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SYNOPSIS OF BIOLOGICAL DATA ON KOI

Anabas testudineus (Bloch, 1792)

PREPARED BY

N. K. Thakur & P. Das

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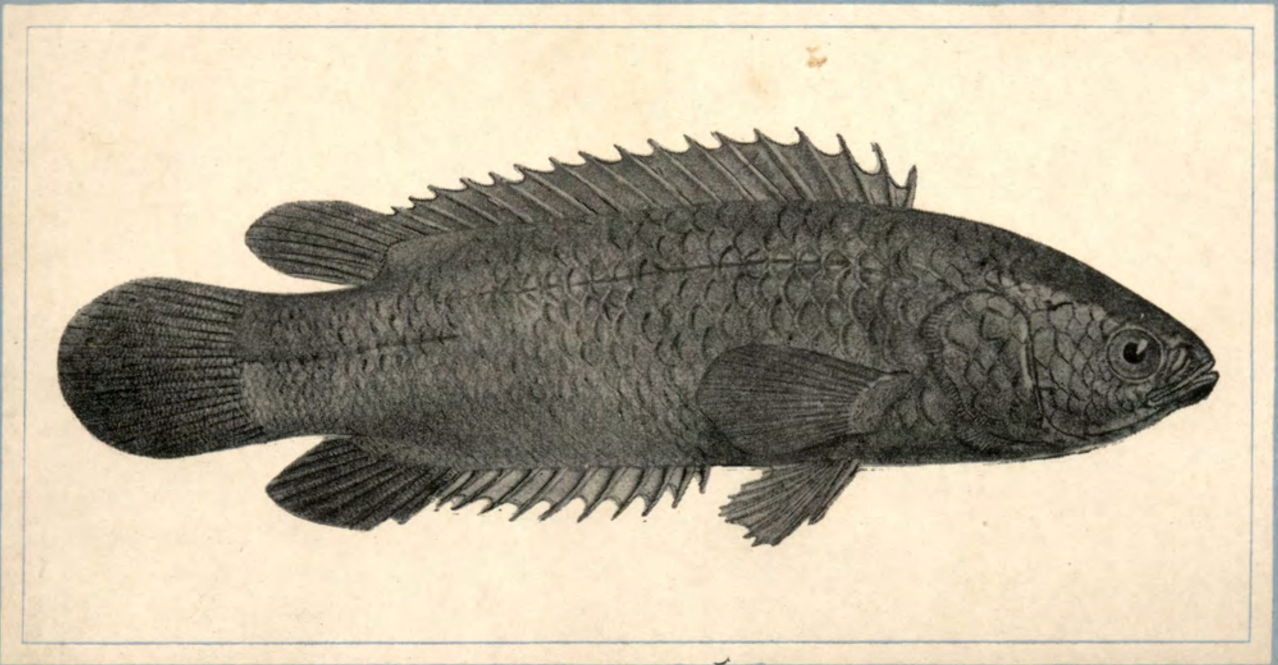

CENTRAL INLAND FISHERIES RESEARCH INSTITUTE • BARRACKPORE

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Anabas testudineus (Bloch, 1792)

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CENTRAL INLAND FISHERIES RESEARCH INSTITUTE

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1. IDENTITY

1.1 Taxonomy

1.1.1 Definition
(According to Berg, 1947)

Phylum Vertebrata
Subphylum Craniata
Superclass Gnathostomata
Series Pisces
Class Teleostomi
Subclass Actinopterygii
Order Perciformes
Suborder Anabantoidei
Family Anabantidae
Genus *Anabas* Cuvier, 1817
Species *Anabas testudineus* Bloch, 1795

1.1.2 Description

D. XV–XIX,7–11; P. 14–16; V. 1,5; A. IX–XI, 8–11; C. 17
L.1 26–32; L. tr. 3–4/9–10; VERT. 10/16; Caec.pyl. 0–3

Body oblong, posteriorly compressed. Head rather broad. Head length 3.5–3.6 and body depth 3–4 in total length. Eye Diamoter 4.4–5 in head length and 1.7 in interorbital width. Mouth not protractile, lower jaw slightly longer. Opercle and preorbital strongly serrated, posterior edges of opercle, subopercle and interopercle strongly spinous. Teeth villiform on jaws, vomer with samller teeth, palatines toothless. Spinous portion of dorsal 0.8 in entire length of the fin, soft portion higher than spinous portion. Dorsal longer than anal, originating before the origin of anal. Caudal rounded. Lateral line interrupted at 18th scale, 19th scale perforated and situated just below 18th. Scales strongly ctenoid. Some scales covering bases of dorsal, pectoral, anal and caudal fins.

Colour description of the fish, as described by different authors, is given in Table I.

A. testudineous possesses a pair of accessory respiratory organs which enables it to breathe from air and survive out of water for prolonged periods. These organs are in the form of spacious air-chamber on either side of the skull, communicating freely with the bucco-pharyngeal cavity on one side and opercular cavity on the other. The respiratory epithelium lining the air-chambers are highly vascularized. Besides this, a characteristic labyrinthine organ is lodged in the air-chambers which are rosette like structures made up of a number of concentrically arranged shell-like plates, with wavy edges. These are, in fact, outgrowths from the branchial arches and evolution of the accessory respiratory organs of Anabas attracted considerable attention of the scientists in the past (Zograff. 1888; Henninger, 1907; Rauther, 1910; Das, 1927; Marlier, 1938 etc.). Morphological and anatomical details of the accessory respiratory organs of the fish have been studied by Misra and Munshi (1958), Saxena (1964), Munshi (1968), Reddy and Natarajan (1970 and 1971) while its fine structures through electron microscopy have been studied by Hughes and Munshi (1968 and 1973).

A. testudineus was first introduced to the scientific literature in a memoir written in the year 1797 by Daldorf, a lieutenant in the service of the Danish East India Company at Tranquebar (Chandy, 1970). The fish derives its name "the climbing perch" from the widely held belief that it can climb on trees, which is actually the result of faulty observation. Anabas is certainly found lying very often in the forked branches of the trees or inside the toddy containers hung on palm trees, but they do not reach there by themselves. They are, in fact, dropped or placed there by crows and kites which catch the stranded fishes in drying pools or during their overland travels for migrating from one pond to another.

A. testudineus is considered as a valuable item of diet for sick and convalescent. According to Saha (1971), the fish contains high values of physiologically available iron and copper essentially needed for haemoglobin synthesis. In addition, it also contains easily digestible fat of very low melting point and good many of essential amino-acids.

1.2 Nomenclature

1.2.1 Valid scientific name

Anabas testudineus Bloch, 1795

1.2.2 Synonyms

Table I
Colour description of *A. testudineus*

Author	Colour description
Day (1889)	Rifle green, becoming lighter on the abdomen. During life, usually 4 wide vertical bands and a dark stripe from the angle of mouth to preopercle. Young have a black blotch on the sides of base of the tail, surrounded by a light, sometimes yellow ring, usually they have a black spot at the end of opercle, and sometimes another at the base of the pectorals.
Shaw and Shebbeare (1937)	Greenish brown, lighter beneath. Traces of 4 wide vertical bands.
Mookerjee & Mazumdar(1946)	Dark green colour on the back passing to a pale green along the sides and brownish below.
Munro (1955)	Light to dark green above, greenish yellow to orange below. About 10 indistinct olive cross bars. Black spot on caudal peduncle and sometimes another behind opercle. Dorsal pale green. Paired fin pinkish. Eyes orange. Young have large ocellus on caudal peduncle.
Misra (1959)	Light to dark green above, greenish yellow to orange below; 4 wide cross bands on body; a black spot on caudal peduncle.
CSIR (1962)	Green or greenish brown, lighter below.
Hora and Pillay (1962)	Rifle green, lighter on the belly. Young usually with 4 vertical bands on the body and a dark stripe from corner of mouth below eye. Often a large dark blotch on the side of tail base, surrounded by bright sometimes yellow rings.
Srivastava (1968)	Greyish black along dorsal side, becoming lighter along the sides and abdomen. A black spot at the posterior end of the opercle and another black blotch on the sides of the base of tail.
Rao (1971)	Greenish on dorsal side and flanks, pale yellow on abdomen. Paired fins are yellow. A distinct dark spot on the base of the caudal. The two largest spines of the gill cover connected by a black membrane. Juveniles have 4 faint vertical bands which disappear with age. Specimens from Kolleru lake, which have got connection with the sea, are as a rule very dark. This may be associated with various environmental factors.

