

THESIS



ABSTRACT

AGE AND GROWTH STUDIES OF THE CLIMBING PERCH
ANABAS TESTUDINEUS (BLOCH)
IN LAM LOOK-GA FLOODED AREA
CENTRAL PART OF THAILAND

By

Thiraphan Bhukaswan

The validity of age determination from scales of climbing perch is demonstrated. This study is based on 184 fish collected from Lam Look-Ga flooded area, Central Part of Thailand, from July 10, 1969 to May 22, 1970. The fish were from 116 mm to 206 mm, total length. Age groups I to III were represented in the samples. The maximum growth in length occurred in the first year of life. The calculated annual increments of growth in weight increased from 25.19 grams in the first year to a maximum 40.66 grams in the second. A relative abundance of sexes indicated females were dominant (2.07:1).

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INTRODUCTION

The age and growth of fish has been studied since the beginning of the twentieth century. A knowledge of correct age and rate of growth of fish is extremely useful in fishery biology and fishery management. They are together the most important basic of fishery study for solving life history problems such as longevity, sexual maturity or spawning time, catchable size, environmental conditions of natural water bodies, suitability of stocking and continuing studies in fisheries production.

Several methods have been used in age and growth studies of fish. Among those, the scale method is the most popular aging technique. Scientists of many countries have studied age and rate of growth in fish by means of the structure of scales. Several significant methods have been used in order to get precise results. However, the results of the studies are similar whether they used the same techniques of study or not, they also get a high degree of accuracy.

The study of age and growth by the scale method is much more practical in the fish of the temperate zone especially in the western hemisphere. In contrast, in tropical countries, it is rarely used because the unclear sculptural appearance of annuli on scales of tropical fish makes an accurate interpretation of age difficult. Among the more useful publications on this topic are the reports of Menon (1953) and De Bont (1967).

The objectives of this study are:

1. To study age and growth of the climbing perch, Anabas testudineus by the scale method.
2. To evaluate the scale method for aging technique applied to tropical fish.

General Geography of Thailand

The Kingdom of Thailand is located in the Indochina peninsula of Southeast Asia, between 5° and 21° N latitude and 97° and 106° E longitude with an area of nearly 200,000 square miles. It is bounded on the west and northwest by Burma, on the north and northeast by Laos, on the southeast by Cambodia, and on the south by Malaysia.

The country is tropical and presents regionally varied landscapes in which the dominant features are forested mountains in the north and south, relatively dry plateaus in the northeast and fertile river plains in the central.

The climate is a tropical monsoon with clearly defined wet and dry seasons. The rainy season runs from

May to October, a cool dry season from November to February, and a hot dry season from March to May, except in the south where there is no pronounced dry season.

There is little temperature variation throughout the year; seasonal variations are effected by the direction and force of the prevailing winds. It is coolest in December and January and hottest in April. The diurnal range is comparatively wider, especially in the higher altitudes of the north where the temperature may drop during the cool season to 50°F and rise during the summer to above 100°F (Nuttonson, 1963).

The rainfall of Thailand is largely influenced by the monsoons, Seasonal variations in rainfall for the Central, Northern and Northeastern Thailand are as follows: a light rainfall in March, a dry April, light rains in May and June, heavy rain in July, August, September and most of October. This contrasts with showers in October, heavy rains in November, December and January, and light rain in February for the South. The annual precipitation varies from 30 to as much as 165 inches (Smith, et al., 1967).

In the Central region, (where the specimens were taken) at least 90 percent of the rainfall occurs during the wet monsoon from May to October. From March to September, the period of the wet monsoon, the mean maximum temperature is near 98°F with records of above 100°F; the minimum is about 80°F. During the dry season the

maximum temperature is about 90°F with a mean considerably lower; the minimum temperature is near 57°F (Smith, et al., 1967).

Description of Species

The climbing perch or walking fish, Anabas testudineus (Bloch) is one of the most interesting and outstanding of the freshwater fish of Thailand. This species is very common in all kinds of freshwaters. Its common name refers to a mode of overland migration by means of pectoral fins and gill cover. Because of a supplementary breathing organ, it can thrive in water deficient of oxygen and is able to leave the water to migrate long distance on land especially at night and after showers. This fish is very hardy and able to aestivate during the dry season. Buried in the mud, it passes into a resting stage similar to that observed in the African Lungfish (Forelius, 1957; Sterba, 1963).

Characteristics.--It has a perch like-shape with oblong body, posteriorly compressed, head and anterior part rather broad, mouth not protractile. Small conical teeth on jaws and vomer, gill covers serrated. Dorsal and anal fins rather long, compose of spiny spines and soft fin-rays. Dorsal and anal spines strong, soft portion higher than the spinous part, rounded in the dorsal, obtusely pointed in the anal. Caudal rounded. Scales are large, strongly ctenoid. Lateral line interrupted about 18th scale to caudal. Greyish black or dark brown along the dorsal,

lighter below. Young and half grown with transverse dark stripes on hinderpart of body and tail, a similar longitudinal stripe running from the angle of mouth below eye to preopercle. A large dark spot at the base of caudal and a small one at hindborder of the operculum. In adults, the stripes disappear and the black blotches are often wanting. Fins are brownish or dusky. Length is up to 250 millimeters.

The climbing perch is essentially a freshwater river and swamp fish, but in some regions is adapted to live in estuarine environments (Nicholes, 1943; Day, 1958; Bhuiyan, 1964; Srivastava, 1968). It breeds in confined waters, attains maturity when about 80 millimeters long, or approximately 6 months of age. Spawning period during the monsoon or rainy season, temperature for breeding 25-29°C. The eggs are stated to be laid at random, generally at night. Eggs are yellow or whitish, about 0.8 mm average in diameter, bouyant, floating freely on the surface until they hatch. Embryos hatch out after 24 hours at a temperature of 28°C (Hora and Pillay, 1962).

Larvae and young fry feed on phytoplankton and zooplankton. Large fry and adult fish feed on crustaceans, worms, molluscs and insects, algae, soft higher plants and organic debris (Hora and Pillay, 1962; Bhuiyan, 1964).

Geographic Distribution

The original range of the climbing perch was confined to the areas affected by the monsoon. It lives in

lakes, rivers, ponds, marshes, ditches and estuaries of Singapore; Sumatra; Nias; Bintang; Banka; Java; Bawean Island; Borneo; Madura; Bali; Sumbawa; Sumba; Rotti; Timor; Celebes; Ambon; Batjan; Halmahera; Philippines; Vietnam; South China; Laos; Cambodia; Thailand; Malaysia; India; Burma; East Pakistan and Ceylon (Weber and De Beaufort, 1922; Nicholes, 1943; Smith, 1945; Munro, 1955; Forselius, 1957; Day, 1958; Sterba, 1963; Bhuiyan, 1964).

Local Distribution

In Thailand the distribution is wide in all kinds of freshwaters, including large streams, but it flourishes most in canals, ditches, lakes, ponds, swamps and reservoirs over the whole country.

The climbing perch is a valuable food fish in Thailand, India, Burma, Malaysia, China and the Islands lying off the southeast coast of Asia (Smith, 1945). Over most of Thailand this fish is known as pla mor, sometimes, as in the Central region, amplified to pla mor-thai. In parts of northern Thailand it is called pla sadet, and pla kheng is common in the Northeastern.

COLLECTION OF MATERIAL FOR THE STUDY

Collection of Specimens

The specimens were collected from Lam Look-Ga flooded area, Pratumthani province, about 30 miles north of Bangkok, Thailand. The samples were captured every two months, one year round by draining ponds. About 40 fish were selected for study each time of the collection. Total length, standard length, weight, sex and stage of maturity of the fish were measured and determined. Data were recorded, and the scales were taken from the fish for continuing study.

Technique of the Scale Collection

The scales of the climbing perch were collected after the fish had been weighted and its length measured. Scales were taken from the middle of the body below the origin of the dorsal fin and just below the lateral line. The scales were removed with a knife, passing it from posterior to anterior where the scales were to be taken. Ten to twenty scales were taken from every fish. Collected scales of individuals were pressed between a piece of paper held

together by the mucus on the scales, then, put in collection envelopes. Reference data were recorded on the envelope telling of locality, weight, length, sex, maturity, time of capture, temperature, method of capture, date and collector.

After the scales were collected, the fish was opened, the sex and ripeness of the sexual products (roe and milt) determined and recorded.

THE SCALE METHOD FOR AGE DETERMINATION

Preparation of Scale Impression

Impression method is the most practical technique at the present time for aging fish from its scales. Because the plastic impression has many advantages such as saving time, no cleaning is needed, and no effect of pitting or other irregularity on the inner surface of the scales interfered with age determination.

A roller press is used. The size of its rollers is 8 cm in diameter. The gap between the rollers is adjusted by two special screws, situated on both sides of the upper plate of the metal frame (above the upper roller). The rollers are rotated by means of a handle with gearing and it is quite easy to pass the cellulose acetate stripe between them.

Clear cellulose acetate is considered as the best material for scale impression because of its low flammability properties, unbreakable and very durable (Arnold, 1951). Cellulose acetate of 0.020 inch thickness and the slide size of 1-1/2 by 2 inches were used in this study.

The size of the opening between the rollers is adjusted according to the thickness of cellulose acetate plate. Smith (1954) gave the formula to determine the opening between rollers of 3 inches in diameter that will exert a pressure at the crushing point of cellulose acetate as follows:

$$P = (0.9156T) - 0.00258$$

where: P is the opening between rollers

T is the thickness of the cellulose acetate plate.

