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Growth of juvenile milkfish *Chanos chanos* in a natural habitat*

Shigeru Kumagai[1], Teodora Bagarinao[2] & Abdul Unggui[2]

[1] Kagawa Saibai Center, Yashima, Takamatsu, Kagawa, Japan 760–01
[2] Aquaculture Department, Southeast Asian Fisheries Development Center (SEAFDEC), Box 256, Iloilo City, Philippines 5901

ABSTRACT: A population of juvenile milkfish, *Chanos chanos* (Forsskål) was studied in a small mangrove lagoon in Naburut Island, central Philippines. Several size groups of milkfish occurred in the lagoon as a result of its periodic connection with the sea. Some 903 specimens were collected in Mar to Nov 1979, covering a fork length range of 12 to 180 mm. Body-weight to fork-length relation was: $\log W = -5.2991 + 3.2388 \log L$, similar to that of pond-cultured specimens. In Naburut lagoon, juvenile milkfish take in primarily blue-green algae, as well as mangrove and seagrass debris, diatoms and detritus. Variations in condition factor and gut weights of samples taken at different times of day and night indicate diurnal feeding. The condition factor of fish caught during the day from May to Nov stayed constant, indicating that lagoon conditions for growth in terms of food did not change markedly during the year. The monthly size-frequency distribution shows that juvenile milkfish in the lagoon grew at a rate of 7 to 9 mm wk^{-1} in 1979. Compared with pond-cultured specimens, their growth rate was lower during the first month but higher during the second month in the nursery. Specimens larger than 150 mm fork length were almost absent from the lagoon, indicating that they leave after a stay of 4 to 5 mo. The limited area and depth of Naburut lagoon probably set the limit to the size of juvenile milkfish; these can be sustained there to just 150 to 180 mm fork length.

INTRODUCTION

In the Philippines, *Chanos chanos* (Forsskål) postlarvae (10 to 17 mm total length, TL) occur in tremendous numbers in shore waters and support a big fry fishery that supplies a centuries-old pond culture industry with seed. In contrast, adults (50 to 150 cm TL) occur only as incidental catches in coastal traps at limited times of the year. Juveniles (2 to 50 cm TL) are hardly seen in nature, but are produced by the tons in brackish water ponds. The ecology of milkfish, particularly at the juvenile stage, is of interest to both the fishery biologist and the aquaculturist. Juvenile milkfish occur naturally in a variety of undisturbed coastal wetlands, such as lagoons, creeks, estuaries and swamps, that share the common characteristics of being semi-enclosed, calm and shallow, free from many predators, and rich in bottom flora, fauna and deposits that serve as food (Buri et al. 1981, Kumagai & Bagarinao 1981), characteristics that are well-approximated by culture ponds. These coastal wetlands serve as nursery grounds for milkfish under conditions similarly to those in culture ponds. It is interesting to note that in places like India, Thailand, Vietnam, Papua, New Guinea, Fiji and Sri Lanka, where there is no milkfish pond industry to speak of, juvenile milkfish can be collected in commercial quantities from tidal creeks and coastal lagoons (Schuster 1952, Lichatowich 1978, Villaluz et al. 1982).

A study was conducted to determine how well wild milkfish fare in their natural habitats. They were found to be highly adaptable and to do very well in different habitats on different diets (Kumagai & Bagarinao 1981). This paper reports on the growth of wild juvenile milkfish in a small mangrove lagoon in Naburut Island (123°12'E, 11° 35'N) in central Philippines (Fig. 1), based on the size-frequency distribution of samples collected over a period of 9 consecutive months. Tropical marine fishes are quite difficult to age from markings on scales, otoliths and vertebrae, more so those specimens less than 1 yr old (Panella

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1974). The numbers of juvenile milkfish collected from natural habitats had been low (Kumagai & Bagarinao 1981) and inadequate for analysis. Moreover, the spawning season of milkfish is relatively long; settlement of postlarvae in many coastal wetlands is continuous over the season, and size groups could not be defined. The small mangrove lagoon in Naburut Island had special characteristics that made it possible for the first time to determine growth rates, length-weight relationship, food habits and duration of stay of juvenile milkfish in a natural habitat.