1795 Anabas testudineus Bloch, Naturges. ausland, Fish.,7, p. 121, pl. 322; type locality: Japan (It is, in fact, an error as the fish does not occur in Japna

1797 Perca scandens Daldorff, Trans. Linn. Soc., 3, p. 62; type locality; Transquebar

1801 Amphiprion testudineus Schneider, Syst. Ichth., p. 204; (Anabas testudienus Bloch)

1801 Amphiprion scansor Schneider, Syst. Ichth., p. 204 (= Perca scandens Daldorff)

1803 Lutjanus testudo Lacepede, Hist. Nat. Poise.,p. 235 1

1803 Lutjanus scandens Lacepede, Hist. Nat. Poiss., 4, p.239

1803 Sparus testudineus Shaw, General zool., 4, p.475

1803 Sparus scandens Shaw, General Zool., 4, p. 475

1817 Anabas testudienus Cuvier, Regne Animal, 2, p. 310

1822 Cojus cobojius Hamilton, Fish. Ganges, pp. 98, 370, pl. 13, fig.33; type locality: Gengetic provinces p.375

1861 Anabas testudineus Cunther, Cat. Fish. Brit. Mus., ?,

1877 Anabas testudineus Day, Fish. India, p. 370, pl.78, fig.3

1889 Anabas testudineus Day, Faun. Brit. Ind. Fish.,2,p.367, fig. 120

1934 Anabas spinosus Gray, Ill.Ind. Zool., 2, pl.89, fig.1

1937 Anabas testudienus Shaw and Shebbeare, J. Asiat. Soc.Beng., 3, p.112; Terai and Duars, N. Bengal

1954 Anabas testudineus Menon, Rec. Indian Mus., 52,p.22; Manipur

1.2.3 Standard common name and vernacular names

The standard common name in native language is "Koi" while in English it is called as "the climbing perch". The vernacular names of *A. testudineus* are given in Table II.

Country	Vernacular names
Bangladesh	Koi
Burma	Nga bye ma
Cambodia	Trey kranh
Ceylon	Kavaiya, Kavaiyan, Pana ayri kend ai
India	Koi, koyee (bengali); Kawai, Kabai, Kavai(Hindi); Kou(Oriya); Sennal, Pauni-eyri, Panaieeri-Kendai (Tamil); Undee-collee (Malayalam); Kai (Assamese)
Indonesia	Betik, Betok, Betrik, Boreg, Puju puju, Pupuju, Bele beleng, Oseng
Japan	Kinoboriuwo
Malaya	Puyu
North Borneo	Ikan karok
Philippines	Atas, Puyo, Ararco, Liwalo, Tinikan, Piit, Puyo puyo, Gutan
Thailand	Pla mor, Pla mor thai, Pla sadet
Vietnam	Ca ro, Ca Ro Dong

1.3 General variability

1.3.1 Subspecific fragmentation (races, varieties, hybrids)

Day (1889) stated that A. testudineus being extensively employed for stocking ponds, considerable differences are found as to its body proportions, the Bengal forms/ On the basis of morphometric studies, Das (1964) segregated 3 ecological varieties of the fish and named them as A. testudineus riveri, A. testudineus lacustri and A. testudineus ricci.

Dube and Munshi (1974) who carried out studies on the blood-water diffusion barrier of secondary gill lamellae of the fish, observed that there occurs a significant intraspecific difference in the thickness of the diffusion barrier which led the authors to identify two varieties of the species, differing from each other not only in the thickness of this diffusion barrier but also in their external morphology. Depending upon the contrasting difference in the the depth of the body, they designated the two varieties as "narrow trunked" and "broad trunked", the former having thinner blood/water barrier than the latter. The authors concluded that the thickness in the blood/water barrier in the two varieties may be functionally related to the ecological conditions of their habitat.

Rao (1971) stated that hitherto it was thought that a single species Anabas, testudienus (= scandens) occurs in our country out the recent investigations made by him (Rao, 1968) revealed the presence of 2 species Anabas testudineus (Bloch, 1795) and Anabas oligolepis (Bleeker, 1855), the former being distinguishable from the latter by its less deep body, longer pectorals, shorter snout and dark spot at the base of the caudal, which, however, fades with age.

Recently, Dutt Ramaseshaiah (1980) found out that the two species (testudineus and oligolepis) differ from each other in their diploid number of chromosomes as well (See: Section 1.3.2). They also observed that the labyrinthine plates in A. testudineus are more convoluted compared to A. oligolepis.

/ as a rule being rather more elongated than the Madras forms.

1.3.2 Genetic data
(Chromosome number, protein specificity)

Kaur and Srivastava (1965) while studying the karyotypes of the freshwater fishes of Uttar Pradesh, counted 48 diploid chromosomes in the adult males of A. testudineus, all the chromosomes being rod-shaped, differing from each other slightly in length. Manna and Prasad (1974) recorded 46 rod-like chromosomes in specimens which they assumed to be A. testudineus. They suggested that the differences between their observations and those of Kaur and Srivastava (1965) in the morphology and number of chromosomes indicate the existence of different "chromosomal races" unless there were technical shortcomings in the work of the earlier authors. Natarajan and Subrahmanyam (1974) counted 48 chromosomes in the fish from Porto Novo in south India.

With a view to clarify the existing controversy concernihg the chromosome number in the fish, Dutt and Ramaseshaiah (1980) conducted studies on the specimens of A. testudineus and A. oligolepis collected from the lake Kolleru in Andhra Pradesh. Observations on the metaphase chromosomes from kidney and gill epithelium cells of the two species revealed the diploid number of chromosomes as 48 in A. testudineus and 46 in A. oligolepis. The authors concluded that the "testudineus" of Manna and Prasad (1974) was, in fact, "oligolepis" and the "narrow" and "broad" trunked specimens studied by Dube and Munshi (1974) were, in actuality, "testudineus" and "oligolepis" respectively.

2. DISTRIBUTION

2.1 Natural range of distribution

Day (1889):	Estuaries and freshwaters of India, Ceylon and Burma, to the Malay Archipelago and Philippines.
Misra (1959)	Fresh and brackishwaters of India and Pakistan, Burma, Ceylon, Malaya, Malay Archipelago, Siam, Indo-China, China, Philippines, Indonesia and South China.
Hora & Pillay (1962)	India, East Pakistan, Ceylon, Burma, Thailand, Malaya, Philippines, Indonesia and South China.
Menon (1974)	Ceylon, India, Nepal, Pakistan, Bangaldesh, Burma, Thailand, Cambodia, South China, Indo-China, Malaya and the Malay Archipelago.

Myers (1937) stated that Anabas has been carried by man across Wallace's line to the eastern part of the Indo-Australian Archipelago. Liem (1963), however, opined that Osphronemus goramy which is as hardy a fish as Anabas, but is far superior as a food fish, has not been carried across Wallace's line by man, Osphronemus would probably be preferred above Anabas for transportation by native. It seems, therefore, less questionable to ascribe the wide range of geographical distribution of Anabas to its exceptional physiological adaptations with respect to air-breathing habit and salinity tolerance (See: Section 3.3.2).

2.2 Ecological characterization of the habitat

Same as reported for Clarias batrachus.

3. BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.1.1 Sexuality

Mookerjee and Mazumdar (1946) observed that during the breeding season, the female puts on a light brown colour on the body and the fins, particularly the pelvics which turn deep brown. Usually, it appears in March-April and gradually disappears after spawning. The colouration actually indicates the ripening of the ova. The mature males during the breeding season acquire glazy black colouration.

Dehadrai et. al. (1973) observed that mature males, at the time of breeding, acquire reddish hue on the body, particularly on the pectoral and ventral fins. The females do not exibit such colouration on the body but their fins do show reddish hue, though faint. The black spot at caudal peduncle becomes very prominent. In males, the spot takes the shape of a diamond shwoing sharp boundary whereas in females, it is oblong and somewhat diffused. Fully ripe females have prominently bulged abdomen due to which the ventral distance between the bases of two pectorals measures markedly more than in males. In females, while this distance remains either equal or more than the length of the isthmus, in males, it invariably falls short to the isthmus length. With the onset of the breeding season, females exibit prominent outgrowth at the vent in the form of genital papilla when gently pressed at the abdomen. Males show complete absence of such a structure.

Banerji and Prasad (1974) reported that the colour difference as described by Mookerjee and Mazumdar (1946) was not noticed in any of the specimens examined. They stated that the ripe or near ripe females, because of the maturing ova, become somewhat pot-bellied anteriorly. As a result, the ventral distance between the pectorals is relatively larger in females than in males.

3.1.2 Maturity

Under favourable conditions, A. testudineus attains sexual maturity in the first year of its life. This has now been also confirmed through rearing experiments.

Based on the study of the relative condition factor, Chanchal et al. (1978) concluded that the males and females attain their first sexual maturity when they grow to 11.3 and 12.2 g in weight and 8.0 and 8.2 cm length respectively.

