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Buri, Prasit

Aquaculture Department, Southeast Asian Fisheries Development Center

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Developmental and ecological stages in the life history of milkfish, *Chanos chanos* Forsskal

Prasit Buri, Shigeru Kumagai, Vicente Bañada, Avelino Triño
and Nelson Castillo

Seven stages in the life history of milkfish are recognized and suggested: A, embryonic; B, yolksac larval; C, larval; D, postlarval; E, juvenile; F, subadult and G, adult stage. These stages were determined based on their more or less distinctive external and internal morphological differences (organ development, body proportions etc.), on their sexual maturity and their particular biology and ecological requirements (behaviour, food and feeding habits, habitat preferences etc.). Inspite of the authors' knowledge that a detailed and complex terminology for the different developmental stages of finfishes has been suggested elsewhere, for the sake of simplicity, the terminology used in tbis paper is to be considered as follows: A, from spawning to hatching; B, from hatching until yolk is resorbed; C, from the beginning of external feeding until the time of mass appearance or migration to coastal waters; D, the time of mass appearance to metamorphosis (fry stage); E, from metamorphosis to approximately one year old; F, more than one year old with developing gonads but still immature; G, four years old and above with maturing or rematuring gonads. It should be noted that overlapping of stages do occur especially because transitional period exists between stages.

From various literatures as well as from the authors' published and unpublished data, the life history of milkfish can be summarized as following.

Spawning and fertilization takes place in the sea during night time. Spawning activity is not precisely correlated with moonphase per se, however, a preference of spawning on dark nights can be recognized. This selective advantage favouring nocturnal breeding can be attributed to the evolutionary response to predation pressure. Field observation suggests a kind of bouyancy controlled vertical transport or drift rather than simple passive even distribution of the eggs in the water column. The embryo hatches 20-24 hours later, the time of which also falls in the evening or night period. The biology of the yolksac larval and larval stages is still unknown, due to extreme difficulties in obtaining specimens in their natural habitat. There are, however, indirect evidences indicating that before reaching the postlarval stage the fish more or less stay away from shallow coastal waters. It is suggested that the larvae remain in deeper water. Daily vertical migrations in search for food seems most probable like any other particulate feeding finfish larvae. Laboratory experiments show that external feeding starts within 3 days after hatching.

Milkfish eggs have been collected within distances of few hundred meters as well as up to many kilometers from the coastal areas where postlarvae (fry) are collected in great numbers. Since, however, these postlarvae are of limited size range and probably of similar age, it is suggested that certain activity must be involved in delaying or speeding up their appearance or arrival at shore waters. This idea is in favour of the active migration coupled with certain energy economizing passive but controlled drift of the postlarvae. It has been shown that the postlarvae have distinctive behavioural pattern and ecological requirements, thus the authors regard this stage as an ecologically and morphologically different stage from the preceeding larval stage. Although feeding intensity has been found to be very low, stomach content analysis of postlarvae have shown that the fish ingest not only planktonic food organisms but also benthic or resuspended benthic food sources.

Accumulating evidences show that the postlarvae seek only specific coastal areas where they can find depositional environments in form of protected bays, mangrove lagoons, nipa swamps etc. Postlarvae therefore can be caught irrespectively of shore morphology, sandy, muddy or rocky shores provided that they lead to or are connected with habitat of rich bottom deposits consisting of decayed leaves of terrestrial plants, mangrove leaves, seagrasses, marine algae etc. In general it can therefore be said that milkfish postlarvae occur throughout the Philippines, the numbers of which depend strictly from the magnitude of the mentioned depositional environments.

Probably guided by some specific odor of these backwaters the fish, at certain developmental period within the larval and postlarval stage, is capable of detecting suitable nursery grounds from unsuitable habitats. Through odor gradient it is possible to arrive at the desired environment. Field observations indicate that chemical property (odor) rather than salinity or other physico-chemical parameters of the water attract and guide the postlarvae to their juvenile habitat. Within the nursery ground the fish after a short time complete their metamorphosis. Here major morphological features as well as behavioural pattern change. With the shift from particulate feeding to mainly depositional and/or filter feeding, there is a rapid increase in intestinal ratio, rapid development of gill rakers etc. which reflect in changes in body proportions. The postlarval stage ceases here as the juvenile stage begins. Adaptation to the new and specific environmental condition can be seen through relative gills surface area to dissolved oxygen level, relative eye diameter to light condition, turbidity, vegetation cover etc. Body transparency as a means for protection against predation is abandoned and replaced with the countershading coloration. Schooling becomes more distinctive. Ossification proceeds very rapid and upon reaching 5-6 cm FL all skeletal system are completed including the minute intermuscular bones. The juvenile fish feeds now mainly on bottom deposits together with its associate flora and fauna. Depending on food availability, strictly selective feeding might occur. Where physico-chemical parameter of the habitat is mainly influenced by tidal fluctuations, feeding activities become tidal periodic.