AREA AND MATERIAL STUDIED

The small Naburut lagoon is 16,000 m^2 in area, less than 0.5 m deep in most parts and heavily forested by mangroves (Fig. 1). A large volume of mangrove leaves and seagrass carried in by the tides decomposes in the lagoon to form a thick detritus carpet. In addition, there is a rich benthic and epiphytic algal and bacterial flora. The lagoon is separated from the sea by a 50 to 100 m wide coral terrace and an extensive sand dune except for 2 small channels whose elevations were shown by geodetic survey to be higher than mean high water level (Fig. 1). Water exchange between lagoon and sea is possible only during the high tides of spring-tide periods, i.e. at 2-wk intervals. The bottom is largely muddy and rich in hydrogen sulfide. There is no freshwater inflow and salinity is higher (36 ‰) than in the sea outside, except when it rains heavily (20 ‰). Temperatures are quite constant under the mangrove thickets (about 27 °C) but vary considerably in the shallow exposed parts (25 to 40 °C). Although milkfish postlarvae occur in shore waters from day to day, ingress into the lagoon and egress back to sea, are limited to 2-wk intervals.

A total of 1,151 milkfish were obtained from Naburut lagoon from May 1978 to November 1979 by gill nets (stretched mesh 4, 5 and 6 cm) and dragged seines (mesh 1 to 2 mm) operated at different times of day and night. Samples were preserved in 10 % formalin at the site, then measured and weighed in the laboratory one month later. The 903 specimens in the monthly samples in March-November 1979, covering a fork length (FL) range of 12 to 180 mm (13 to 220 mm TL), were used for growth analysis. One to several size groups occurred in each of the monthly samples. They were distinguished and separated using probability paper (Harding 1949).