3.1.3 Mating

Studies on ova-diameter and gonadosomatic index of the fish (Banerji and Prasad, 1974) reveal that A. testudineus has a single specific sqawning, implying that each indiviidual spawns only once during the breeding season.

A. testudineus is monogamous (De, 1910). Banerji and thakur(1981) observed that whenever two males were put with a female to form a breeding set, one of the males proved dominant over the other. In each such sets, within an hour after injection, agitational movement was noticed with the dominant male trying to chase away the other male with sharp pushes and bites. The second male, hwoever, was observed to contribute significantly in the overall spawning saccess. It not only hastened the spawning process but actually involved itself at the later phases of matings.

3.1.4 Fertilization

Fertilization is external. Unlike other Anabantoids, *A. testudineus* neither builds nest of bubbles for laying eggs nor it guards or care for the eggs (Mookerjee and Mazumdar, 1946).

3.1.5 Fecundity

Mookerjee and Mazumdar (1946) examined 3 specimens of almost same length/weight reared under laboratory and natural conditions to record the number of ripe ova in the fish. The average number of ova worked out to be 4590.7 and 9934.6 for the specimens reared under laboratory and natural conditions respectively (Table III°. Khan and Mukhopadhyay (1972) made observations on the fecundity of the fish obtained from Port Canning in West Bengal and found the same to vary from 10,002 to 36,477 in the specimens measuring 99 to 169 mm in total length. The log to log relationship of fecundity to length and weight of the fish, worked out by them, are as under:

$$\text{Log } F = 1.9386 \text{ Log } L + 0.1707 \quad (r=0.7242)$$
$$\text{Log } F = 0.5877 \text{ Log } W + 3.3517 \quad (r=0.6856)$$

Table III

Number of ripe ova in one year old *A. testudineus* (Mookerjee & Mazumdar, 1946)

Fish lengh (cm)	Fish weight (g)	Number of ripe ova
	Laboratory reared specimens	
11.2	25.0	4,200
11.5	26.2	5,000
11.6	26.0	4,572
	Pond reared specimens	
13.8	49.0	10,500
14.6	54.0	10,804
12.8	45.0	8,500

Banerji and Prasad (1974) observed the fecundity of the fish to vary from 4,588 to 34,993 in the size range of 7,3 to 18.2 cm (Table IV).

Table IV

Number of ova in A. testudineus in relation to its length & weight

Fish length (cm)	Fish weight (g)	Weight of ovary (g)	Number of ova	Number of ova/g body wt.	ova/g ovary wt.
&	8.4	1.3	4,588	546	3,529
13.0	37.5	4.3	14,560	388	3,381
14.2	54.4	5.2	18.320	337	3,523
14.7	57.6	8.7	17.509	478	3,162
14.8	164.1	7.6	24.560	383	3,232
16.0	63.7	8.7	15,812	405	2,967
17.1	80.5	12.3	34.993	434	2,845
18.2	100.2	12.7	34,736	340	2,680

Observations made at the Assam Centre reveal that the fecundity of A. testudineus varies form 3.812 to 28,490 in the lengh/weight range of 74 to 138 mm/7 to 57 g (Workshop Report, 1976)

Working on the specimens obtained from Patna wholesale fish markets, Chanchal et al. (1978) estimated the fecundity of the fish to range from 3,481 to 42,564 in the weight range of 9.0 to 53.1 g (Table V).

3.1.6 Spawning

- Spawning season

The spawning season of the fish as mentioned by various authors are as follows:

Day (1889)	: About June and July
De (1910)	: April and May
Willey (1910)	: Found an egg-laden female in January in Sri Lanka
Raj (1916)	: Mid-April to Mid-June
Mookerjee & Mazumdar (1946)	: Middle of April to middle of June
Alikunhi (1957)	: Pre-to post-monsoon
Hora & Pillay (1962)	: During monsoon or rainy season. In India: May to Oct. In Indonesia: December to May
Chaudhuri (1969)	: During rainy season
Banerji & Prasad (1974)	: Gonadal maturity manifests with : early rains and the retrogression is noticed abruptly from September. Breeding takes plaee only after the rains have fully set 1 in and have filled the ditches around the perennial waters

- Frequency of spawning

A. testudineus spawns only once during the breeding season. During spawning, 78 to 85% of the eggs are shed and those with-held, are resorbed iltimately (Banerji and Prasad, 1974).

- Spawning time of day

In nature, depending upon the availability of the favourable conditions, the fish spawns irrespective of the dark and lighted hours of the day. Under controlled conditions, it can be bred at any desired time of the day merely by adjusting the time of injection. Moitra *et al.* (1979) stated that the fish breeds even during day time if the temperature is controlled and the surroundings remain dark, calm and quiet.

- Spawning ground

Mookerjee and Mazumdar (1946) observed that during breeding season, after a heavy shower of rain, the fish migrates from the perennial pond to breed in paddy-fi lds or some seasonal ponds with atleast 8 or 9 inches of water. They further stated that "agreeing with Innes (1935), we also found that the fish does not build nest of bubbles like other Anabantoids". Chaudhuri (1971) has also expressed similar views with regard to the spawning ground of the fish.

A. testudineus has been observed to have regionalized availability in the state of Bihar. It occurs mostly in the northern part and rarely in the southern part of the state. Banerji and Prasad (1974) tried to investigate upon this point through the observations on the spawning ground, breeding behaviour and the factors limiting the survival of fry of the fish and came forward with reasonings to explain as to why the fish is confined only to particular belts. They stated that the hydrography of the areas naturally inhabited by the fish, offer myriads of pools, puddles and depressed lands with seasonal accumlations of rain water where the ripe fish migrate for breeding. Even if the fish happen to breed within the regime of the perennial water, their buoyant eggs and the immediately hatched out larvae are likely to float out with spills to the seasonal waters, where the conditions for the survival of the progeny are more conducive as compared to the perennials. Where such a situation is not obtainable, the fish finds it difficult to establish in the natural course.

3.1.7 Induction of spawning

Mookerjee and Mazumdar (1946) bred A. testudineus as early as in 1941 by keeping the fish in rain water collected in and aquarium (22"XII"XII), the temperature and pH of the water being 83°F and 8.0 respectively. In 1942, they again experimented on the breeding of the fish under the constant flow of water maintained through a siphonic system. The water was supplied from a reservoir filled from a jhil. In this case, the fish did not get actual rain water but they got the water from the jhil which had rain waters in addition to its old water. The fish bred successfully, the temperature and pH of the water being 79°F and 7.9 respectively. Based on the results of these experiments, they concluded that the increase in the oxygen contents of water produced either by falling of rain or by rushing of water, simulated the fish to spawn in aquarium.

Khan (1972) and Khan and Mukhopadhyay (1975) conducted experiments on the imduced breeding of *A. testudineus* through hypophysation using the pituitary glands of the Indian major carps and was able to breed the fish at the dowe of 60 and 50 mg/Kg body weight to the female and male recipients respectively, Banerji and Prasad (1974), however, observed a low dose of merely 15 to 20 mg of carp gland administered in a single instalment to the quite effective for the purpose. Contrary to the findings of Mookerjee and Mazumdar (1946), they observed that the dissolved oxygen content of the water does not have any relevance in the breeding of the fish. They were able to breed the fish in water collected from a derelict pond with D.O. content 0.8 ppm and free CO_2 12ppm under the influence of he pituitary injection. They also reported that during July 1972, when the water temperature did not come down below 32°C/could be induced to breed by simply controlling the temperature of the aquarium water using ice. A 10 month old female of 7 cm length was the smallest to breed in the laboratory, induced only by the control of temperature. Moitra *et al.* (1979) who observed successful spawning of *A. testudineus* under laboratory conditions, also opined that temperature is the vital point to be considered for proper spawning, 28.5 ± 1°C being its optimum range.

Spawners of *A. testudineus* picked up during the course of their migration, respond readily to breeding without injection. On 16.6.1973, one female and two males were cought during the course of their migration in torrential rains from a swampy water mass to the low lying meadows in Assam. The fishes were kept in a plastic pool, filled with tap water. The fish bred naturally when due to incessant rain, the water temperature came down to 26.5°c. The fertilization was 90% (Workshop Report, 1976). Banerji and Prasad (1974) also reported such instances of natural breeding when migrating pairs were kept together without inducement.

Giving details about the technique of breeding the fish under controlled conditions, Thakur and Murugesan (1979) wrote that the adult specimens procured from the markets during summer months thrive well in captivity on a regular food of cerial bran and live aquatic insects such as *Anisops*, *Corixa* etc. They serve allright as spawners during the breeding season. For better and surer results, however, the best is to use spawners freshly collected from ponds. Pairing is usually done in the ratio of 1 female : 2 males. For the preparation of the pituitary extract, standard mothodlogy, as prescribed for carps, is followed, the concentration of the same being 1 mg of the gland/0.2 ml of the solvent. Injections are given intramuscularly, a little posterior to the base of the dorsal fin.