After setting the scale press for the thickness of plastic used, scale impressions were made of 6 to 12 scales from each fish. The scales were placed, sculptured surface upward on one plastic slide and covered with another slide, then passed between the press rollers. The marking were pressed into the plate and the scales were put back into the scale envelop for further reference. The slides were labeled. Completed impression slides were kept in the envelops from which the scales were taken in order to keep them with their respective collection information.

Techniques to Identify Annulus

The identification of annuli is sometimes very difficult because of unclear characteristics of the scales. Several hypotheses of how to find true annulus were given by many prominent scientists. Lagler (1952) had listed the recommendation for identifying annulus as a true year

mark on the scales of the fish. Firstly, the discontinuous ridges on the scale located between two continuous one; secondly, the feature of "cutting over" which resulted from incomplete circuli formation during the seasonal cessation against the resumption of growth; and thirdly, the relative approximation of the circuli, are usually closer together just inside the line which marks the annulus and farther apart just outside of it.

Another valuable criterion how to identify an annulus and where it should be located on the scales of different fish species were given by Tesch (1968) are as follows:

1. A zone of closely-spaced ridges is followed by a zone of widely spaced ridges; the annulus is considered to be at the outer border of the closely-spaced ridges.

2. A clear zone, devoid of ridges (perhaps with ridges absorbed), occurs between a zone of closely-spaced ridges and a zone of widely-spaced ridges.

3. Ridges become markedly discontinuous.

4. "Cutting over" occurs where one or two ridges appear to cut across several others. This is usually discernible on the dorso-lateral and ventro-lateral parts of the scale.

5. In Clupeidae, where the ridges form two broad arcs across the anterior field of the scale, the annual mark is indicated by a slight bend or waviness in the ridges.

6. In some scales, especially ctenoid scales, the radii end or bend at the annual marks.

The Validity of Fish Scales for Age Determination

Practically, the fish scales used for age determination should be collected from specific given area of each species. The characteristics of scale sculpture useful in age determination are variable and have been described for several species. Van Oosten (1929) presented the basic requirements of scale growth necessary to their usefulness in aging fish.

1. The scales must remain constant in number and identity throughout the life of the fish.

2. Growth of the scales must be proportional to the growth of the fish.

3. The annulus must be formed yearly and at the same approximate time each year.

Recently, Regier (1962) has given some valuable suggestions for recognition on the validation of the fish scales for age determination as follows:

1. A check with a zone of relatively widely-spaced circuli proximal to the focus, and closely-spaced circuli distally, is usually an accessory check. This feature is usually closest in an anterolateral angle of the scales.

2. Lack of extensive anastomosis of circuli with the check, and limited extension of the check across the posterolateral field frequently characterize accessory checks. In annuli, circuli proximal to the check are

usually discontinuous, distal circuli continuous, in accessory checks the reverse is sometimes true, or some circuli may be continuous through the check.

3. Loss of a scale may produce on accessory check on adjacent scales, although such check can usually be distinguished from annuli. In locating location of accessory checks with regenerated portions in adjacent scales, it should be noted that scars on such scales are usually smaller than the size of the scale lost, except perhaps on a starving fish.

4. A given annulus is usually well defined on all scales of an individual fish, but an accessory check may not be.

5. Accessory checks are sometimes more conspicuous than annuli on the anterior field of the scale.

6. Particularly a dark band on a scale should be treated with suspicion. Erosion pits on the nonsculptured under surface sometimes obscure scale ridge.

7. Consider a questionable check to be an annulus provisionally. If the individual's growth history as estimated from scale proportions does not approximate the growth pattern of its provisional year class, then the check stands suspect. Use of the growth pattern as a criterion presupposes that the fish population has been discrete during the period under investigation.

8. Recognition of the first annulus is sometimes difficult if the annulus is less than 0.25 millimeter from

the focus. Cutting over may be confined to a single circulus, may be present on some scales and absent on others of the same fish, or may be absent entirely. Where cutting over is absent, the annulus may be marked only by small segments of a circulus in the anterior field, or only by a relatively wide-spaced between circuli.

9. Scale abnormalities are apparently more common in fish growing at unusually rapid or slow rates than those growing at the average rate.

10. The only clear indications of recent annuli in a large, slowly growing fish may be in an anterolateral corner of the scales. Larger fish in starving population may not form annuli, or portion of scales on which annuli were formed may be resorbed.

AGE DETERMINATION

The scales of the climbing perch were read at least twice and at different time, by using a scale projector of 22.5X magnification, two reading of age usually agreed. Whenever, the two age determinations were different, scales were read a third time. When consistent interpretation was impossible, that specimen was discarded. Annuli were counted and their number marked on a scale card. The number of counted annuli from scales indicate directly the number of years through which the fish has lived.

Time of Annulus Formation

Age determination for this study was made by analyzing the scales of each fish collected for the presence of annuli. Knowing the time at which annual rings are laid down is very important for age study of fish. It is well known that in fish of different ages the period in which annual rings are laid down occurs at different time, also in different localities. Generally, the annulus or winter mark is laid down during winter months for the fish in temperate zone--as the results of growth cessation during

the periods of decreasing temperature. In the tropical regions where the winter is warm, the annuli develop as the result of cessation of growth during the periods of seasonal deterioration of food conditions caused by water level reduction during the dry periods and in connection with gonad maturation. The annuli which formed during the monsoon period some authors named "monsoon ring" (Menon, 1953).

The determination of time of annulus formation on the scales of the climbing perch was determined by comparing the frequencies of marginal growth of scale radius between the last annulus and the scale edge (June and Roithmayr, 1960). The measurements were made at the time of scale reading. The time of annulus formation was inferred from the frequency distribution curve.

Backiel (1962) recommended that the existence of one minimum marginal growth in the year testifies that only once a year a new annulus is formed on the scales of the fish. He also assumed that time of annulus formation can be determined by means of locating the minimum marginal growth.

The average values of marginal growth of scale radius from the last annulus to the scale edge of the climbing perch collected every two months were plotted and a curve drawn (Figure 1). The curve shows that the minimum and maximum average marginal growths are in January and November respectively. Therefore, the time of annulus formation

Figure 1.--The average values of marginal growth of scale radius from the last annulus to scale edge for the climbing perch at two month intervals.

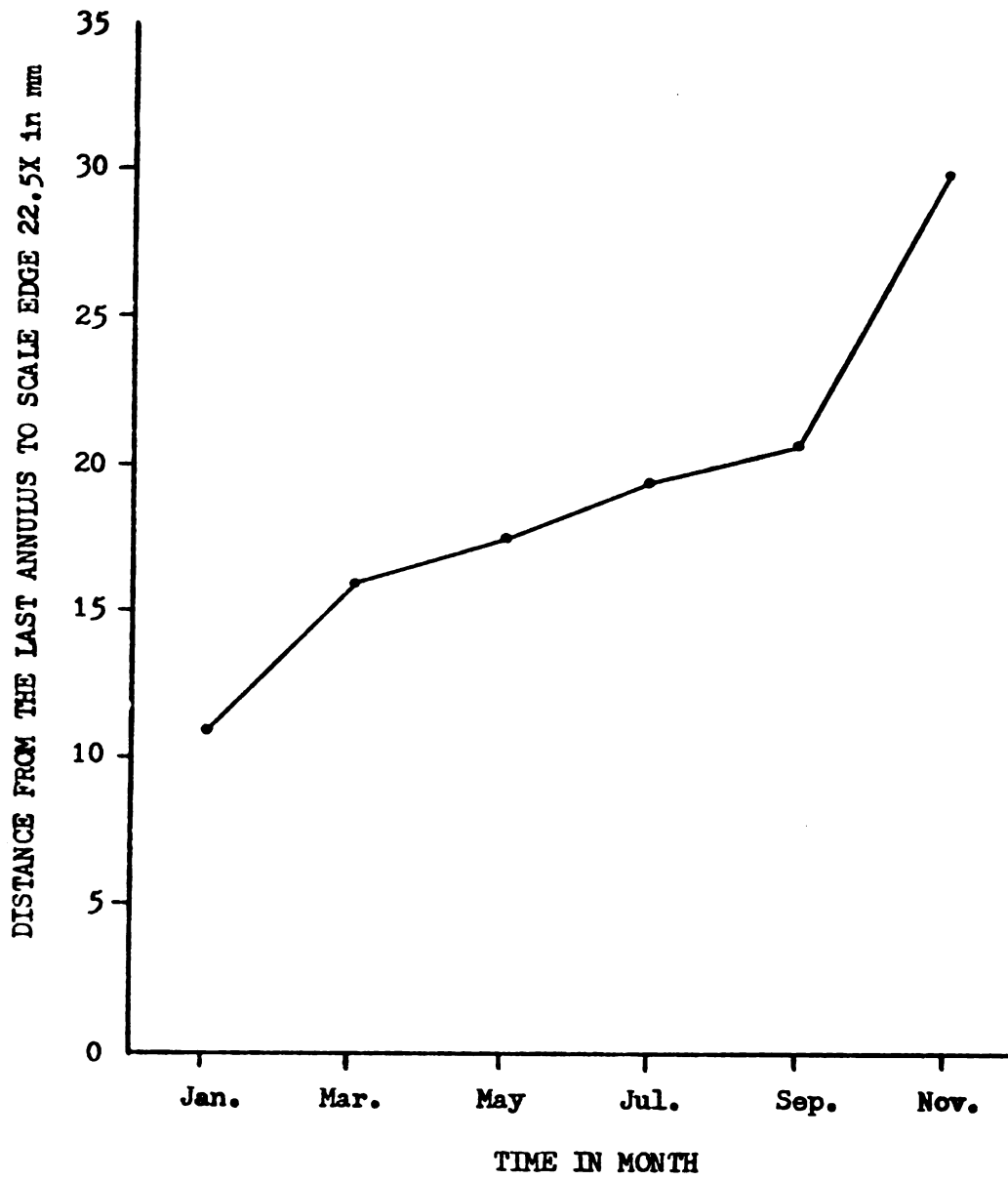


Figure 1

on the scales of the climbing perch is assumed to be somewhere between the end of November to January.