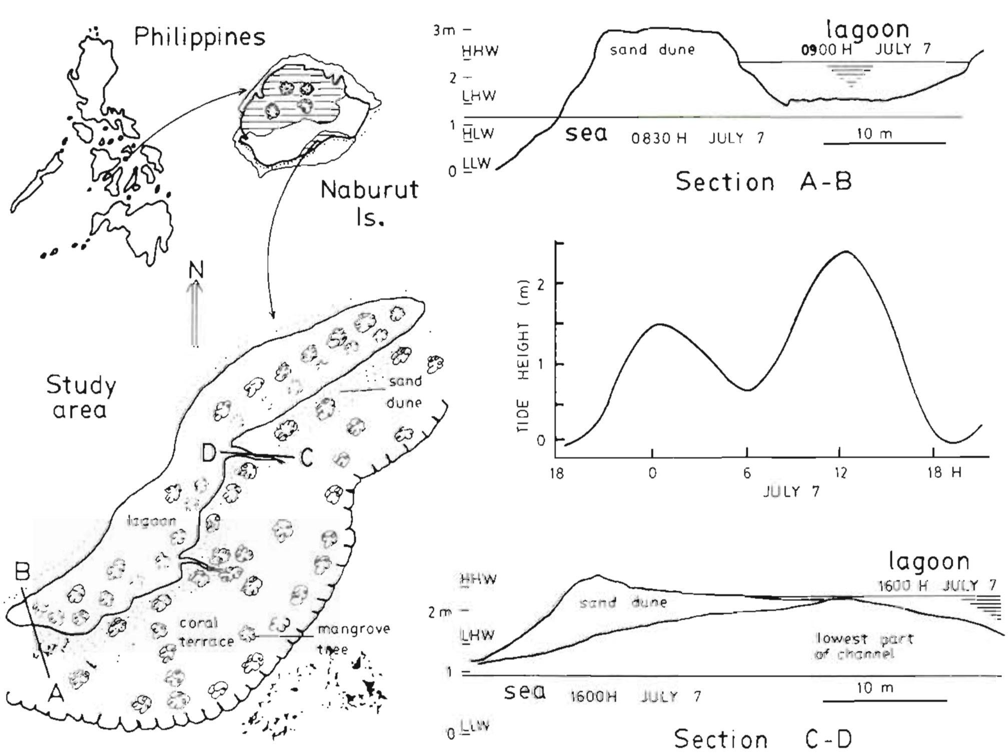

Fig. 1. Small mangrove lagoon in Naburut Island in central Philippines, where the population of juvenile milkfish was studied. Right panel shows semi-diurnal tide pattern in Naburut, and cross-sectional profiles of the lagoon at one end (A – B) and at one channel (C – D). The lagoon is connected with the sea only during high tides of spring-tide periods (higher high water, HHW). Coral terrace is at the lower low water (LLW) level. LHW: lower high water; HLW: higher low water

RESULTS AND DISCUSSION

Length-weight relation

The May 1979 sample had 4 size groups covering a fork length range of 22.3 to 107.7 mm. Fig. 2 shows the body-weight to fork-length relation, the regression equation of which was determined to be:

$$W = 5.0223 \times 10^{-6} L^{3.2388}$$

where W is expressed in g and L in mm. This relation in log form ($\log W = -5.2991 + 3.2388 \log L$) compares well with those obtained for pond-cultured milkfish by Grover & Juliano (1976) ($\log W = -5.0463 + 2.9889 \log L$, where L = total length), and by Arroyo et al. (1976) ($\log W = -5.2120 + 3.1831 \log L$, where L = fork length). In theory, when the slope b = 3.0, the fish puts on weight isometrically with increase in length, and body form remains constant (Royce 1972). The slope value b = 3.2388 in wild juvenile milkfish in Naburut Island suggests that they become wider of girth with growth.

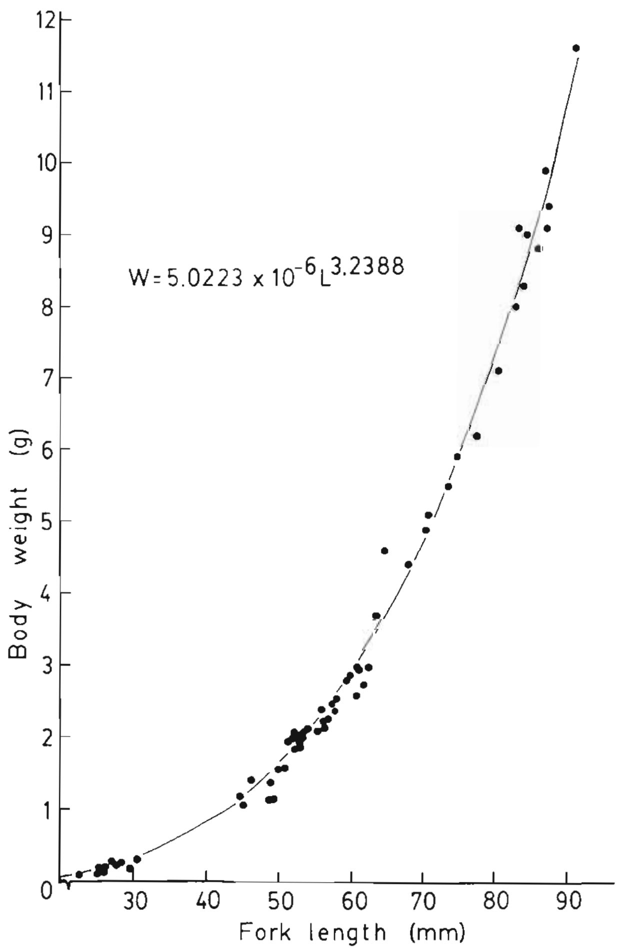

Fig. 2. *Chanos chanos.* Length-weight relation in wild juveniles from Naburut lagoon (May 1979 sample)

Food and condition factor

Juvenile milkfish take food from the substrate. The major items in their diet differ by habitat but detritus is common to all (Kumagai & Bagarinao 1981). In Naburut lagoon, milkfish take in primarily blue-green algae, as well as mangrove and seagrass debris, diatoms and detritus.

