below the water surface were made in Nomo Bay, Nomozaki. A total of 17 milkfish fry were caught (Table 2).

Occurrence of fry in relation to water temperature and density. The surface water temperature observed at each collection site ranged from 24.0 to 33.2°C. Milkfish fry occurred at any temperatures observed, with the frequent occurrence between 27.0 and 30.0°C (Tables 1, 2).

The fry were found at any density of water observed during the study period, 1.17–26.96 σ_{15} . The lowest density, at which two fry were collected, was observed at the mouth of the Hishida River flowing into Shibushi Bay, Kagoshima Prefecture on August 29, 1978. The collection was made at the low tide, when the river was almost separated from the sea by a sand bar.

Size of fry collected. The size composition of the fry collected during the study period is shown in Fig. 2. Total length of the fry ranged from 10.9 to 16.1 mm, with the mode at 13.5–14.0 mm.

Vertebral number. The vertebral number was determined for 136 fry out of 240 fry collected. The counts ranged from 42 to 45, and fish with 43 and 44 vertebrae accounted for 51.5 and 43.4 % of total, respectively. The mean vertebral count and its 95 % confidence limits were 43.426 \pm 0.100.

Table 1. Collection records of milkfish fry with a small seine in southern Japan in 1977, 1978 and 1979.

Location	Date			No. of fry collected	Surface water	
	d	mn	y		temp °C	σ_{15}
Fuchaku, Okinawa	26	7	77	1	28.7	-
Yaka, Okinawa	26	7	77	13	29.3	23.14
Kise, Okinawa	25	7	77	2	29.3	-
Chabana, Yoron	29	7	77	72	29.6	25.83
Hedono, Tokunoshima	31	7	77	3	27.9	25.05
Nase, Amami Oshima	3	8	77	3	30.0	25.43
Miyanoura, Yakushima	27	8	77	41	28.7	24.84
Kumano, Tanegashima	26	8	77	14	27.2	26.02
Shimama, Tanegashima	27	8	77	6	27.5	23.48
Hamamura, Kagoshima	18	8	77	3	29.2	25.23
Eiokawa, Kagoshima	24	7	78	1	28.2	18.40
Irikihama, Kagoshima	18	8	77	3	30.3	25.50
Hishidagawa, Kagoshima	29	8	77	2	24.0	1.17
Teuchi, Koshikijima	30	8	77	2	29.3	24.90
Nakakoshiki, Koshikijima	19	7	78	1	28.3	25.53
" , "	20	7	78	2	28.7	25.95
Eishi, Koshikijima	19	7	78	2	33.2	24.30
" , "	20	7	78	1	29.4	25.53
Takamatsu, Miyazaki	29	8	77	2	28.3	25.33
" , "	25	7	78	5	29.6	25.92
Odozu, Miyazaki	10	8	79	1	27.8	25.71
Aoshima Miyazaki	10	8	79	1	26.6	23.04
Satsukiura, Amakusa	29	8	79	1	29.4	25.04
Takahama, Amakusa	29	8	79	11	27.1	22.91
Tomioka, Amakusa	28	8	79	1	27.4	24.65
Akase, Nomozaki	4	9	78	2	27.4	25.65
Wakimisaki, Nomozaki	15	8	78	1	29.2	25.58
Tamanoura, Goto	10	8	78	1	27.4	25.68
Miiraku, Goto	9	8	78	1	29.9	19.90
Shin-uonome, Goto	11	8	78	5	29.0	26.10
Ukujima, Goto	8	8	78	2	27.4	23.54
Susaki, Kochi	25	8	78	3	28.9	16.10
Usa, Kochi	25	8	78	3	28.6	22.37
Ugui, Wakayama	30	8	79	4	24.5	16.24

Discussion

Milkfish fry were widely found in the shallow waters close to the waterline of from Okinawa through the Satsunan Islands to the Goto Islands and the Pacific coast of Kii Peninsula. A considerable number of fry was obtained at Chabana of Yoron island, Miyanoura of Yakushima island, and

Kumano of Tanegashima island. The high incidence of occurrence of milkfish fry along the beaches during this study makes a remarkable contrast with the results of larval net collections made during the Cooperative Survey for Exploitation of the Warm Tsushima Current organized by the Fisheries Agency, with 26 research organizations as participants. According to Uchida

Table 2. Collection records of milkfish fry attracted to a light.