By this time, Thailand falls into the cool season. Temperature and amount of rainfall continuing decrease, reach the lowest point about January. The difference between the maximum and minimum of monthly average temperature is approximately 5°C. There is much greater difference of rainfall between the peak in August, September and October as compared with November, December and January (see the values of 10 year average in Table 1 and 2).

A report of Menon (1953) referred to the works of Chevey (1930a,b,c, and 1932) who made an interesting study on the value of the method of age determination by scales as applied to the fish of Indo-China, Cochin-China and Cambodia. He found the concentric zones of growth in the samples collected from Tonkin in North Vietnam where the temperature of the surface water was 27°C to 28°C in summer and 23°C to 24°C in winter. He concluded that "a difference of 4°C to 5°C seems to be sufficient to provoke the slowing of growth in fish and the marking of the scales." He also made a very interesting observation on the effect of the flooding of the Grand Lac and Tonle-Sap. He found that in the scales of fishes from both these freshwater areas, the growth checks occurred with lowering of the water level and as this lowering of water level occurred only once every year. Those checks were valid indices of the age of the fish.

TABLE 1.--Monthly mean temperature in degree centigrade of Don Muang during 1960-1969.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1960	26.9	27.8	29.9	30.4	30.5	29.9	28.4	29.5	28.8	28.2	28.0	26.0	28.69
1961	25.6	27.8	29.3	30.5	29.6	29.4	28.8	28.7	28.7	28.4	28.8	27.5	28.59
1962	25.0	26.0	28.7	30.2	29.9	29.1	28.8	28.4	27.7	27.8	27.6	24.8	27.83
1963	23.0	26.8	28.3	29.8	30.7	29.2	28.6	28.3	28.2	28.3	28.2	25.9	27.94
1964	25.1	27.3	29.3	30.6	29.4	29.4	28.9	28.5	28.2	28.4	26.1	24.8	28.00
1965	24.8	27.9	28.8	30.1	29.5	28.9	28.1	29.0	28.1	28.3	27.9	27.3	28.23
1966	27.6	28.5	30.2	30.8	29.3	29.4	28.8	28.7	28.5	29.2	28.1	27.8	28.91
1967	26.1	27.9	29.7	30.3	29.7	29.8	29.1	28.7	28.6	27.8	27.7	25.1	28.38
1968	25.9	26.9	28.9	28.8	29.3	29.2	29.3	28.3	28.7	28.0	28.1	27.7	28.26
1969	27.7	28.0	29.5	30.4	30.4	29.6	28.8	28.4	28.3	28.7	26.7	24.7	28.43
Mean	25.77	27.49	29.26	30.10	29.83	29.39	28.76	28.65	28.38	28.31	27.72	26.16	
Std. Dev.	1.42	0.74	0.59	0.56	0.52	0.31	0.34	0.37	0.34	0.42	0.78	0.30	

Source: Based on published and unpublished records of Meteorological Department, Bangkok, Thailand.

TABLE 2.--Monthly rainfall in millimeters of Don Muang during 1960-1969.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1960	0.0	0.0	8.4	20.7	85.2	50.0	175.3	266.6	429.4	353.8	42.9	4.5	119.73
1961	2.1	93.5	26.2	149.6	135.8	228.4	100.7	243.2	76.1	320.0	25.9	17.1	118.21
1962	0.0	8.9	13.1	46.3	100.8	185.8	161.7	375.3	335.7	304.2	12.2	1.0	128.75
1963	0.0	14.6	10.4	30.8	132.5	162.3	164.7	175.0	467.3	243.3	85.2	26.2	126.03
1964	0.8	15.3	22.0	54.5	302.2	102.2	257.9	239.6	221.1	164.3	6.7	15.9	116.88
1965	0.0	69.3	44.0	24.1	231.3	73.9	37.5	219.5	469.2	102.9	15.0	7.5	107.85
1966	0.1	33.4	12.2	21.2	355.3	123.8	134.4	192.1	117.8	208.3	8.8	50.7	104.84
1967	0.0	0.1	1.1	120.5	255.2	95.0	228.7	173.1	343.2	193.3	42.5	0.0	121.06
1968	4.8	43.8	26.3	45.4	147.3	131.5	121.2	342.1	251.3	84.8	50.5	0.7	104.14
1969	34.0	1.3	20.5	60.9	111.8	135.3	89.9	274.3	259.1	136.9	48.1	22.4	99.54
Average	4.18	28.02	18.42	57.40	185.74	128.82	147.20	250.08	297.62	211.18	33.78	14.60	
Std. Dev.	10.59	32.07	12.14	43.77	93.58	53.17	65.42	67.51	137.44	92.86	24.78	15.81	

Source: Based on published and unpublished records of Meteorological Department, Bangkok, Thailand.

It seems to me that the annulus formation on the scales of the climbing perch is the result of decreasing temperature together with lowering water level during the cool season, from November to January. Firstly is the difference of 5°C between temperature in the summer and the cool season. Secondly, the wet monsoon (southwest monsoon) causes heavy rain in the central region of Thailand, at least 90 percent of the rainfall occurs from May to October (Smith, et al., 1967). It causes flooding over lower plains along the Chao Phraya Basin for many months. The water level is nearly constant throughout the rainy season. Lowering water level begins at the end of the wet monsoon approximately late October or early November. It takes about two months, more or less for lowering period. Then, the fish move to lower areas or to the river channels for feeding. During this period of movement the fish probably have less food available to them and their feeding activity may be restricted. The effects of decreasing temperature and food shortage during lowering period seem to be sufficient reasons for the time of annulus formation on the scales of the climbing perch taken from Thailand.

The average distances between the last annulus and the scale edge of the samples show that the widest were taken on November 23, 1969 and the narrowest taken on January 22, 1970. Association of decreased distance from last annulus to scale edge with decreasing temperature

and lowering water level at this period should indicate that "the annulus was laid down on the scales of the climbing perch somewhere between November 23rd and January 22nd. Considering the marginal growth of scale radius of the specimens taken in January shows that the fish have made some growth after the last annulus was laid down and keep on growing. This makes me believe that the annulus might be laid down at the end of November or at the beginning of December (Figure 1).

Annulus Formation

The scales of climbing perch are typically ctenoid, more or less crenulated, and strongly imbricated. Its shape rather concentric, broader anteriorly and posteriorly rounded. There are many ctenii on the posterior field. Scales are hard and thick especially in older fish. The focus near the center of the scale is a small clear area. Ridges or circuli are clear and numerous, more or less concentric around the focus. Ridges are continuous and homogenous with the general bony surface resulting from elevation of the ostoid marginal area. Radii are variable on the anterior field, cutting across the ridges surface of the scale from the focus zone to anterior margin (Figure 2).

Annulus formation is dependent upon the cessation of growth. Significant factors affecting the growth of fish are available food, space of living, temperature, rainfall and including the concentration of dissolved organic

matters, salts and gas in water, the fertility and physical nature of the bottom, the configuration of the basin or stream bed, the elevation of surrounding land, rate and volume of stream flows, water level and water pollution (Van Oosten, 1929). These factors also affect the annulus formation on the scales of fish both directly and indirectly.

As mentioned previously, the annulus formation on the scales of the climbing perch taken from the central part of Thailand is the result of change in temperature together with lowering water level during the cool season.

Annulus Determination

Recognition of annuli on the scales of the climbing perch is based on recurrent interpretations of the uniformly spaced ridges in the anterior field. Such areas of discontinuous and irregular ridges form narrow, continuous, light band which normally stands out in sharp contrast to the bold, continuous and regular ridges on either side. Occasionally, there are gaps between ridges along the lateral field, in this case, some ridges are partly destroyed. "Cutting over" is observed in the lateral field as the ridges passing from the anterior of the scale wedge out, being cut across when they reach the annulus. Annuli are present in the same relative position on the scales of an individual fish. They are roughly parallel to the margin and may be traced around the entire sculptured portion of the scale (Figures 2-4).

Figure 2.--Scale of Climbing Perch with one ring 10.7X
(TL 131 mm).

Figure 3.--Scale of Climbing Perch with two rings 10.7X
(TL 165 mm).