The condition factor, $F = 1000 \, WL^{-3}$, was computed for all specimens greater than 100 mm fork length. The July sample consisted of fish caught at 7 different times of day. F values were higher in daytime than at night, indicating weight differences due to feeding (Fig. 3). Dissection showed that fish caught at 0300 h and 2200 h all had empty guts (mean gut weight = 10 % of body weight, n = 8), whereas those caught at other times were all full (mean gut weight of fish at 1600 h about 20 % of body weight, n = 8). Samples taken in other months likewise showed diurnal variation in condition factor (Fig. 3). It seems that juvenile milkfish in Naburut lagoon feed actively in daytime and hardly at night.

The condition factor of fish reflects the quality of its environment. Table 1 shows the condition factors of day-caught juvenile milkfish (FL > 100 mm) from May to November. The values stayed at a more or less constant value of 14, indicating that lagoon conditions for growth in terms of food did not change markedly during the year.

Buri (1980) discusses at great length the feeding ecology of juvenile milkfish, in part using the same material as in the present study.

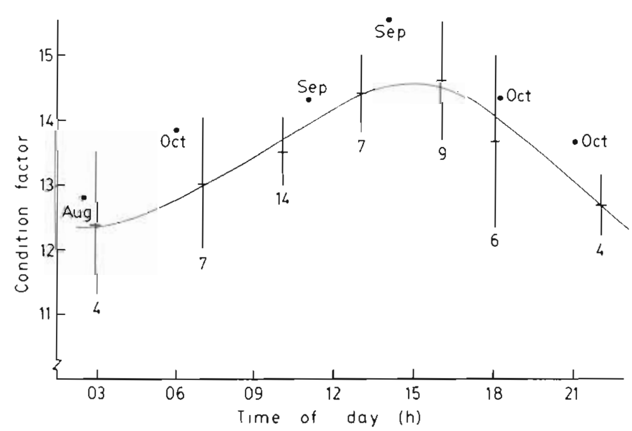

Fig. 3. *Chanos chanos.* Diel variation in the condition factor (mean ± standard error) of juveniles from Naburut lagoon in July 1979. Dissection showed that all fish at 0300 h and 2200 h had empty guts (mean gut weight about 10 % of body weight), whereas those caught at other times had full guts (gut weights of fish at 1600 h about 20 % of body weight). Mean condition factor of fish in other months (●) also indicate diurnal feeding. Number of specimens indicated below vertical bars. All specimens longer than 100 mm FL

Table 1. *Chanos chanos*. Condition factor (1000 WL^{-3}) of juveniles (L > 100 mm) collected in Naburut lagoon from May to November 1979 during daytime (0600 to 1800 h)

Month of collection	Sample size	Condition factor (mean ± standard error)
May	8	14.65 ± 0.79
Jun	41	14.45 ± 0.49
Jul	42	13.99 ± 0.38
Aug	no daytime catch	
Sep	17	14.81 ± 0.65
Oct	7	14.31 ± 0.88
Nov	4	14.77 ± 1.17

W = body weight in g; L = fork length in cm

Monthly size composition and growth

Since ingress of postlarvae into the lagoon was only at 2-wk intervals, one to several size groups of milkfish occurred in the lagoon in different months (Fig. 4). Postlarvae were caught in the lagoon only in March although they were expected to occur every month. Considering the fact that very small numbers of postlarvae occur in shore waters following storms, the absence of postlarvae in the lagoon in April and May may have been due to 2 storms which struck 1 to 2 wk before sampling. In March and April, there was only 1 size group each, of 13 mm mean fork (postlarvae only) and 26 mm, respectively. In May, June and July, there were 3 to 4 size groups, with obvious trends of increasing mean fork lengths. In August to November, there were only 1 to 2 size groups, mostly of fish larger than 100 mm FL, except for a few very small specimens in August. Following the linear trends of increase of mean fork length of different size groups in successive months (Fig. 4), the growth of juvenile milkfish was approximated by the equation: $L = A + bT$, where L = fork length (mm); T = time (weeks) from ingress into the lagoon. Each line represents growth of a batch of milkfish that had entered the lagoon at the same time; 4 lines are drawn to show the variation in growth rate of batches of 4 different estimated times of ingress:

Estimated time of ingress	Growth equation
End Mar	$L = 12.92 + 8.65\ T$
Mid Apr	$L = 10.89 + 7.61\ T$
Mid May	$L = 13.24 + 7.36\ T$
End May	$L = 11.61 + 7.03\ T$

These equations indicate growth rates of 7 to 9 mm wk^{-1} for wild juvenile milkfish in Naburut lagoon in 1979, with slightly slower growth later in the year, for reasons that are not clear. In comparison, milkfish postlarvae stocked in prepared nursery ponds grown at a rate of 5 to 10 mm wk^{-1} during the first 4 wk (Rabanal et al. 1952).

The 4 equations above were used to estimate the sizes of wild juvenile milkfish for every 2-wk interval to compare their growth with those from ponds (Rabanal et al. 1952, Schuster 1952); Table 2 shows these measurements. It appears that during the first month, the fish in the wild nursery do not grow as fast as fish in the ponds. During the second month, however, fish in the wild grow faster than fish stocked in ponds at densities of 10 to 40 m^{-2}. This growth rate difference may be due to the condition of the habitat and the kind of food available to the fish during the adaptation period in the first month. Nursery ponds are more or less controlled environments with competitors and predators eliminated, and with a nutritious food complex (the benthic mat of blue-green algae and diatoms locally known as 'lablab') expressly provided, prior to stocking of milkfish postlarvae. Wild fish have to contend with competitors and utilize whatever food is available in the natural habitats. Once the wild fish get adapted to the available food, they can grow fast

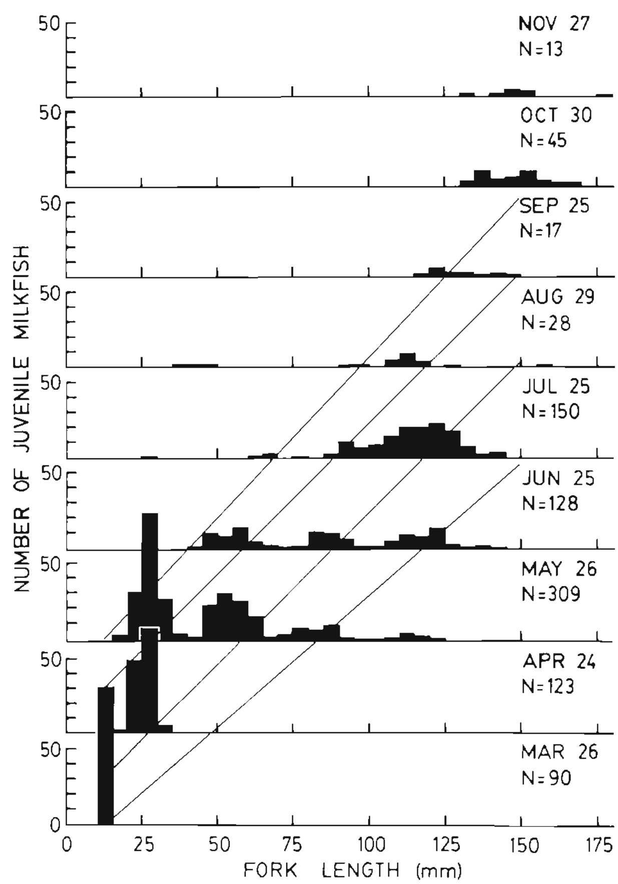

Fig. 4. *Chanos chanos*. Size composition of monthly catches of juveniles from Naburut lagoon in 1979. Lines trace the increase with time of the mean length of 4 batches of milkfish of different estimated times of ingress into the lagoon. Mean length of size groups was determined by probability paper

Table 2. *Chanos chanos*. Comparison of the growth of wild and cultured juveniles. Total length at time of ingress or stocking is 13.5 mm