Depending on the size of the nursery ground the juvenile milkfish return to the open sea at the age of 10-12 months old or approximately 25-35 cm in FL. In the case of relatively 1 large habitat, the fish might remain longer, however, only until the beginning of adult stage. Although it is assumed that subadult like adult milkfish inhabit mainly open waters but also frequent coastal feeding grounds, very few specimens of small subadult fish has been recorded in literatures. Only few specimens have been collected by the authors. Since there still remain the difficulties in distinguishing immature subadult from rematuring adult, this stage is also little known. As of now no valid method for determining the age of milkfish caught from the wild has been established.

Throughout the juvenile, subadult and adult stages the milkfish remains an opportunistic feeder, ingesting from large zooplankton to benthic algae and deposits. High intestinal ratio, fine gill rakers, epibranchial organs among others allow the fish to ingest and utilize food sources belonging to different trophic levels efficiently. Fat ribbons surrounding the pyroric caecae are often found in wild specimens feeding only on detrital matter.

In conclusion it can be said that the milkfish, throughout their known stages of their life history, is well adapted and equipped for optimal survival. To mention a few are; high swimming performance, broad flexibility in feeding habits, high adaptability to a wide range of physico-chemical condition of the environment etc. It is suggested that the main driving force in all developmental stages in the life history of milkfish is the evolutionary response to food distribution and availability followed by predation pressure.

The present study has shown that further ecological knowledge through developmental and functional anatomy, field data, behavioural study and laboratory experiments can be implimented for the improvement of aquacultural management.

The primary objective of the first author in this ecological investigation is also to

a) utilize ecological principles for optimal aquaculture production with minimum degradation of the ecosystem,

b) forecast future changes, and

c) evaluate consequences of intervention.

It should be recognized that major habitat of milkfish have been modified by man, either deliberately or accidentally. Man induces changes by altering the recruitement of postlarvae through efficient collection method and modifying the nursery ground by pond construction, introduction of mineral salts and removal of vegetation cover, by damaging the adult feeding and spawning grounds through dynamite fishing etc. Such activities bring about associated changes leading to widespread destruction of the magnitude not well known to us.