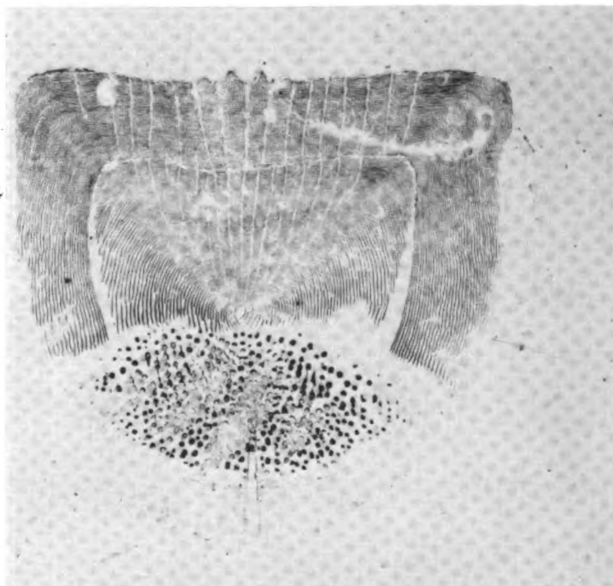


Figure 2

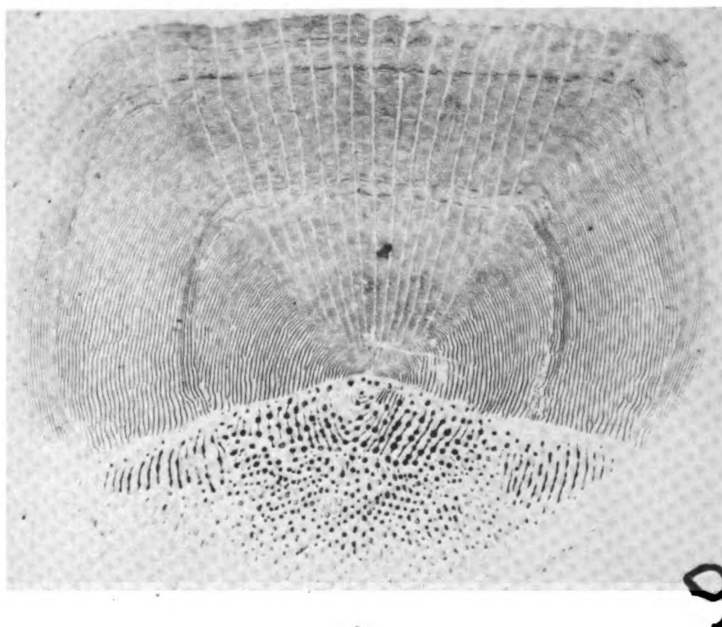


Figure 3

Figure 4.--Scale of Climbing Perch with three rings 10.7X
(TL 170 mm).

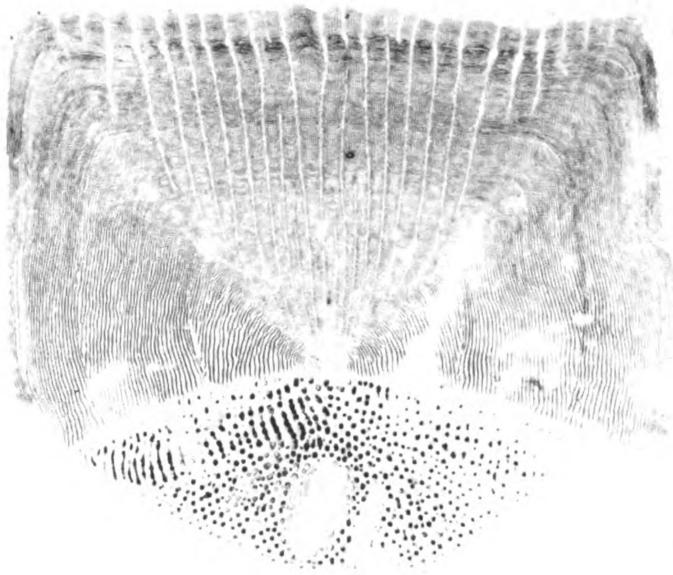


Figure 4

Sometimes the annulus is indistinct. It must then be identified with the densest part of the dark-colored zone of narrow crowded ridges; the ridges on the dark-colored zone gradually expand towards both the focus and outward.

Irregularities in Scale Structures

Age determination of climbing perch from their scales is always difficult because of an unclear sculpture appearance of annuli. Abnormalities of growth are reflected on the scales and lead to the formation of an accessory annulus and the "false" annual ring frequently results in an error of age determination. The principal factors that make the scale unsuitable for age determination of climbing perch are as follows:

1. Accessory Annuli. These rings frequently appear as folds in the sculptured pattern, and the ridges crossing such folds show a continuity and regularity of the defined age ring. They usually occur at irregular intervals between regularly spaced and more or less close to next annulus (Figure 5). However, they are not present on scales of all individual fish.

In the climbing perch, the formation of accessory rings is connected with the spawning period. They may be observed and identified only before the following annual increment has appeared on the scale. As mentioned previously, because the climbing perch reach maturity at the age of 6 months, spawning marks may be located before the

first annulus for the young of age group 0 and I, and are between two annuli for the fish of two years and older. Their positions vary in different years, however, they are usually nearer the outward annulus (Figure 6).

2. Regenerated Scales. The most common irregularity in the scales of climbing perch occurs in the central area of the anterior field where the distinct, regularly spaced ridges are replaced with short, discontinuous scars. This area is generally granular in appearance, irregular in outline, and highly variable in relative size, and sometimes remains blank (Figure 7). Scales with such an area were considered to be regenerated scale and are not used in the age determination. The major reason for regenerated scales in the climbing perch might be the result of losing scales during overland migration.

3. Skipped Annuli. Some scales have no annulus formation apparent at the position where it should be located each year. The circuli are very uniform, widely spaced and parallel to the margin of scale. No bands of closely spaced circuli being regarded as indicating slow growth during one growing season (Figure 8). This condition indicates that under environmental conditions the fish grew rapidly throughout the year.

4. Dislocated Scales. Some scales appeared to be a smaller scale set off center in a larger scale, the two with foci in different positions and main axes at different angles (Figure 9). This condition is presumed to be

Figure 5.--Scale of Climbing Perch showing accessory annulus
10.7X (TL 146 mm).

Figure 6.--Scale of Climbing Perch showing spawning mark 10.7X
(TL 137 mm).

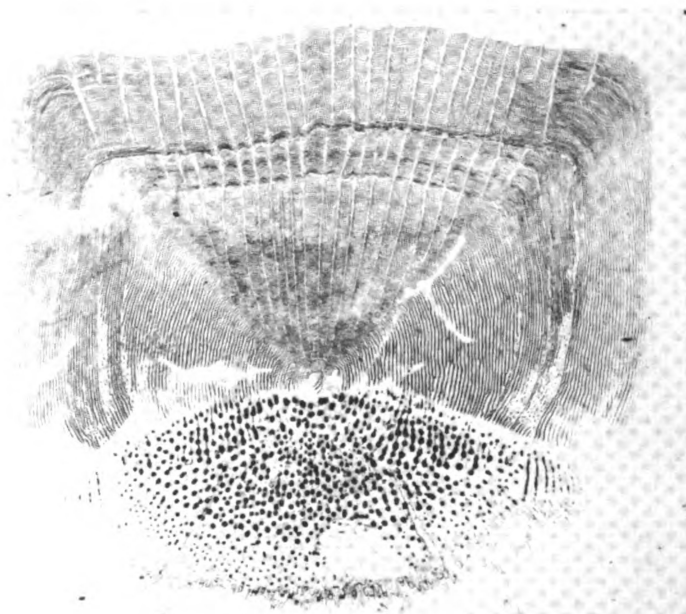


Figure 5

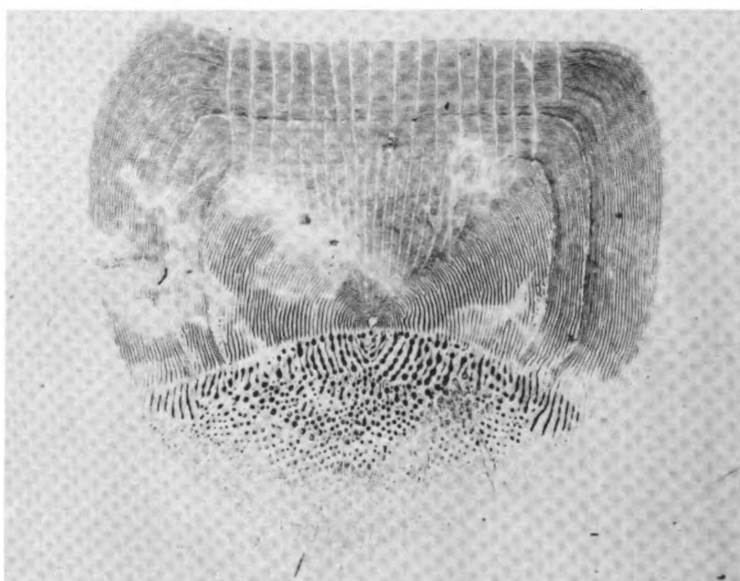


Figure 6

Figure 7.--Scale of Climbing Perch showing a regenerated central area 10.7X (TL 171 mm).

Figure 8.--Scale of Climbing Perch showing a skipped annulus 10.7X (TL 176 mm).

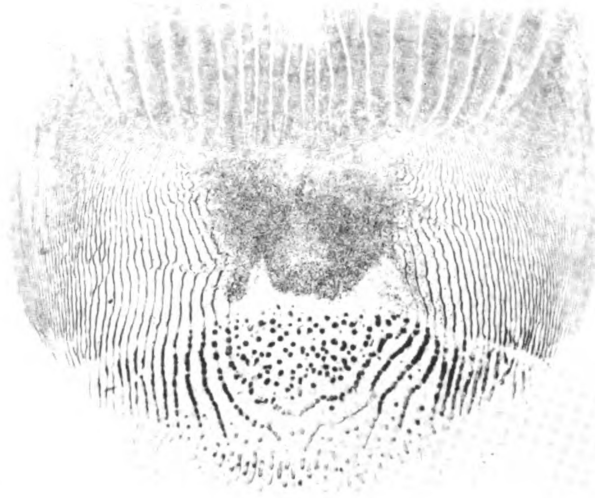


Figure 7



Figure 8

Figure 9.--Scale of Climbing Perch showing a rotated central area
10.7X (TL 137 mm).