Location	Date			No. of fry collected	Surface water	
	d	mn	y		temp °C	σ_{15}
Chabana, Yoron*	29	7	77	7	-	-
Nomo Bay, Nomozaki**	22	8	78	5	28.7	25.32
" , "	23	8	78	1	-	-
" , "	4	9	78	2	28.0	25.40
" , "	5	9	78	1	27.9	25.65
" , "	18	7	79	1	28.2	21.52
" , "	20	7	79	1	28.0	21.52
" , "	26	7	79	1	27.9	21.72
" , "	27	8	79	3	26.9	21.49
" , "	7	9	79	1	26.4	22.47
" , "	11	9	79	1	-	-

* A kerosene lamp was used.

** An underwater lamp was used.

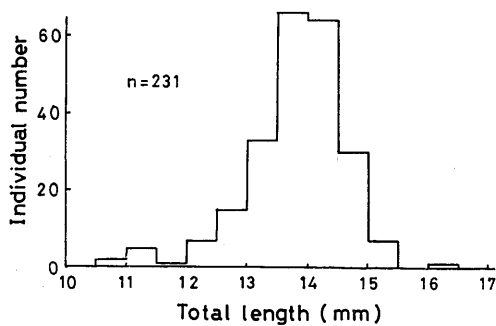


Fig. 2. Size composition of milkfish fry collected in southern Japan.

and Dotsu (1958), more than 8200 horizontal surface hauls with a larval net were made during the years from 1952 to 1956. It is considered that about one-fifth of the above hauls were made in the waters around the Ryukyu and Satsunan Islands or west of Kyushu and in the summer months. No milkfish fry was found in the plankton samples thus collected, except for a single specimen caught at the sea about 10 nautical miles west of Fukue island as stated earlier in the introduction. According to the authors' experience in the Philippines, milkfish fry were very seldom collected with a larval net even in the waters not far off the beaches where a lot of milkfish

fry were being caught by local fry collectors. It is sure that the population density of milkfish fry is much higher along the beach than in offshore waters. It may be possible that the fry tend to gather along the beach attracted by some factors prevailing there, e.g. higher turbidity of water.

The northern limits of occurrence of milkfish fry in Japan must be subject to the influence of the warm currents, the Kuroshio and Tsushima Current. In the years when the warm currents are strong, the northern limits must extend further north, and vice versa.

Although milkfish fry were attracted to the light, the number of fry gathered was never big. This may be mainly due to the fact that the density of the fry in the surrounding waters was low.

Although the lowest temperature at which any milkfish fry occurred was 24.0°C, most of the fry were collected at temperatures higher than 27.0°C. This agrees with the temperature threshold of 27°C to the appearance and disappearance of milkfish fry in the Vietnamese coasts (Kuronuma and Yamashita, 1962). It seems that the salinity

of the water has no effect on the occurrence of the fry.

The size composition of the fry collected during this study was almost the same as those of Taiwan (Liao, et al, 1977), the Philippines (Rabanal, et al, 1952; Kumagai et al, 1976), Vietnam (Kuronuma and Yamashita, 1962), Burma (Htin, 1969), and India (Rao, 1970). It is likely that the nature in milkfish of crowding along the beach arises at a total length of from 10 to 11 mm TL and lasts until the fish reaches 15 to 16 mm TL, when they change either their habitat or their behavior and are no more collected with ordinary fry collecting gears.

Based on mean vertebral counts in milkfish, Senta and Kumagai (1977) suggested the existence of at least four subpopulations among the fish throughout the tropical Indo-Pacific waters. So far as the mean vertebral count concerns, milkfish fry occurring in the Japanese waters belong to the same group as "Indonesian-Philippine (including Taiwan)" group.