/because of the prevailing drought conditions, 3 ripe pairs selected from the specimens reared in cages with water temperature over 34°c

Spawners take varying periods of 6 to 28 hours after the injection for the commencement of spawning activity. A female weighing about 50 g, on an average, pordųces about 20,000 eggs.

A. testudineus is notorious for migrating and breeding into prepared carp nurseries. This habit can be taken advantage of in breeding the fish in some of the sparable nurseries of a fish farm under inducement. This also helps in solving the problem of larval rearing to a great extent.

3.1.8 Spawn

Describing the impregnated eggs of *A. testudineus*, Mookerjee and Mazumdar (1946) wrote that the fertilization eggs are small, almost circular and lighter than water, measuring about 0.7 mm in diameter. They float on the surface scattered here and there with oil globule placed at the top. They look like crystal clear tiny glass spheres with no adhesive filament or any adhesive substance. Living eggs are transparent and exibit signs of development while the unfertilized ones look opaque and milky.

3.2 Larval history

3.2.1 Embryonic phase

The developmental features of the fertilized eggs of *A. testudineus* are given in Table V.

Table V.

Developmental features of the fertilized eggs of A. testudineus (Mookerjee and Mazumdar, 1946)

Time after fertilization	Developmental features
0 h 0 min	Fertilized eggs
0 h 40 min	Two-celled stage
1 h 05 "	Four-celled stage
1 h 25 "	8-celled stage
1 h 50 "	16-celled stage
2 h 00 "	32-celled stage
2 h 20 "	Multi-celled stage, looking like cauli flower
3 h 00 "	Cauli flower like appearance lost as the cells spreads out
4 h 00 "	Blastoderm extends over more than half of the yolk mass
4 h 45 "	Blastoderm spreads over 3/4th of the yolk mass
9 h 00 "	Yolk invasion is nearly complete
10 h 00 "	Formation of ambryonic ridge
10 h 30 "	Head and tail ends of the embryonic ridge
12 h 00 "	2-somite stage
12 h 30 "	12-somite stage
12 h 45 "	16-somite stage, optic cups appear, Kupfer's vesicle visible
13 h 15 "	Pigments appear, tail moves and getting detched from the yolk
14 h 20 "	Pigments increase on the nape, fin-fold expands, 1/3rd of tail detached from yolk and it moves faster
15 h 00 "	Otocysts appear, pigments develop on ventrolateral region
16 h 00 "	Embryo exhibits jerking movements
17 h 30 "	Egg membrane weekens, heart pulsates @ 140 to 160 bpm
18 h 30 "	Larva hatches out

Mookerjee and Mazumdar (1946) stated that the period of incubation varies between wide limits with variation of temperature. They noted that the eggs usually hatch out between 18½ to 20 hours at 83°F and in majority of the cases, the tail comes out first. Chaudhuri (1969), however, stated that the incubation period is 24 hours at 27 to 30°C while Hora and Pillay (1962) wrote that embryos hatch out after 24 hours at 28°C.

3.2.2 Larval phase

The larva on emergence, measures 1.9 mm in length. It rests in upside-down position with the yolk-sac directed upwards at the water surface. If disturbed, it moves down to mid-water and swims in the same inverted positiontill it returns to the water surface. Larva, at this stage, possesses no mouth. Heart pulsated @ 120 bpm. Pigments on head are round while those on the yolk-sac, are stellate and scattered.

The different stages of the larval development of the fish are given in Table VI(next page).

Table VI

Larval development of A. testudineus
(Mookerjee and Mazumdar, 1946)

Time after hatching	Lenght of larva (mm)	Developmental fearures
6 hours	2.0	Patches of pigments prominent at nape, above eyes and in front of it. No pigments on fin-fold. Slit-like mouth, inferior in position.
9 hours		Lens in eyes appear as tiny globules. Pits to form otocysts deepen. Pectoral buds appear. Otoliths visible.
12 hours		Pigments on eyes increase. Pericardium enclosing the heart noticeable. Heart appears two-chambered. Blood greenish yellow in colour.
15 hours	2.5	Pectorals assume flap-like shape. Otocysts constricted. Narial apeartures formed.
20 hours		Gall bladder formed.
1 day	3.0	Mouth elliptical. Lower jaw moves occasinally. Formation of air-bladder indicated. Gills appear as combs. Operculum membraneous. Yolk-sac rapidly diminishing. Pectorals fringed, broad and more or less paddleshaped. Black melanophores extend tothe ventro-lateral region.
2 day		Mouth opens, occupying terminal position. Lower jaw moves briskly. Larva begins to orients it body in the normal upright position and starts wandering in the mid-water as well as at the bettom. Gut contains yellowish. Air-bladder round, small and silvery white in colour.
3 day	3.5	Gape of mouth quite large. Rudimentary rays appear in pectorals. Gill filaments quite prominent. Yolk completely absorbed.

By around 5th day, the post-larva attains about 6mm in length. Head becomes considerably enlarged. Eyes look conspicuously prominent. Upward deflection of vertebral column at tail-end is noticcable. Nine rudimentary rays appear in caudal fin. Opercular bones are differentiating. Stomach region tends to grow saggy. On 10th day, the length of post-larva increases to about 9 mm. Caudal fin shows 11 distinct rays and dorsal, 18 spinous and 9 soft rays. Seven vertical bands are formed on either side/of the caudal peduncle near the base of the tail. Scales appear. Aerial respiration manifests after the attainment of about 10 mm size.

By 15th day, the size of he post-larva increases to 15mm. Scales are fully formed. The number of vertical bands increases to 10 and the blotch at the caudal peduncle gets surrounded by a light yellow ring. A black spot also develops at the end of the operele. On 20th day, the post-larva attains an average length of 24 mm. All the fins show their usual number of spines and rays and the post-larva looks like miniature adult.

Mookerjee and Mazumdar (1946) stated that the question of feeding the larvae arises by the 2nd day of hatching itself when mouth of the larva opens and it starts accepting ciliates and flagellates. No sooner the yolk is absorted, it shows increasing appetite for food. The post-larva, at this stage, shows greater preference towards a protozoan diet. The fish turns to small crustaceans such as Daphnia and Cyslops only from the 10th day onwards when it becomes capable to seize such diets. From 15th day, the fry is able to consume mosquito larvae and likewise the liking for crustacean and insect diet gets established in the fish.

In nature, the just hatched out larvae are very much disposed to destructions by various kinds of predators and harmful organisms. A paradox is that the Cyclops, otherwise a preferred food to the young fry, can on other hand prove highly damaging to the crop of young larvae, sucking through their soft body wall. Banerji and Prasad (1974) observed that a concentration of 1500 number/litre of water, the Cyclops become substantially harmful to the spawn of A. testudineus and the stage at which the fry can ward off attacks of Cyclops is only when it attains the length of over 7 mm (See: Table VII).

/ of the body and a black blotch on either side

Table VII

Survival of fry of A. testudineus with different densities of Cyclops (Banerji and Prasad, 1974)

Number of Cyclops/1 od water	Survival of fry in size range of 5-7 mm at 6 h	12 h	24 h	Survival of fry in size range of 6-9 mm at 6 h	12 h	24 h	Remarks
3,000	9	nil	nil	14	13	13	Surviving ones
1,000	11	nil	nil	12	10	9	between 7.8 to
750	22	22	16	25	23	23	9mm size range

* Experiment was conducted in glass jars with 2½ litres of tube-well water and 25 number of fry in each case.

Banerji and Prasad (1974) observed that the risk from Cyclops could be considerably circumvented by rearing the larvae in hapas/in zooplankton. The cloth wall cuts down the entry of Cyclops and at the same time allows the ingress of innocuous food organisms like protozoans and rotifers etc. The larvae start feeding within 24 hours of hatching and those reared in hapas gorge their stomach with Brachionus, Keratella, ciliates etc. Occasionally, small Cyolops, cladocerans and blue-green algae are also taken. In hapas, the size over 7 mm, non-vulnerable to the attacks of Cyclops, is attained in about 10 days time. As an alternative to hapa rearing, the larvae could as well be reared in plastic pools or other suitable containers holding clean tube-well water, sustainingly fed upon a diet of rotifers and other such minute organisms sieved out from the plankton collection through fine mesh cloth, if necessary through double fold.