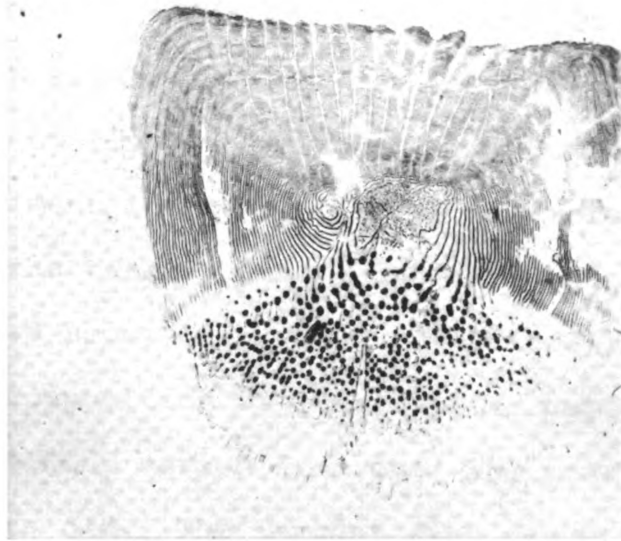


Figure 9

the result of a younger scale being dislocated and rotated slightly in the scale pocket (Van Oosten, 1929).

Age Composition

The age composition of catches is one of the most important elements in the study of the population dynamics of fish and in the prediction of catches. Practically, the age of each fish was determined by the scale method and the number of fish of each age group counted. The number of specimens in each age group is expressed as a percentage of the total in the sample, although the sexes may be expressed separately (Chugunova, 1963).

The age composition of 184 climbing perch determined by the scale method, varied from over one year old to more than three years old. The largest fish caught was a female of age 3, measuring 206 millimeters in total length and weighing 202 grams. The smallest fish was male of age one with total length of 116 millimeters and of 29 grams in weight. The variation of the length for every age group and percentage of age composition of the specimens, both non-separated and separated males and females are presented in Table 3 and 4 respectively.

As a result, age composition of the samples composed of 51.63; 40.76 and 7.61 percent for the fish of age group I, II and III respectively. The total number of each age group decreased continuously as the fish increased in age and size. The percentage of females is greater than those of males of every year class. This phenomenon shows

TABLE 3.--Range of variation of the length in millimeters
of climbing perch for each age group at capture.

Total length Group (mm)	Age-Year			Total
	1	2	3	
116 - 120	2			2
121 - 125	6			6
126 - 130	12			12
131 - 135	19			19
136 - 140	15			15
141 - 145	13	1		14
146 - 150	13	2		15
151 - 155	11	4		15
156 - 160	4	8	1	13
161 - 165		13	1	14
166 - 170		14	4	18
171 - 175		12	2	14
176 - 180		8	-	8
181 - 185		6	1	7
186 - 190		7	1	8
191 - 195			2	2
196 - 200			-	-
201 - 205			1	1
206 - 210			1	1
Number of Specimens	95	75	14	184
Percentage	51.63	40.76	7.61	100

TABLE 4.--Range of variation of total length in millimeters of climbing perch separated by sex for each age group at capture.

Total length Group (mm)	Age-Year						Total
	1		2		3		
	Male	Female	Male	Female	Male	Female	
116 - 120	2						2
121 - 125	1	5					6
126 - 130	2	10					12
131 - 135	4	15					19
136 - 140	5	10					15
141 - 145	8	5	1				14
146 - 150	8	5	2				15
151 - 155	4	7	1	3			15
156 - 160	2	2	4	4	1		13
161 - 165			6	7		1	14
166 - 170			6	8		4	18
171 - 175			2	10		2	14
176 - 180			1	7		-	8
181 - 185				6		1	7
186 - 190				7		1	8
191 - 195						2	2
196 - 200						-	-
201 - 205						1	1
206 - 210						1	1
Number of Specimens	36	59	23	52	1	13	184
Percentage	19.57	32.07	12.50	28.26	0.54	7.06	100

that the females of climbing perch are more dominant in natural population than the males.

Length-Frequency Distribution

Length frequency distribution is valuable for aging determination. The method is based on the fact that the length of fish of one age tends to form a normal distribution (Rounsefell and Everhart, 1953). Counting the peaks of the sample help to estimate the age of the fish. This method has been adequate for the first 2 to 4 years of life, but has failed in the older age groups, because of increasing overlap in length distribution. Generally, it is used as a check on the scale method of age determination, especially for the younger age group.

The length frequency distribution curve was plotted by using 5-mm intervals of 184 climbing perch. Their total length were plotted against a number of specimens for each length. Age groups in the catch are determined by the number of peaks in the frequency distribution curve which shows that they could be composed of the fish population range from one year old to three years old (Figure 10).

The modal lengths of age groups I and II probably might stand out in the length frequency distribution of most random samples of the population. In age group III, however, length is an exceedingly poor index of age, since most of specimens were covered by the age group II. The extensive overlap of the length frequency distributions

Figure 10.--Total length frequency distribution and age composition of climbing perch taken from Lam Look-Ga flooded area, Central Part of Thailand during July 10, 1969 to May 22, 1970.

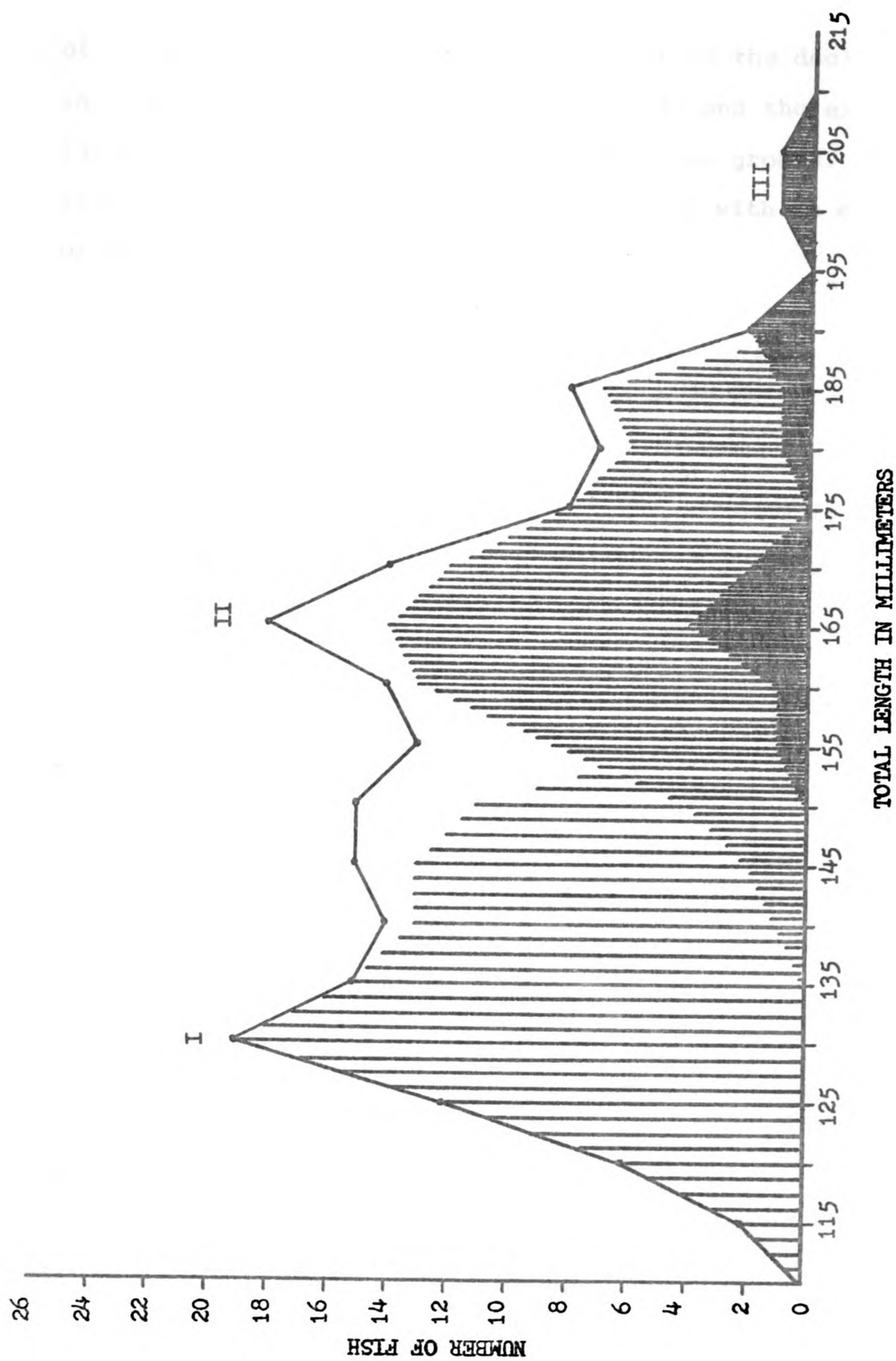


Figure 10

of the age groups is the combined result of the decline in growth rate in the later years of life and the extremely large range of length in the individual age groups. Age group III had the greatest range of length with an extreme of 206 millimeters, total length.

GROWTH STUDY

The growth of the fish is very important to modern fishery productivity and management. Most of the studies of growth in fish have been restricted to a determination on the annual increments in length (or weight) of the different age groups sampled from the population. A knowledge of growth rate is of notable significance and leads to an effective and conclusive assessment of maintenance of maximum productivity of the fishery.

Total length-Standard length Relationship

Length relations of fish are useful for converting length information on growth and change in body form of fish during development, generally in terms of total length and standard length. Determination of relations is made by the method of least squares. The regression coefficient was calculated by using the formula:

$$b = \frac{\Sigma XY - \frac{(\Sigma X)(\Sigma Y)}{n}}{\Sigma X^2 - \frac{(\Sigma X)^2}{n}}$$

where: X,Y represent total length and standard length of the fish respectively, n is number of specimens.

Data of 215 climbing perch were plotted and a regression line drawn (Figure 11). The relation shows a high degree of correlation ($r^2 = 0.8987$). Calculation resolved that the slope (b) of the regression line was 0.7724, and the ratio between total length to standard length was 1.2947 (TL = 1.2947SL).