There are two important questions to be answered, the origin of the fry occurring in the Japanese waters, and their fate.

Spawning grounds of milkfish have so far been proved through collections of eggs from the sea only in the waters of Indonesia (Delsman, 1926 and 1929), India (Jacob and Krishnamoorthi, 1948; Chacko, 1960) and the Philippines (Senta, et al, 1980). Although Lin (1968) supposed that "the fish... haunt the coastal waters of Taiwan and go as far north as South Japan for the purpose of feeding and spawning", he seems to have no direct evidence.

Yoshida (1933) and Kafuku (1975) consider that the milkfish fry occurring along Taiwan have their origin in eggs spawned in the Philippine waters, with the hatched and growing larvae being carried northward

by the Kuroshio. If this is true, the fry collected in the Japanese waters must also have been derived from eggs in the Philippine waters. Assuming that the fry are carried by the Kuroshio at a mean velocity of 3 knots, it takes about 12 days to reach from Luzon island to Tanegashima along the shortest distance, 840 nautical miles. As it takes about four weeks to develop from eggs to the fry size (Vanstone, et al, 1977), it is possible for milkfish larvae born in the Philippine waters to arrive in Tanegashima waters before they grow to the fry size. However, the possibility that the fish also spawn around the Ryukyu Islands or the Satsunan Islands can not be completely eliminated because of the following facts: A fry as small as 10.9 mm TL was collected; the size composition of the fry occurring in southern Japan is the same as those known in tropical waters; the fry occur in Tanegashima waters and south of it with rather high incidence and in a considerable number.

A juvenile milkfish was found in a tide pool at Ugui coast of Kii Peninsula in August, and frequent collections of young milkfish have been reported from Lake Hamana in October and November (Senta and Hirai, 1980a). These indicate that at least some part of the fry drifted to Japanese waters survive and grow there through summer. What will happen, however, when the water temperature falls in winter? Are they killed by a low temperature like as many other tropical forms drifted to Japan during summer (Nishimura, 1973), or do they migrate back to the warmer waters? The authors presently have no precise answer for the question. A dead milkfish, 171.4 mm SL, was once found stranded on Miho beach, Shizuoka Prefecture in early December (Senta and Hirai,

1980a). This may suggest the fate of at least some of the fry.