Pal et al. (1977) experimented with 6 different types of feeds (wheat flour, rice bran, soyabean powder, prawn meal, zooplankton and cooked hen egg) on 3 day old spawn of A. testudineus and found that the young larvae could be reared up to fry stage (15 day old) on cooked egg diet with over 70% survival. They observed that one egg gives about 20 g of feed which is sufficient for feeding 100,000 spawn/day. They also noted that feeding with zooplankton gives relatively better rate of growth but survival comes down to 48 to 58%. The suthors, however, suggested to make use of zooplankton as diet provided the Cyclops are avoided.

/made of synthetic cloth (with 50/mesh/linear cm) fixed in ponds rich

Banerji and Prasad (1974) observed that survival of fry in a brood of *A. testudineus* gets markedly reduced owing to intra-brood belligerence which can be borne out by the fact that nearly 2% of them outgrow the rest as "shoot" fry. To get an idea of the extent of harm caused due to intrabrood hostility. they kept 1200 spawn in a synthetic hapa enclosing about 700 litres of water and noted the decline in population during the course of rearing. Apparently, there was 78% fall in population by the time fry attained an average length of 20 mm within first 10 days of rearing itself. Even in the surviving population, the smaller specimens bore marks of agression like torn caudal fin or abrased caudal peduncle.

Banerji and Prasad (1974) further noted that even after the risk form *Cyclops* is avoided and care is taken about the intra-brood cannibalism through the removal of "shoot" fry, the space is another important factor which is required to be looked into. They observed that to achieve over 50% survival in raising stockable fry of about 20 mm length, on an average, 1.5 litres of water space has to be provided to each fry. Mookerjee and Mazumdar (1946), however, recommended provision of 3 to 6 square inches of water surface to each *Anabas* fry of 3 to 20 mm length.

Pal *et al.* (1976) made certain observations to ascertain the oxygen requirement of *A. testudineus* during its post-larval stage and found out that the consumption of oxygen by 2 days' old spawn is about three times more than the 4 to 6 days' spawn. They suggested that the high rate of oxygen consumption of 2 days' old spawn should be taken into consideration while transporting it in closed containers.

3.3 Adult history

3.3.1 Longivity

Preliminary observations on the age and growth of the fish (Thakur, unpublished) have revealed the presence of up to 3 annual grwoth rings in its otolith, which indicate 3 years life span of the fish, the maximum total length in the sample being 185 mm. The length of the largest recorded *A. testudineus* is, however, 260 mm (See: Section 3.3.7).

3.3.2 Hardiness

A. testudineus is an extraordinarily hardy fish. There is a common saying that *Anabas* is so hardy a fish that it keeps a witness to the man who catches it, who cleans and cuts it and even to the person who puts it into the fry-pan for cooking. It can survive in very poorly oxygenated waters owing to its ability to breathe from air and even outside water it is able to live for prolonged periods. According to CSIR (1962), the fish can survive out of water in moist air up to 6 days. Hora and Pillay (1962) stated that the fish is able to withstand such adversities by retaining water in the labyrinthiform organs. They further stated that the optimum temperature range of the fish is 20 to 30°C but it has resistant even to temperatures below freezing point.

A. testudineus is reported to have more than usual salt tolerance. Liem (1963) stated that numerous specimens of *Anabas* are collected daily form the Bay of Djakarta (Java) and it is very likely that it is able to cross narrow sea barriers, which is probably the reason for its wide geographical distribution.

Khan *et al.* (1976) carried out experiments on salinity tolerance of *Anabas* fry of 14 mm average length in which no mortality was recorded up to 11.5‰. At 12.5‰, however, total mortality occurred within 29 hours. With the increase in salinity concentration,/ 25 minutes at 30‰.

Banerji and Prasad (1974) observed that in the early stages, *Anabas* is as/any other fish. They noted that the larvae delicate reared in plastic pools fixed under open sky, during sunny whether showed sudden mortalities whereas larvae kept under shade in the same conditions behaved quite satisfactorily. Obviously, the larvae could not stand diurnal fluctuations of 4 to 5°C of water temperature. Another evidence of its sensitivity to sudden environmental change was experienced when some fry in the size range of 25 to 28 mm reared in plastic pools were transferred to synthetic hapas fixed in a derelict pond. No sooner the fry were stocked, they started dying, althrough the pond had healthy stock of other air-breathing fishes including *Anabas* without showing any sign of distress. The pond had 2 degress of higher water themperature that the water in plastic pool and had the other conditions common as seen in a deep muck-laden pond in a sunny afternoon including *Microcystis* bloom.

/the time required for complete kill was also reduced being only

3.3.3 Competitors

Same as reported for *Clarias batrachus* and *Heteropneustes fossilis*.

3.3.4 Predators

Same as stated for *Clarias batrachus* and *Heteropneustes fossilis*.

3.3.5 Parasites and diseases

The following parasites and diseases have been reported from *A. testudineus* :

Tumours	: In labortary reared specimens (Southwell and Prasad, 1918; Mookerjee and $Ma_{z}umdar$, 1946). Pal (1976) reported on treatement of tumours.
Lymphocystis	: In cage reared specimens in a sewage fed pond at Darbhangà (Workshop Report, 1976; Thakur and Nasar, 1977).
Trichodina & Myxosporidian parasites	: In specimens collected form Pitkàti beel in Assam (Workshop Report, 1972).
Tail and fin rot	: In specimens collected from Sorbhog beel in Assam (Workshop Report, 1972).

3.3.6 Injuries and abnormalities

No reports are available concerning injuries and abnormalties in *A. testudineus*.

3.3.7 Maximum size

The maximum recorded size of *A. testudineus* is 23 to 26 cm (CSIR, 1962). Day(1889) stated that it attains atleast 8½ inches in length. Hora and Pillay(1962) recorded the maximum size up to 230 mm. Shaw and Shebbeare(1937) encountered mostly smaller specimens than Day. Mookerjee and Mazumdar (1946) noted it up to 177 mm while Misra(1959) observed it up to 203 mm, Rao (1971) 150mm and Banerji and Prasad (1974) 190 mm.

3.4 Nutrition and growth

3.4.1 Food and feeding habits

The food habits of *A. testudineus* as described by various authors are given in Table VIII.

TABLE VIII

Food habits of *A. testudineus*

Author	Food habits of *A. testudineus*
Mookerjee & Mazumdar (1946)	Fry (3-9 mm) take ciliates and flagellates. Fry bigger than 9 mm, begin to take samll crustaceans and unicellular algae. Fry form 15 mm start taking mosquito larvae, worms etc. Adults (60-177 mm) take damsel fly larvae, dragon fly larvae, mosquito eggs and larvae, black and red ants, crickets, locusts, crustaceans, nematodes, rotifers, protozoans, fish, fish eggs and scales, unicellular algae, diatoms, aquatic vegetation, boiled rice and paddy.
Alikunhi (1957)	Though predatory in nature, it is not highly piscivorous and does very little harm to carp fingerlings over 4" in length. Young ones feed voraciously on microcustacea and insects. Adults are predominently insectivorous, though shrimps, ostracods, gastropod shells, and young fish are also taken.
CSIR (1962)	It is a voracious carnivore.
Hora and Pillay (1962)	Larvae and young feed on phyto- and zooplankton in about equal parts. Large fry and adults feed on crustaceans, worms molluscs and insects, which make up about 70% of its diet. Algae and soft higher plants constitute about 25% and the rest is organic debris. In paddy-fields, it feeds on paddy grains and in ponds, on white ants and dead forage fish.
Chaudhuri(1971)	Same as *C. batrachus* and *H. fossilis*.
Jhingran (1975)	Fry: minute protozoans, animalcules and water fleas. Fingerlings: Mosquito and other insect larvae, water fleas etc. Adults: Insects, water fleas, vegetable debris, fish etc.
Assam Centre (Workshop Report, 1976)	In 67-90 mm size range: *Synedra*, *Navicula*, insect larvae, nauplii of copepods, Euglena, cladocerans, tubifex, ctenoid scales and debris. In 91-110 mm size range: *Synedra*, *navicula*, filamentous algae, *Cyclotella*, *Diaptomus*, half digested insects, rotifers, *Cyclops*, nematodes and debris.
Bihar Centre (Workshop Report,1978)	The scope of natural food of the fish is very wide as it can vary form a diet of filamentous algae to a diet of pure carnivorous nature. The fragmentary nature of

....Contd. ....

	the food items encountered in the gut contents indicates that the fish makes good use of its pharyngeal teeth in masticating the items it feeds on.
Singh and Samuel (1981)	A microplankton feeder in its larval and fry stage but soon becomes insectivorous and voracious feeder.

A. testudineus is predominatly an insectivorous fish. Experiments carried out on the capacity of the fish to feed on insects revealed that the number of insects (*Anisops*) consumed/fish per day is significantly high (Table IX). However, considering the unit weight of the insects consumed per unit body weight of the fish, there occurs a gradual decrease in consumption with the increase in the weight of the fish which conforms to the higher rates of mrtabolism in small fish compared to the larger ones.