Standard length-weight Relationship

The length-weight relationship of fish has interested fishery biologists because it affords an opportunity to study changes in body form as the fish grows. It serves as the basis for the calculation of unknown weight of fish of known length or to determine the length of fish of known weight. The relationship between length and weight in fish has been calculated by the parabolic equation:

$$W = c L^n$$

where: W is weight in grams, L is standard length in millimeters, c and n are constants.

Beckman (1948) expressed this equation in logarithmic form so it became a straight line:

$$\log W = \log c + n \log L.$$

The values of log c and n are determined by fitting a straight line to the logarithmics of L and W.

Figure 11.--The regression coefficient of total length and standard length for 215 climbing perch.

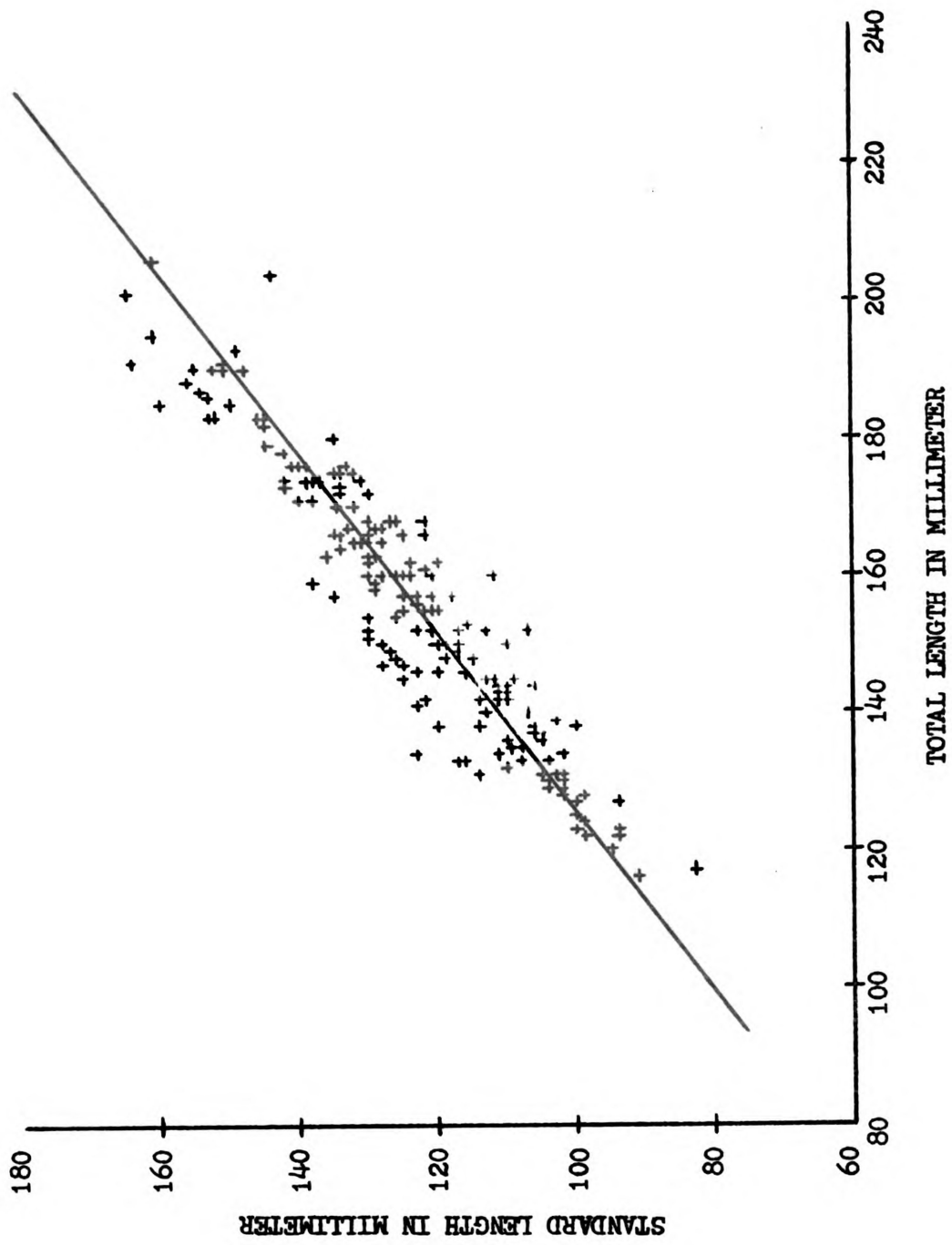


Figure 11

The standard length-weight relationship of climbing perch was determined from 215 fish of the collection taken at different times of the year. The fish ranged from 83 mm to 165 mm in standard length. Data were plotted by using separated symbols for sex. A single regression line was drawn by inspection (Figure 12).

Ten points uniformly spaced with respect to length were selected, logs of those values were plotted, a regression line drawn (Table 5; Figure 13). This regression line was determined by the equation:

$$Y - Y_1 = \frac{Y_2 - Y_1}{X_2 - X_1} (X - X_1).$$

where: Y equals log W; X equals log L; X_1 , Y_1 ;
and X_2 , Y_2 represent two points along the
logarithmic regression line.

The regression coefficient was calculated to be 3.443. Standard length-weight relationship for climbing perch of both sexes can be expressed mathematically as $\log W = 3.443SL - 5.3726$. The result indicated that the weight of climbing perch will vary as the cube of its standard length, and the shape of the fish remains constant with increase of length over the length covered.

Condition

The values of the coefficient of condition or condition factor are interpreted as expressing the relative plumpness of the fish. They have also been used as an

Figure 12.--Standard length-weight relationship for 215
climbing perch.

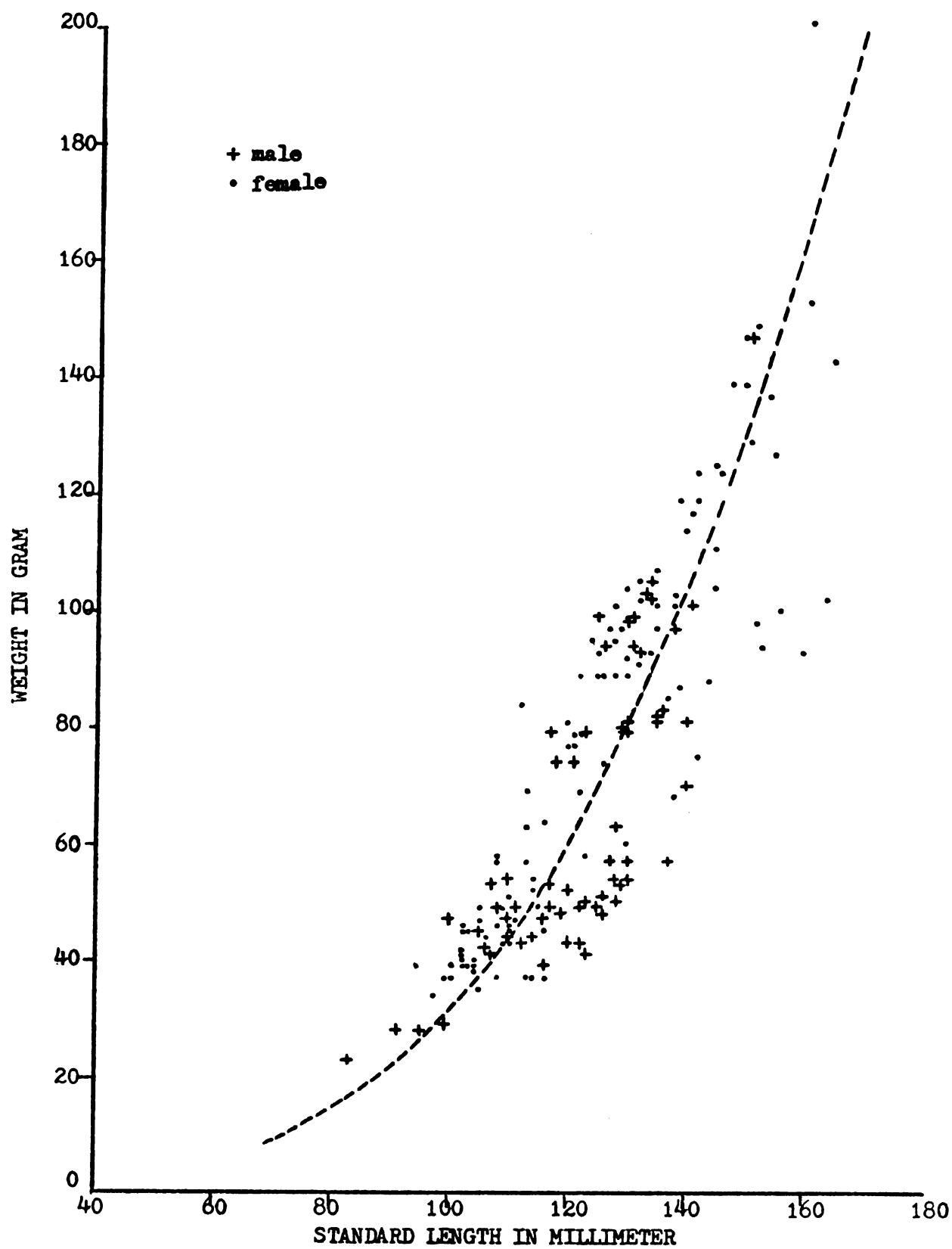


Figure 12

TABLE 5.--The relation of logarithmic values of calculated standard length-weight of the climbing perch taken from Table 12.