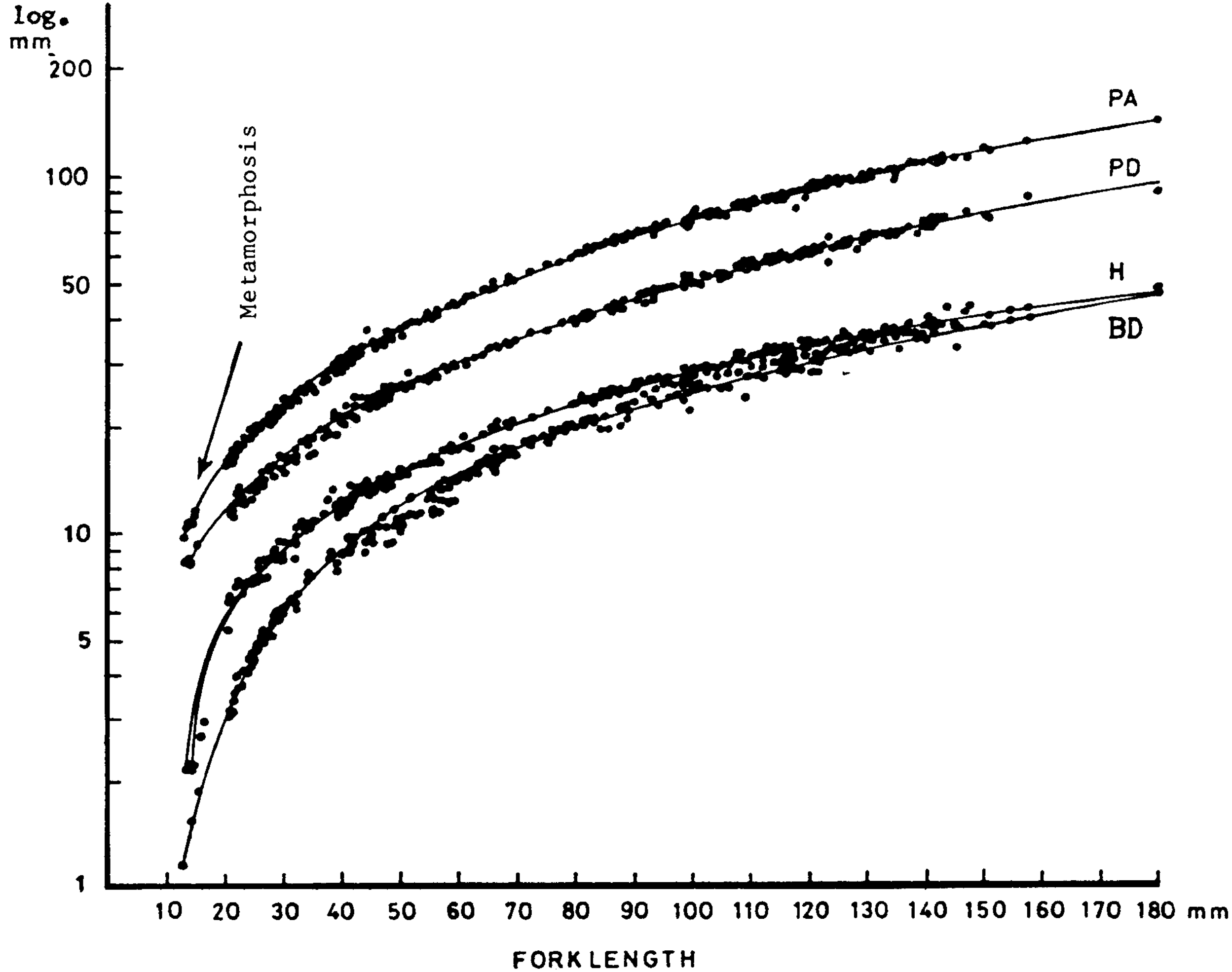

Fig. 1. Body proportions of postlarvae and juvenile milkfish; PA preanal length, PD predorsal length, H head length and BD body depth.