Table IX

Capacity of *A. testudineus* to feed on *Anisops*
(Workshop Report, 1972; Dehadrai & Banerji, 1973)

Expt. No.	Nos. of fish used	Av. fish length(cm)	Av. fish wt.(g)	Av.nos. *Anisops* consumed/ fish/day	Av.wt.(g) *Anisops* consumed/ fish/day	Consumption of *Anisops* (% in the body wt. of fish)
1	8	3.66	1.98	21	0.315	15.9
2	8	4.95	3.29	31	0.465	19.7
3.	8	5.12	3.55	38	0.570	16.1
4	8	13.10	36.80	123	1.845	5.0
5	8	13.53	37.20	130	1.950	5.2
6	8	13.15	37.50	152	2.280	6.1

Average weight of each *Anisops* being 15 mg

Mookerjee and Mazumdar (1946) stated that the proportions of isects and crustaceans in the diet of the fish varies considerably according to the locality inhabited by the fish and its environmental conditions. For instance, in the specimens collected form paddy-fields the percentage of insects in the diet remains invariably more compared to the specimens collected form ponds. Discussing about the occurrence of terrestrial ants in the gut contents of the fish, they stated that the ants fall victim to the fish during their accidental plunge into the water while moving on plants over-hanging the pond surface.

Going by the nature of the various items of food encountered in the gut contents, it appears that A. testudineus utilizes all the available niches of a water mass to derive its food.

Taking cue from the findings of Menon and Chacko (1955) that algae (Spirogyra maxima) forms one of the natural foods of Anabas, Vivekanandan et al. (1977) studied the effects of algal and animal food combinations on surfacing activity and food utilization in the fish. They fed the fish on 5 different combinations of the alga and goat liver. With increasing liver supplementation, the following increases were noted: consumption of food from 31 to 152 cal/g live fish/day, assimilation efficiency form 88 to 98%, production rate form 1.5 to 45.5 cal/g/day and the efficiency from 5 to 17%. During culrure operation of the fish, the authors have recommended the supplementation of algal food up to 22%. To exchange atmospheric air, the fish surfaced 432 and 1296 times/day when fed on 100% S. maxima and 100% liver, respectively.

Pandian et al. (1977) studied the effects of fluctuations in the Po_2 on surfacing activity and food utilization in the fish. They noted that the fed fishes surfaced 555 times, swimming 278 m/day in non-aerated water (Po2: 66 mm Hg) and 855 times, travelling 428 m/day in aerated water (Po2: 147 mm Hg). Consumption, assimilation, production and metabolism of either series averaged 22, 18, 5 and 13 mg dry substance/g live fish/day, respectivelt. The high Po2 elevated the rate of metabolism, increased the surfacing and swimming activities but failed to alter food utilization They concluded that the culture of Anabas in aerated water would offer no advantage over non-aerated water. Starved fishes in non-aerated and aerated waters surfaced 330 times and swam 164 m/day, expending 1,5 mg/g/day.

3.4.2 Age and growth

No reports are available pertaining to the detailed studies on the age and growth of *A. testudineus*.

Mookerjee and Mazumdar (1946) studied the growth rates of the individuals of the same brood stock grown under laboratory and natural conditions (Table X). The authors concluded that the growth of the fish is influenced by the environment which in turn also reflects on the reproductive activity of the fish as can be observed by the differences in the number of ova in the specimens reared under laboratory conditions/at the Bihar Centre were observed to have attained weights of 13 to 28.2 g in one year and 31.2 to 40.6 g in the second year (Workshop Report, 1972). Hora and Pillay (1962) observed that in ponds, the fish /length grows to about 12 cm in /-in 1st year and 20 cm at the end of the second.

Table X

Growth of *A. testudineus* grown under laboratory & natural conditions (Mookerjee and Mazumdar, 1946)

Months	Growth rate of the fish under Laboratory condition		Natural condition	
	Length (mm)	Weight (g)	Length (mm)	Weight (g)
1	32.0	2.00	50.0	5.0
2	60.0	7.00	80.0	16.0
3	80.0	10.00	114.0	24.0
4	91.4	11.65	126.0	34.0
5	96.5	16.00	134.0	40.0
6	102.0	20.25	135.0	42.0
7	107.8	20.55	137.0	45.0
8	108.2	20.75	138.0	46.0
9	112.9	20.95	140.0	47.0
10	112.9	22.75	141.0	49.9
11	114.0	24.90	146.0	50.5
12	114.5	25.20	149.0	54.0

/(See Table III) specimens reared under laboratory conditions

*The initial length of the fish at the time of stocking being 1.9 mm

Thakur and Das (1977) worked out the following regressions of length-weight relationship in the fish:

Juvenile		Log W = −6.0211 + 3.7107 Log L
Adults:	Male	Log W = −5.2297 + 3,2178 Log L
	Female	Log W = −5.1715 + 3,1899 Log L
Combined (Male+Female)		Log W = −5.2039 + 3.2053 Log L

Chanchal *et al.* (1978), however, observed that weight of the male fish increases by an exponent (regression coefficient) of 2.41 and female by 2.38.

Thakur and Das (1977) observed that the values of relative condition plotted against length of the fish displays distinct "valleys" and "peaks" which are probably attributable to the phases spawning and recovery during the life span of the fish. The changes in the mean values of relative condition during different months are largely due to cyclical change in the gonad weight of the fish. Chanchal *et al.* (1978) noted the point of first inflection in the relative condition curve of the fish at 11.3 g in the case of males and 12.2 g in females which, according to them, are indicative of the size at which the first sexual maturity is attained by the fish. They have also confirmed their findings through histological observations on the gonads of the fish.

3.5 Behaviour

3.5.1 "Walking" on land

A. testudineus is well know for its habit of "walking" on land. Mookerjee and Mazumbar (1946) stated that such overland journeys are performed by the fish mainly with two purposes: (1) in search of a safer place to deposit its spawn and (2) in search of a shelter to avoid high temperatures of summer months when its old babitat starts drying up. Hora and Pillay (1962), however, are of the view that the fish leaves the water in search of earthworms etc.

Describing about the walking behaviour, Rao (1971) wrote that during such movements, the fish uses its gill covers and fins. Though it can move on land in upright position, the usual movement is effected with the animal lying on lateral side. In this position, the gill covers and the tail fin are used. The gill cover facing the ground opens out and gains hold with the help of its spinous margin. Meanwhile, the tail fin hits against the ground, the fish jerks forward and the gill cover comes back to normal position. The process is repeated and likewise the "walking" is effected. While moving in an upright position, the paired fins are well spread, the gill covers open and close persistently and the tail fin lashes vigourously propelling the fish forward.

Climbing of Anbas on palmyra trees to about 5 feet from ground level is discounted by many ichthyologists. But even today native fishermen narrate stories of having seen Anabas climbing wild date-palm and drinking toddy. Smith (1945), a noted ichthyologist, stated that in Thailand, Anabas is exposed to sale in large wicker baskets. The fish is often seen climbing up the sides of the wicker baskets and jumping out. He aserts that "a palmyra palm, with its rough bark and its fronds beginning near the ground, would be no more formidable for an Anabas to ascend than would be the vertical side of a wicker basket".

3.5.2 Colour vision

Jana and Sukul (1972) observed that the fish is able to discriminate between hues of colours on their qualitative basis and not on their quantitative basis. They were able to successfully train the fish to differentiate red form green, blue, yellow, grey and violet, violet form blue, green and grey as well as green from blue. Since thewater and ocular media absorb and disperse most of the light of shorter wave lengths, the light of longer wave lengths probably reach retina of the fish in greater quantities and consequently stimulate the photoreceptors to a greater extent. The authors concluded that the fish possesses some mechanism for colour vision which is mediated through trichromasy.

3.5.3 Respiratory behaviour

A. testudineus is an obligatory air-breather. Hora(1935) observed that *Anabas* gets asphyxiated sooner than *Heteropneustes* when not allowed access to the water surface. Hughes and Singh (1970)a and b) observed that *A. testudineus* obtains 53.6% of its total oxygen supply from air and the rest (46.4% form water. Hughes *et al.* (1973) noted that the combined surface area of the labyrinthine organs ans suprabranchial chambers in *Anabas* is greater than that of the gills which suggests that the fish has greater dependence upon air-breathing organs for respiration. Munshi and Dube (1974) observed that the gills of smaller *Anabas* have higher efficiency in oxygen uptake (mg/kg/hr) than those of the bigger ones. The capacity of smaller *Anabas* to survive for longer periods depending upon gill breathing alone than those of bigger ones may also be related up to certain extent to comparatively higher diffusing capacity of their gills in gaseous exchange (Dubw and Munshi, 1974). This is also evident from the fact that in smaller *Anabas*, the number of secondary lamellae/mm remains fairly high in comparison to the bigger ones (Hughes *et al.*, 1973).