Standard length in millimeters		Weight in grams	
X = SL	log X	Y = W	log W
50.0	1.6990	3.0	0.4771
66.8	1.8248	8.1	0.9102
86.0	1.9365	19.7	1.2948
100.0	2.0000	32.6	1.5134
112.5	2.0511	48.9	1.6893
123.6	2.0920	67.6	1.8302
132.5	2.1222	85.9	1.9341
140.0	2.1461	103.9	2.0164
147.0	2.1673	122.8	2.0894
153.0	2.1847	141.0	2.1493

The regression line determined by the equation;

$$Y - Y_1 = \frac{Y_2 - Y_1}{X_2 - X_1} (X - X_1).$$

The regression coefficient was calculated to be 3.443. Then, the standard length-weight equation is:

$$\log W = 3.443SL - 5.3726.$$

Figure 13.--The regression coefficient of logarithmic values of standard length and weight for 215 climbing perch.

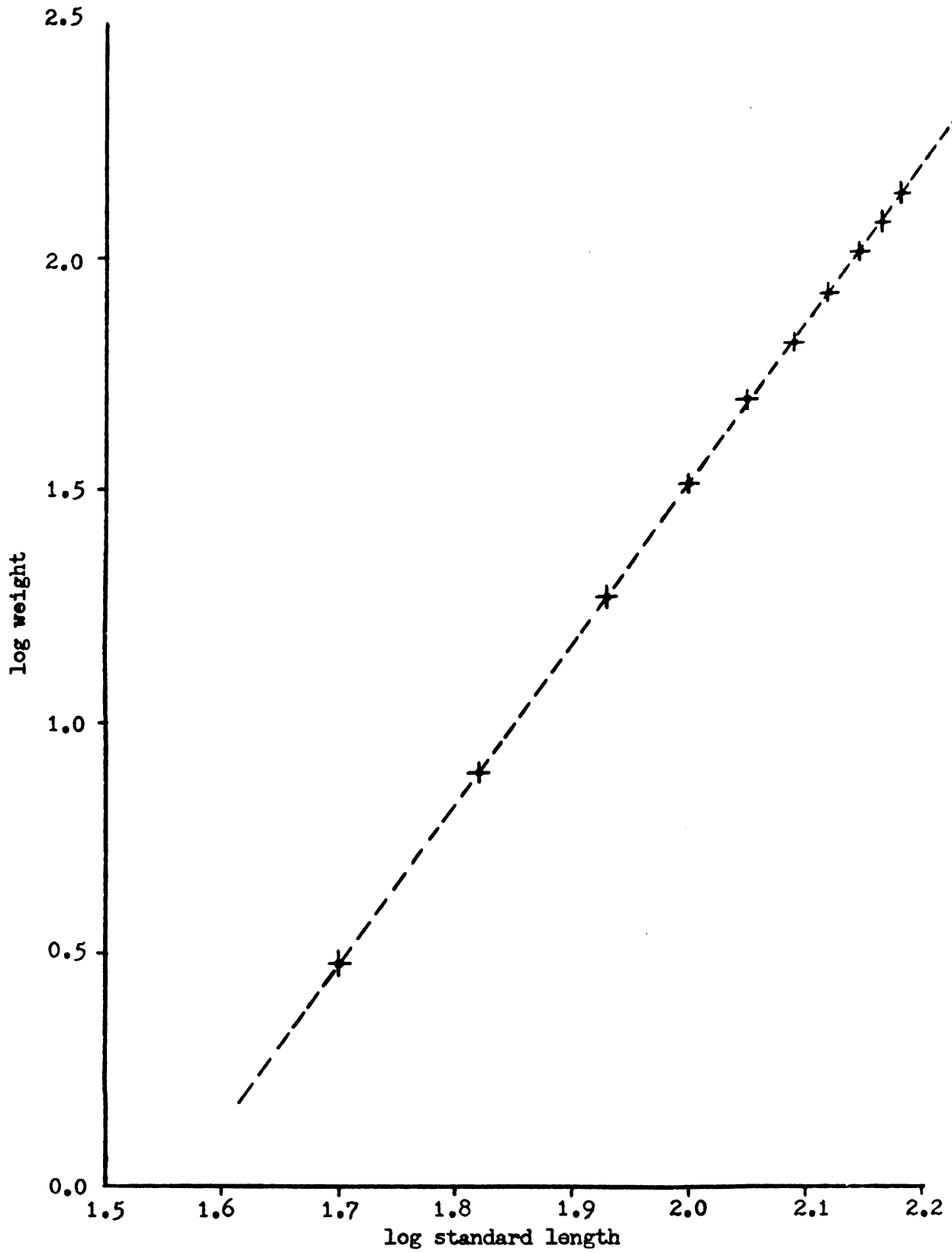


Figure 13

adjunct to age and growth studies. Lagler (1952) reported that the values of the coefficient condition are not only used to express the relative plumpness of the fish, but are also used in age and growth studies to indicate the suitability of an environment for a species by a comparison with the value for a specific locality or area. Moreover, the coefficient of condition is used to define the seasonal changes in the condition of fish in relation to the age and sex of the fish, and differences between the condition of the same species in different waters, which might also serve as an index of the productivity of the water mass (Nikolsky, 1962).

The usual mode of expression of the value of the condition is based on the cube law, the equation is:

$$K = \frac{W \times 10^5}{L^3} .$$

where: W represents weight in grams, and L
represents standard length in millimeters.

The coefficient of condition of the climbing perch was determined from actual average weights and lengths as calculated from the standard length-weight data. The logarithmic equation proposed by Beckman (1948):

$$\log K = a + m \log L$$

where: $a = \log c + 5$
 $m = n - 3.$

Log c and n were obtained from the previous calculations of the standard length-weight relationship.

Calculation values of coefficient conditions for climbing perch of every 10 millimeter intervals in the range covered of standard length are shown in Table 6. The average K -value is 3.584. The result indicates that the climbing perch has become relatively heavier than its increase in length. However, the coefficients of condition are not directly comparable for fish of various lengths and only poorly describe conditions. It must be concerned with many affecting factors. For instance, when the whole body weight is used in calculating the condition coefficient. The weight of the gonad and the intestinal contents might often alter the value of the condition coefficient and mask the true dynamics of the condition of the fish (Nikolsky, 1962).

Body-scale Relationship

Since the scales increase in size with the growth of the fish, a definite relation is found between the fish length and the length of scale. It is therefore possible to compute the length of a fish from the size of the special scale. Creaser (1926) had studied the relation between body and scale growth of bluegill and concluded that "there is little deviation from the direct proportion during the short scale increment of about 0.20 millimeter." He also suggested that for the establishment of the relation of scale length increase to fish length increase in

TABLE 6.--Calculated values of coefficient of condition for the climbing perch taken from the standard length-weight relationship curve at different standard lengths.

Standard length (mm)		Calculated weight (gm)		Calculated values of coefficient condition (K)
SL	log SL	W	log W	
80	1.9031	15.13	1.1798	2.979
90	1.9542	22.69	1.3557	3.113
100	2.0000	32.61	1.5134	3.261
110	2.0414	45.28	1.6559	3.402
120	2.0792	61.10	1.7861	3.536
130	2.1139	80.46	1.9056	3.664
140	2.1461	103.90	2.0164	3.785
150	2.1761	131.70	2.1197	3.904
160	2.2041	164.40	2.2161	4.065
170	2.2304	202.60	2.3067	4.126
Average calculated coefficient condition value				= 3.584

the common sunfish, a definite scale from an area where the scale are quite uniform in size was measured with size of the fish. When the scale measurements are plotted against the fish length, a regression line is formed. If the proportion between scale length and fish length were a simple direct, a straight line originating at the zero-zero point would result.

Van Oosten (1929) had given the scale method of determining the length of fish at successive years of its life and its annual growth increment depends on the validity of the scales as discussed previously.

The methods of calculation of the body-scale relationship have been discussed for many years. Several methods were given by prominent scientists. The following summaries are taken from Lagler (1952), Nikolsky (1962), and Hile (1970).

1. Lea Method. This method assumed that the length of the scale and that of the fish increased in direct proportion to each other. The proportionality is of a linear character, and could be represented by the equation:

$$L_n = \frac{V_n}{V} \cdot L$$

where: L is the measured length of the fish, V is the scale radius, L_n is the calculated length of the fish at age n years, V_n is the distance between the annual ring and the focus at age n years.

2. Lee Method. This method assumed that only the increment in the length of the fish and in the size of the scale are proportional to each other, and not their actual sizes. The main factor which disturbs the proportionality between the length of the fish and that of the scale is the fact that the scale is not laid down at the birth of the fish, but somewhat later, when the fish has already attained a certain length. Rosa Lee therefore proposed to introduce into Lea's formula, the correction length "a" corresponding to the length of the fish at the moment the scale began to be laid down. Then, Lee gave a new body-scale equation:

$$L = a + bS$$

or

$$L_n = \frac{V_n}{V} (L - a) + a$$

where: a and b are constants.

3. Sherriff Method. This method assumed that the mathematical relationship between body length and scale length is expressed by the equation:

$$L = a + bS + cS^2$$

where: L is the body length, S is the scale length, a, b and c are empirically determined constants.

4. Carlander's Third-Degree Polynomial Method. This method is based on a detailed examination of the actual size

of the scale at body length, and involves no assumptions of a fixed mathematical relationship between body length and scale length. Carlander described the body-scale relation by the equation:

$$L = a + bS + cS^2 + dS^3$$

where: a , b , c and d are constants.