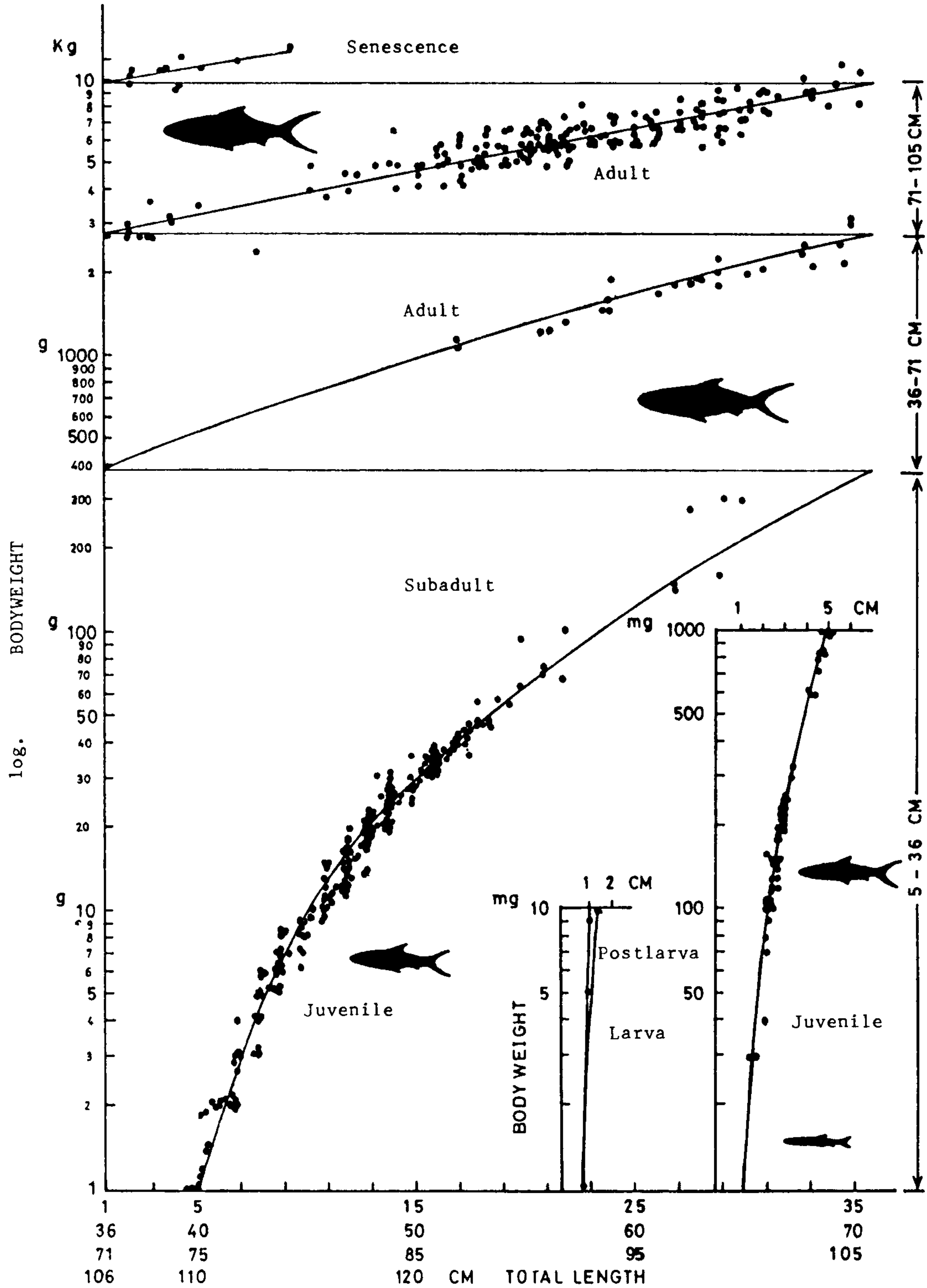

Fig. 2. Relationship between body weight and total length in the different developmental stages of milkfish.

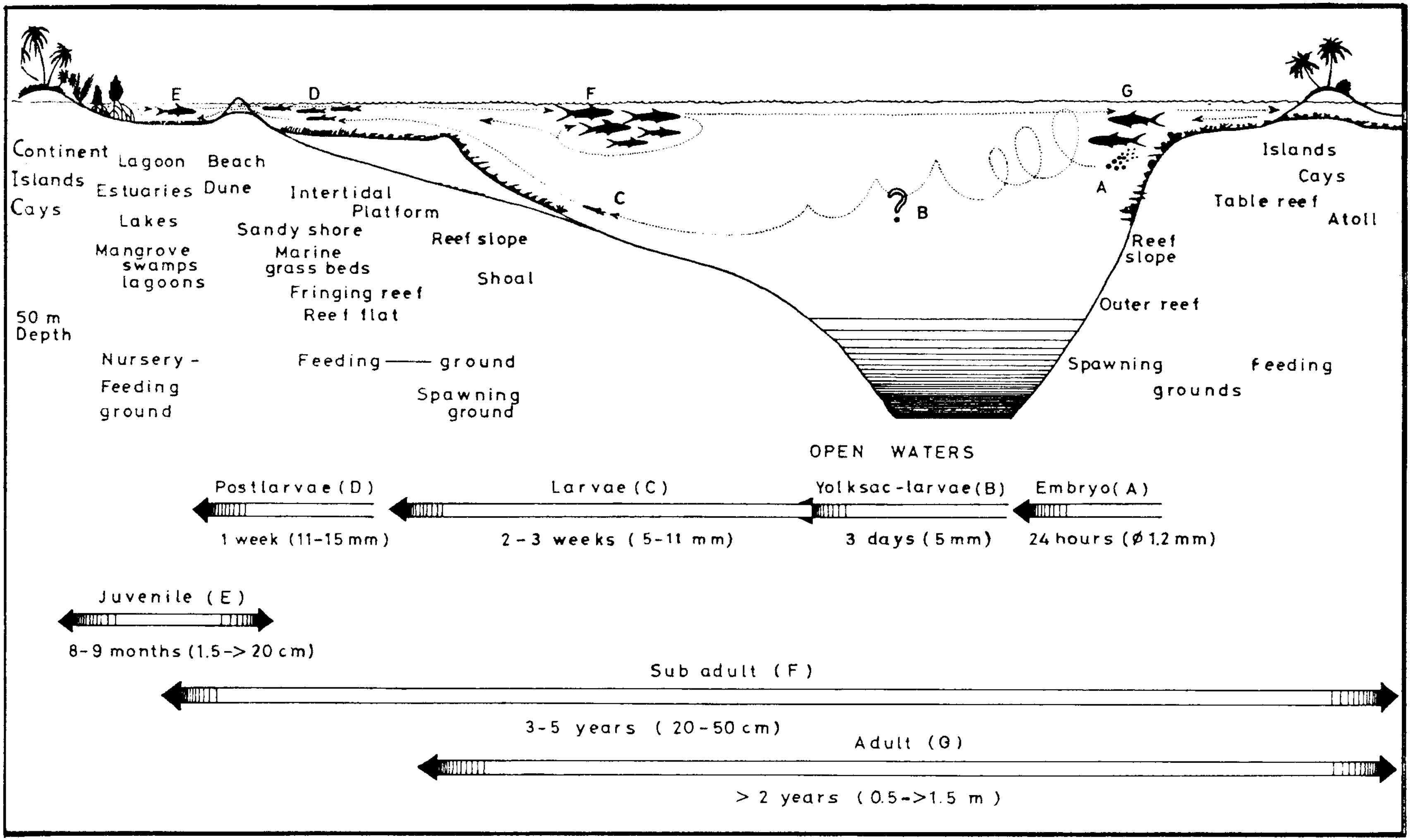

Fig. 3. Schematic diagram of the complete life history of milkfish with indications of major habitats, and duration of each developmental stages.