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Literature Cited

- Chacko, P. I. (1950). Marine plankton from waters around Krusadai Island. *Proc. Ind. Acad. Sci.*, 31, 162-174.
- Delsman, H. C. (1926). Fish eggs and larvae from the Java Sea. 10. On a few larvae of empang fish. *Treubia*, 8, 400-412.
- Delsman, H. C. (1929). Fish eggs and larvae from the Java Sea. 13. *Chanos chanos* (Forsk.). *Treubia*, 11, 281-286.
- Htin, W. (1969). On the occurrence of milkfish *Chanos chanos* (Forsk.) in Burmese waters. *J. Life Sci.*, 2, 271-275.
- Jacob, P. K. and Krishnamoorthi, B. (1948). Breeding and feeding habits of mullets (*Mugil*) in Ennore Creek. *J. Bombay Nat. Soc.*, 47, 663-668.
- Kumagai, S., Villaluz, A. C., Tiro, L. B. Jr. and Vanstone W. E. (1976). The occurrence of milkfish *Chanos chanos* fry in Pandan Bay, Antique, from 21 May to 25 June, 1975. Proc. Intern. Milkfish Conf., May 19-22, 1976, Tigbauan, Iloilo, Philippines, 50-57.
- Kuronuma, K. and Yamashita M., (1962). Milkfish fry in the eastern coast of Vietnam. *J. Oceanogr. Soc. Japan*, 20th Anniv. vol., 679-686.
- Liao, I. C., Yan H. Y., and Su M. S., (1977). Studies on milkfish fry-I. On morphology and its related problems of milkfish fry from the coast of Tungking, Taiwan. *J. Fish. Soc. Taiwan*, 6, 73-83. (in Chinese with English summary)
- Lin, S. Y. (1968). Milkfish farming in Taiwan, a review of practice and problems. Publication from the Taiwan Fisheries Research Institute. 63 pp.
- Nishimura, S. (1973). Currents and long-distance dispersion of organisms. *Kaiyo Kagaku*, June 1973, 74-81. (in Japanese)
- Rabanal, H. R., Esguerra, R. S., and Nemopuceno, M. N. (1953). Studies on the rate of growth of milkfish or "bañgos" *Chanos chanos* (Forsk.) under cultivation. Proc. IPFC 4th Meet. Sect. II, 171-180.
- Rao, A. V. P. (1970) Observations on the larval ingress of the milkfish, *Chanos chanos* (Forsk.) into the Pulicat Lake. *J. Mar. Biol. Ass. India*, 13, 249-257.
- Senta, T. (1956). Occurrence of a postlarval milkfish *Chanos chanos* (Forsk.). Fish. Exp. Sta. Nagasaki Pref., *Gotonada narabini sono shuhen chosa*, (23), 54-56. (in Japanese)
- Senta, T. and Hirai, A. (1980a). Record of milkfish *Chanos chanos* (Forsk.) from mainland Japan. *This Bull.* (48), 13-18.
- Senta, T. and Hirai, A. (1980b). Seasonal occurrence of milkfish *Chanos chanos* (Forsk.) fry at Tanegashima and Yakushima in southern Japan. *Japan. J. Ichthyol.* 27.
- Senta, T. and Kumagai, S. (1977). Variation in the vertebral number of the milkfish *Chanos chanos*, collected from various localities. *This Bull.* (43), 35-40.
- Uchida, K. and Dotsu, Y. (1958). Fish eggs and larvae appearing in the surface layer of the Warm Tsushima Current, a general review. Report of the Cooperative Survey for Exploitation of the Warm Tsushima Current (Fisheries Agency), Sect. II, 3-65. (in Japanese)
- Vanstone, W. E., Tiro, L. B. Jr., Villaluz, A. C., Ramsingh, D. C., Kumagai, S., Dulduco, P. J., Barnes, M. M. L. and Dueñas, C. E. (1977). Breeding and larval rearing of the milkfish *Chanos chanos* (Pisces: Chanidae). SEAFDEC

Aquaculture Dept. Tech. Rep., (3), 3-17.

English summary)

Yoshida, H. (1932). On a post-larva of *Chanos chanos* (Forsk.) from Amami-Oshima. *Bull. Jap. Soc. Sci. Fish.* 1, 25-27. (in Japanese with

Yoshida, H. (1933). On breeding and larvae of milkfish. *Rakusuikaishi*, 28, 25-30. (in Japanese)

南日本におけるサバヒー仔魚の出現

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1977~79年の夏に、沖縄から紀伊半島及び平戸島に至る55箇所の砂浜海岸の波打際近くで、小型の簡易引網による採集をおこない、[31箇所で総計240個体のサバヒー仔魚を得た。仔魚が多かったのは種子ケ島・屋久島以南であるが、出現の北限は太平洋岸では和歌山県宇久井、東支那海側では五島列島北端の埴久島であった。集魚灯によっても少数ながら仔魚を採集することができた。仔魚が採集されたのは水温24.0~33.2°C (多くは27.0°C以上)、比重 σ_{15} 1.17~26.96の範囲であった。仔魚の全長範囲は10.9~16.1mm、モードは13.5~14.0mmであり、熱帯・亜熱帯の各地で種苗として採捕されているものと同じ大きさである。平均脊椎骨数(43.426±0.100)からみる限り、日本に出現するサバヒーはインドネシア・フィリピン・台湾などのものと同一系統群に属する。これら仔魚の起源および冬季水温低下時に辿るべき運命に関しては、現在のところ未だ結論を出す段階にない。

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