Time in nursery (wk)	Total length of fish (mm)								
	Wild (this study) Estimated time of ingress				Cultured (Schuster 1952; Rabanal et al. 1952) Stocking density (fish m^{-2})				
	End Mar	Mid Apr	Mid May	End May	1	10	20	30	40
2	33.22	28.16	30.44	27.61	28	38.38	29.82	34.63	34.52
4	54.52	46.90	48.56	44.92	60	70.47	50.17	57.71	46.82
6	75.81	65.65	66.69	62.25	110	76.24	55.01	53.34	51.15
8	97.12	84.39	84.81	79.56	135	82.50	62.11	54.70	55.91

Fork lengths estimated for wild milkfish from the 4 growth equations were converted to total length using the relation $TL = -3.99 + 1.23\ FL$. Baliao et al. (1980) stocked 13.8 mm fry at 30 fry m^{-2} in a 50 m^2 nursery pond and obtained 56.46 mm juveniles in 60 d. The few other recent literature sources on the growth of milkfish in nursery ponds give data in weight units, or for longer (monthly) intervals

because there is more than enough in these natural environments. In nursery ponds, the natural food is soon exhausted by the fast growing fish and growth is thereby slowed down. Pond fish stocked at a low density of 1 m^{-2} achieve much faster growth (Schuster 1952).

A few reports exist concerning the growth of wild juvenile milkfish. The Madras State Fisheries Department (India) estimates that in the open waters of the neritic zone, milkfish reach a size of 110 mm after 8 mo (Schuster 1960). This is either an underestimate or a really far slower growth rate. In Sri Lanka, Villaluz et al. (1982) observed that milkfish in a 150,000 m^2 tide pool grew from 13 mm to 40 mm FL in 3 wk in May 1982, comparable with the March group in this study. In the brackish water lagoons of Madras, milkfish of the April-May fry season attain a length of 405 to 430 mm in the first year, whereas those from the July-August season grow to a length of 305 mm in 10 mo (Schuster 1960). This apparently 'seasonal' difference in growth rates is also seen in the Naburut population described in this paper. It is possible that this depressed growth rate is due to disturbances in the physicochemical conditions in the lagoon caused by monsoonal rains and rough sea conditions in June-September. Although the fish may survive these perturbations, it is nevertheless energetically costly to resist salinity changes, hypoxic conditions, and high levels of hydrogen sulfide. It was observed that juvenile milkfish in the lagoon were ordinarily not affected by the hydrogen sulfide in the muddy bottom, but were killed *en masse* during severe storms when the substrate was disturbed amd the hydrogen sulfide released.

Duration of stay in the lagoon

The largest specimen collected in Naburut lagoon was 180 mm in fork length. Of the 903 specimens in 1979, only 20 were larger than 150 mm FL. On 2 separate occasions, fish of about 150 mm FL were caught in shore waters just outside the lagoon. From these observations, it appears that juvenile milkfish leave Naburut lagoon when about 150 mm long, after a stay of some 4 to 5 mo. Food was obviously abundant in the lagoon, and the condition factors of the fish remained the same through the different months. It is then probably not the food but the limited depth and area of the lagoon that set the limit to the size of juvenile milkfish which can be sustained there to just about 150 mm FL. In habitats of greater extent and depth, as in the 2.5 m deep Bugang lagoon on the northwestern side of Panay Island, bigger milkfish (about 210 mm FL) have been collected (Kumagai & Bagarinao 1981). The duration of stay of juvenile milkfish in natural nursery grounds probably varies with the food supply, size of habitat, and its connection with the sea. Eventually, milkfish from all coastal nursery grounds presumably return to the open sea.

Schuster (1960) documents a phenomenon well-known among milkfish culturists, a behavior utilized during harvests from ponds: Milkfish, at least fish exceeding a length of 150 mm, become very excited hours before an advancing high tide reaches the pond. When water is let into the pond, they swim against the current and accumulate in front of the pond gate apparently in an effort to get out. It is reasonable to assume that such behavior would also be exhibited by wild milkfish, as they reach the limit size sustainable by the colonized habitat and have to leave.

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