A. testudineus also activates. If its home pond dries up, it walks down to another body of water or burrows itself into the mud where it remains dormant through the dry season.

3.5.4 Feeding behaviour

Mookerjee and Mazumdar (1946) reported that *A. testudineus* is seen to lay in wait and spring up to snatch grass-hoppers and other insects sitting on rice plants or weeds. Its eyes are capable of aerial vision. The fish is guided by its sight to prey upon its food. Rao (1971) stated that *Anabas* is found in paddy fields where it feeds on paddy grains. In a way, it destroys paddy crop. Just before the crop is ready, the plant bends. *Anabas* is then seen jumping out to bite the grain.

In laboratory, according to Rao (1971), the fish accepts almost anything form" idli" to cockroaches. When fed with paddy grains, it immediately swallows them, then makes grinding sounds which are clearly audible form a distance and following this, it vomits out the husk, For this, the fish possesses an efficient grinding apparatus in the pharynx. It consists of two sets of teeth, one on the roof of the pharynx/is in 3 patches. An anterior "T" shaped patch consisting of a number of conical teeth. Behind this, there are two patches of teeth arranged side by side near the longitudinal arm of "T" shaped patch. In these two patches, a number of teeth with blunt surfaces remain crowded together so that a hard, uneven surface is formed very much resembling the face of a "grinding stone". The ventral set of teeth forming the floor of the pharynx consists of two patches. Both these patches are more or less tringular in shape and are so closely set that it appears as a single triangular patch. The sound that is audible when fish feeds on paddy grains is evidently dur to the grinding of grains between these two sets of pharyngeal teeth. As a result of grinding, the paddy grains are dehusked, husk is vomitted and the ground particles are swallowed.

3.5.5 Mating behaviour

Mookerjee and Mazumdar (1946) stated that during the intervals of laying eggs, the female rests for a few seconds at one of the corners of the aquarium. During this period, the male makes advances by nosing her at the vent region. With repeated nudging, the female gets stimulated. The male then suddenly bends round convering its body into a ring round the female which remains motionless and absolutoly submissive. In this posture, the head of the male fish nearly touches its tail and thevent is brought into the proximity with that of the female. Simultaneously, both turn over describing a semicircle, so that the female now remains with ventral side up. The pair remains stationary in this posture for 12 to 15 seconds. The pelvic fins of the male stand erect and pectoral as well as caudal find of both show some signs of movement. The male now relaxing its grip moves to one side and the female with ventral side up, before resuming its normal position, sends up a stream of about 30 eggs which are shot by the force of egection. The act of mating is repeated a number of times till about 5000 eggs are laid. If the spawning party are too much disturbed, it stops spawning and wait till it does not find suitable conditions.

/and the other on the floor. The dorsal set of teeth roofing the pharynx

Banerji and Thakur (1981) made some observations on the spawning behaviour of A. testudineus while breeding the fish through hypophysation. They observed that the impulse to mate manifests when the male changes its listless swimming to frequent tense chases after the female, nudging her at the belly, sides and head. In the beginning, the female shows indifference to the pursuits of the male and tries to glide past it. Each time the female swims up to the surface for air-breathing, the watchful male quickly follows suit and stalls the female tapping her body with light bites. The female ultimately responds by assuming a typical staring pose at the male when it is taking rest after the bouts of chase. During such spells, the male sitting at a distance often make sharp quivering motions erecting its dorsal fin and rapidly flapping its pectorals. It even makes a few obdurate and coaxing chase grazing against the body of the female. To it, the female responds by erecting out the dorsal fin and effecting undulating movement of the body. The play finally consummates into mating in which male and female take parallel position and get chasped to each other. They remain suspended in the column, in this posture, making constant quivering for about 5 to 10 seconds. The male then suddenly bends making an arch round the body of the female which in turn responds by bringing ger ventral side up. Before separating out, the female spurts out a batch of about 20 to 30 eggs. The eggs get dispersed in water and then very slowly rises to the surface. Ejection of milt is not visible owing to its quick miscibility in water. The gaps between successive matings differs form 2 to 10 minutes and there occurs about 20 to 30 matings spread over a duration of 3 to 4 hours. Close of mating act is indicated by relaxing mood of the spawners and their invariable tendency to gulp down a few mouthfuls of the released eggs floating on the surface.

In the sets, where two males are tried with a single female, one of the males dominates over the other. In each such set, within an hour after injection, agitational movements start with the dominant male trying to chase away the other male with sharp pushes and bites. When mating commences, the weaker male, however, always tries to intrude and the dominant male chases him out, no sooner it is free form the mating act. During the closing phase of the mating, however, when the dominant male takes longer spells of rest, the weaker maleavails of the opportunity and mates with the female. The second male thus appears to be more responsible for the final and the overall spawning success.

4 POPULATION

4.1 Structure

4.1.1 Sex ratio

Chanchal et al. (1978) examined more than 200 specimens of *A. testudineus* which revealed the sex ratio in the species to be 3 females : 2 males.

4.1.2 Age and size comp9sition

Banerji and Prasad (1974) analysed the weight frequency distribution of the representative sample of *A. testudineus* form the local collection in North Bihar and found out that the fishes up to 50 g weitht constitute 89.7% of the catch by number, representing previous season's progeny. This is in agreement with the annual nature of the "chaur" fisheries which is the main source of the landing of the fish in that region.

5 EXPLOITATION

5.1 Fishing equipments

5.1.1 Fishing gear

Fishing with hand

Seasonal supply of *A. testudineus* comes mostly form the catches of low lying swampy and marshy tracts as well as derelict pits, pools and puddles which remain in the process of drying up during summer months. The usual practice of fishing is to divide the water area into small segments by erecting coffer dams, bail out the water form the enclosed areas and catch the fish by groping into the mud by hand. Sometimes, plunge baskets are also used to trap the fish in liquid mud.

Like *Clarias batrachus*, *A. testudineus* is also caught during rainy weather when it remains in the process of prowling about on wet land.

- Cast net

Like other air-breathing fishes, Anabas also had the habit of burying itself into mud no sooner a net is cast, Hence, to obtain the catch, the net after casting, is allowed to settle down at the bottom and then its periphery is hurridly sealed by pushing it inside the mud. The enclosed area is then groped into for catching the entrapped fishes.

- Drag net

The trick of trapping Anabas in a drag net is the same as employed for Clarias and Heteropneustes.

- Hook and line

Mookerjee and Mazumdar (1946) stated that grass-hoppers, larvae and pupae of red ants form good baits during fishing particularly with "Barra" and rod and line. Barra is a kind of baited spring, made of thin bamboo splints bent in the form of an arch, with pointed ends, (De, 1910).

5.1.2 Fishing boats

Boats are not needed for the exploitation of Anabas.

5.2 Fishing areas

See Section 2.1

5.3 Fishing season

A. testudineus is caught practically all round the year However, the post-monsoon and summer months are marked out for relatively intensive periods of its occurrence.

6 CULTURE

Despite moderate size, *A. testudineus* is regarded as a highly esteemed fish for its fine flavour, restoratige values and prolonged freshness out of water. It is for these eye-catching qualities that *Anabas* has been attracting attenting of the fish groweres since olden times. Day (1889) wrote that *A. testudineus* is extensively employed for stocking ponds. Alikunhi (1957) mentioned that *A. testudineus* can be grown in carp ponds where fingerlings over 10 cm are stocked. *Anabas* is extensively used for stocking uncleared waters (CSIR, 1962). Hora and Pillay (1962) stated that the fish is suitable for cultivation in ponds, reservoirs and rice fields. They, however, indicated that it is seldom reared alone but often in association with *Trichogaster*, *Ophicephalus* and *Clarias*.

Describing about the cultural possibilities of the Climbing perch, Bardach *et al.* (1972) wrote - "as one might expect, fish farmers take no particular pains to care for a species that may walk away from their pond". Efforts were made at some of the Coordinated Research Project Centres to circumvent this problem of migration by erecting bamboo-mat fence all round the water body towards the inner sides of the pond embankment. It was observed that under such conditions the fish walks up to the fence and loitre here and there probably in search of a escape hole and gets picked up by crows and kites. It has, however, been observed that *Anabas* is not able to scale the embankment when the slopes are steep, nearly at an angle of 75° or more. Ponds with vertical cemented embankments no doubt serve very ideally for the purpose. This problem of migration can also be circumvented by avoiding the period of rearing during rainy season.

6.1 Culture in ponds

A. testudineus can be cultured singly or in combination with *C. batrachus* and *Heteropneustes fossilis*. It also forms a good component for culture in carp ponds.

6.1.1 Procurement of stock

The stocking material of the fish can be had by raising the young ones produced through induced breeding. Collection of seed form nature is slightly cumbersome since there does not exist any worthwhile technique of its mass scale collection.

6.1.2 Transportation

While carrying the spawn, due care is required to be taken with regard to its oxygen requirement whereas for carrying its fry, its aerial respiration. The container in which fry are to be transported, must have enough of open space ot facilitate their surfacing activity. Tin or plastic drums with perforated lids come in quite handy during transportation. In about 10 litres of water, 1000 fry of 1 to 2 cm size can be safely transported involving 2 to 3 hours of road or rail journey. The young ones of the fish have very poor tolerance to sudden temperature fluctuations. Before releasing them into the pond, the container carrying the fry, should be kept party submerged in the pond water till the temperature equalizes.

6.1.3 Holding of stock

Various rates of stocking ranging form 60,000 to 125,000 fry/ha have been tried in mono-culture operations of the fish in different parts of the country. Based on the results obtained in these experiments, it appears that in mono culture operations, depending upon the intensity of the operational management, the ideal rate of stocking would be 25,000 to 50,000/ha.

6.1.4 Management

In order to facilitate effective management, the culture pond should not be more than 0.1 ha in size. No fertilization or manuring would be necessary but supplementary feeding would be essential. The same feed will work as hce been recommended for C. batrachus. Hanging a light over the pond surface would help in attracting terrestrial insects which will fall in the pond and form the food of the stocked fishes.

6.1.5 Harvesting

A. testudineus attains up to 40 to 60 g within six months of culture period. For the effective retrival of fish, the best is to dewater the pond and pick up the harvest by hand. Production potentials of the fish are given in Table XI.

Table XI

Production potentials of *A. testudineus*

Water area(ha)	Stocking density (per ha)	Supplementary feeding	Production achieved	Remark
	46,500 hatchlings		500 fish of 65.5mm length and 55.4 g weight in 7 months	CIFRI (1969)
0.03	80,000 induced-bred young ones	Nil	125 Kg/ha/5 months	Workshop Report (1976)
0.04	40,000 (with *H. fossilis* in 1:1)	Nil	524 Kg/ha/10 months	
0.03	70,000 (with *C. batrachus* & *H. fossilis* in the ratio of 2:3:5)	Nil	1200 Kg/ha/7 months (the contribution of the three species being 11.43%, 37.14% and 51.43% respectively)	
0.04 Makhana pond	100,000 (with *C. batrachus* and *H. fossilis* in the ratio of 2:4:4)	Flat rice husk & fish meal	2250 Kg/ha/10 months with additional 320 Kg/ha of makhana	CIFRI News-letter (1977)
0.10	43,000 with *C. batrachus* and *H. fossilis*	M. oil-cake, rice bran & silk worm pupae	916 Kg/ha/yr	Work-shop Report (1977)
0.07	43,000 with murrels	-do-	1914 Kg/ha/	
0.10	80,000 with *C. batrachus* & *H. fossilis*	-do-	1547 Kg/ha/yr	
0.03	60,000	Rice polish, m.oilcake & fish meal	1800 Kg/ha/170 days	-do-
0.02	125,000	-do-	702 Kg/ha/11 months (at 21.8% recovery) average individual weight being 29.0g	Work-shop Report (1978)

6.2 Culture in cages

Culture in cages fixed in ponds, eliminates problems of retrieval of the fish and predation. Initial attempts on cage culture of A. testudineus were made at the Bihar contre in which mabboo-mat cages were used. These cages were rectangular in shape of 2X1X1 m size. They were installed in one highly alkaline swampy pond. The fishes stocked in cages remained healthy to the extent that they could be used as successful spawners during the breeding season. Details of the experiments are shown in Table XII.

Table XII

Culture of *A. testudineus* in rectangular bamboo-mat cages (Workshop Report, 1972)

Cage No.	Numbers stocked	Av. initial wt.(g/fish)	Harvested wt.(g/fish)	Total duration of culture	Survival (%)
1	200	15.0	35.0	10 months	89
2	120	17.8	42.0	8 "	94
3	268	22.5	33.0	6 "	86

A. testudineus reared in bylon net cages fixed in a sewage fed ditch were observed to have attained growth range of 9.0 to 12.1cm with corresponding weight of 13.0 to 28,2 within about 9 months of growing period (Table XIII). Females registered significantly higher growth than the males.

Table XIII

Culture of *A. testudineus* in nylon net cages with space availability of 12 litres of water per fry (Workshop Report, 1972)

Date of sampling	Numbers of fish	Average growth	
		length(mm)	weight(g)
23.8.1971	25	58.4	-
26.9.1971	20	75.1	-
13.11.1971	20	84.3	-
15.1.1972	20	87.4	-
16.3.1972	20	90.8	12.9
17.5.1972	20	91.9	18.1

Dehadrai *et al.* (1974) made certain observations on the cage culture of *A. testudineus* in swampy waters of Assam in which they used split-bamboo mat cages of 152X76X76 cm size. The cages were kept half immersed in the beel water, supported on bamboo poles. The initial length/weight of the fish was 6.2 cm/6.0 g. Artificial feed comprising rice bran and dried prawn and silk-worm pupae in the ratio of 1:1 was given daily in each cage 1/10th of the total stock weight. Six treatments and 4 replicates were used. The treatments were the variations in the stocking density at 50, 100, 150, 200, 250 and 300 numbers of fishes in respective cages. Monthly samples drawn at random form all the cages and ultimately after three months of the initiation of the experiment indicated mean gain in weight as well as the net yield pattern. It was observed that the overall production of *A. testudineus* does not increase significantly for densities beyond 150 fish/cage. The growth of the fish also remains sufficiently high up to that level beyond which it starts declining drastically.

The Centre in West Bengal carried out experiments on culture of A. testudineus in circular, barrel-shaped bamboo-mat cages made of thick bamboo strips strongly tied with nylon twine, with top lid removed. The pond water could pass freely through the interspaces between the bamboo strips. Two such cages of 5 feet height and 3 feet 9 inches circumference were used for the experiment. The cages were stocked with the fingerlings of the fish produced at the farm itself. A total of 170 fingerlings were released in each cage, the avarage individual weight being 6.0 g and 3.3 g respectively in two cages. Fish meal was given as feed @ 50 g and 40 g/day in two cages respectively.

Within six months of grwoing peroid, the two cages yielded a total of 2.7 kg and 1.7 kg of fish with a survival of nearly 90%. Details of the monthly samplings depicting the growth and survival of the fish in two cages are shown in Table XIV.

Table XIV

Culture of *A. testudineus* in circular bamboo-mat cages (Workshop Report, 1978)

Month	Number of fish		Average growth(g/fish)	
	Cage I	Cage II	Cage I	Cage II
Initial	170	170	6.0	3.3
Dec. '76	151	153	7.3	4.3
Jan. '77	151	153	7.4	4.4
Feb. '77	151	151	8.0	5.0
March '77	151	151	8.0	5.4
April '77	151	151	13.7	10.7
May '77	151	151	17.8	11.2

6.3 Culture in cement cisterns

Culture of *A. testudineus* in cement cisterns was carried out at the Assam centre in which two cisterns were used of 5'X4'X4 size. Prior to stocking, a 3" layer of cowdung, grass straw and paddy husk was layed at the bottom. The cisterns were then filled up with water up to a level of 1.5 feet. A total of 300 *Anabas* fingerlings measuring 35 mm in length and 1.05 g in weight were released into each cistern in June 1977. Within 180 days of growing period, the fingerlings attained an average length/weight of 99mm/38 g, giving ap production of 8.12 kg and 7.41 kg with 80% and 65% survival respectively form the two cisterns (Workshop Report, 1978).

6.4 Culture in plastic pool

An experiment was carried out at the Bihar centre in which 76 number of *A. testudineus* was reared in one plastic pool of 4'X2' size. The fish could be reared successfully for a peroid of 150 days. Feeding was done moderately using rice husk as the only ingredient. The net gain in total biomass at the end of the experiment was 417 g showing average individual net gain of 5.8 g (Workshop Report, 1976).

6.5 Culture in pens

The split-bamboo screens called "chilwans", commonly used to put fishing barriers across the creeks and canals in north Bihar, serve ideally for making pend. In pen culture, the stock requires to be taken out before the rains in order to forestall possible loss by way of land excursions of the fish.

As a test case, a "chilwan" with enclosed area of 15X5 m having a depth of about 1 m in a suwage fed ditch was stocked with 120 number of adult *A. testudineus* in April. Two months later, a total of 68 specimens could be netted out, showing a retrieval of nearly 57% (Workshop Report, 1972).

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