5. Monastyrsky Logarithmic Method. This method assumed that, for a certain fish the relationship between the growth of the scales and that of the body has a curvilinear character. The method holds that the increase in the logarithm of the length of the scale is proportional to the increase in logarithm of the body length. The equation which expressed this relationship is the general parabola:

$$L = aS^n$$

or

$$\log L = \log a + n \log S.$$

where: L is the length of the fish, S is the corresponding length of the scale, a is intercept of the straight line on the axis of the ordinate, and n is the slope.

6. Fry's Modification of the Monastyrsky Method. Fry believed that the constant a , corresponds to the length at scale formation is, of course, subject to the same criticism outlined previously. He added a constant to the Monastyrsky equation to give it the following formula:

$$\log (L - a) = \log b + n \log S.$$

The new constant, a , was defined as length at first scale formation. The introduction of the additional constant creates the difficulty of mathematical fitting of the equation and is impractical. In practice, the one giving the closest fit being determined by inspection, and the value of b and n , must be estimated from graph.

The relations between length of the fish and length of scales are usually expressed in terms of scale radius-total length relationship. In this study, scale samples used were the same set as used for the scale method of age determination. From the sample of scale impressions for each fish selected at random, non regenerated scales were used. The microprojector technique is used to measure annulus and scale radius. The measurement was taken from the mid-point of focus to each annulus and to the margin of the scale along standard axis from the focus to the middle of the front margin at longest distance. The exact position of the annulus has to be measured precisely and consistently to the same morphological position. Scale radius and annulus measurements were observed at a magnification of 22.5X and recorded on scale cards which were calibrated in millimeter (see appendix).

The relation of total length and scale radii of 215 climbing perch is shown in Figure 14. The regression coefficient was calculated by the computer. Data given an intercept of 69.622 and the slope of the regression line is 0.996.

Figure 14.--Regression line for the total length-scale radius relationship for climbing perch collected from Lam Look-Ga, Central Part of Thailand.

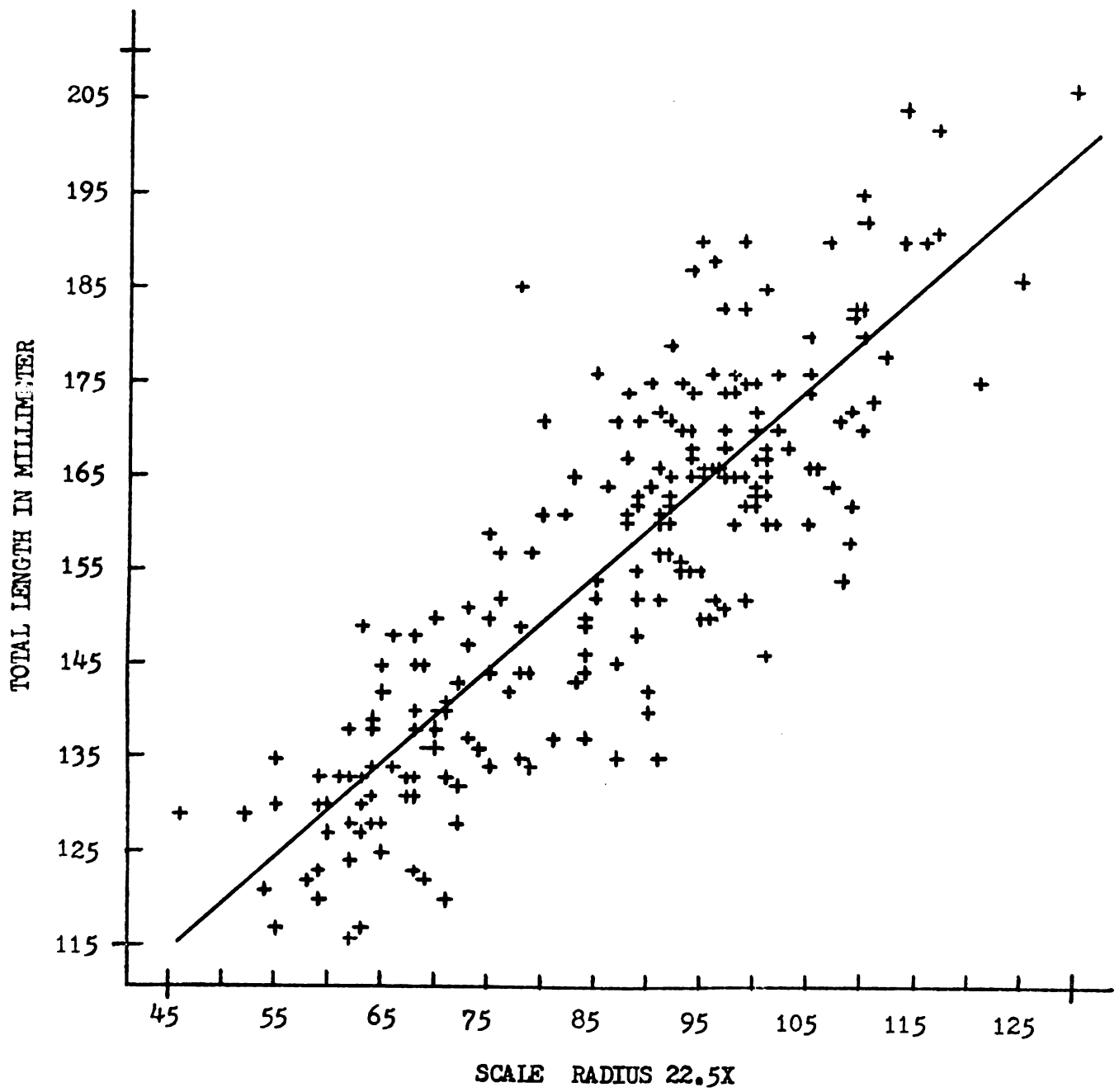


Figure 14

The Lee method was employed to determine the total length of the climbing perch at respective annuli. The calculated values of the total length-scale radius relationship of 184 climbing perch taken from Lam-Look-Ga flood plain, Central part of Thailand, were presented in Table 7.

Average lengths and weights of the age groups

Comparisons of the average total lengths and weights of male and female climbing perch indicated that the females were larger than the males of the same age excepting the first year of life when males are larger than females (Table 8). The data demonstrated that males of the average size of the age group I were 3.70 millimeters longer and 4.28 grams heavier than females of the same age. The average for age group II and III females were 10.72 and 20.62 millimeters longer and 17.51 and 44.46 grams heavier than males of the same age respectively. It should be noted, however, that sex differences of age group III may not be significant because of the small sample with a single male in this year class.

Growth

The study of the calculated growth of the climbing perch was determined from the combination of the data for all age group calculated over the span of one year samples.

TABLE 7.--Calculated and measured lengths of 184 climbing perch taken from Lam Look-Ga, Central Part of Thailand, from July 10, 1969 to May 22, 1970.

Number of Sample	Age Group	Average TL at Captured (mm)	Average calculated TL (mm) at each annulus		
			1	2	3
95	I	139.06	117.54		
75	II	169.69	115.65	154.68	
14	III	179.14	111.24	143.00	168.19
Mean total length in millimeters			114.81	148.84	168.19
Incremental growth			34.03	19.35	
Specific growth			0.2964	0.1300	

TABLE 8.--Average measured total length and weight of climbing perch according to sex at capture.

Title	Sex	Age-Year		
		1	2	3
Total length in millimeters	male	141.36	162.36	160.00
	female	137.66	172.98	180.62
	both	139.06	169.69	179.14
-----		-----	-----	-----
Weight in grams	male	54.53	86.43	75.00
	female	50.25	103.94	119.46
	both	49.20	98.52	116.29

Growth in length.--The calculated lengths of the climbing perch show their greatest growth in length occurred during the first year of life (117.54 mm). The annual increments of length decreased rather rapidly after the first year. Growth in length in later years was relatively slow.

Growth in weight.--The weights in Table 9, which were computed by means of the general standard length-weight equation ($\log W = 3.443SL - 5.3726$) and the total length-standard length equation ($TL = 1.2947SL$). Calculated weight was determined from the average calculated total length of fish at annulus (1-3) of each age group in Table 7.

TABLE 9.--Calculated weights of climbing perch at different annulus of each age group.

Age group (at annulus)	Calculated length (mm)		Calculated weight (gm)
	TL	SL	
1	117.54	92.77	25.19
2	154.68	122.08	65.85
3	168.19	132.74	86.40

The calculated weights were relatively greater than the corresponding changes in calculated lengths. The relatively large increases of weights in the later years is in contrast with the small increases of length in corresponding

years. The calculated weights, sexes combined were greatest in the first two years of life and declined in the third year. The annual increments of weight decreased after the second year and so on.

Growth rate.--The annual growth of climbing perch is different consistently with seasons. The general trends in the annual fluctuations in growth rate can be determined by the examination of the growth of scales of Figure 1. The fish start growing rapidly in late rainy season to early cool season, September to November. During this period, the central plain of Thailand where the fish were taken were flooded. Of course, flooded waters have abundant organic matter which is food for this fish, and slowly decreasing temperatures still do not effect food consumption of the fish, therefore rapid increase in growth results.

In the cool season, temperature continues to decrease, till reaches minimum point somewhere between late November to early December. This critical period causes the fish to quit eating and stop growing. As a result an annulus was formed on the scales as described previously. Thereafter, the fish grew rapidly in late December to January and more slowly from February to March. Growth rate increased slowly through summer and early rainy seasons.

SUMMARY

1. Scales for assessment of the validity of annuli as age indicators were obtained from 184 climbing perch taken from the central region of Thailand. Scale samples were collected over one year, from July 10, 1969 to May 22, 1970.

2. Scales of climbing perch are typically ctenoid with strongly sharp spines on the posterior field. The anterior field is sculptured with rings running parallel to the anterior margin. Six to nine scales were impressed on plastic (cellulose acetate) by roller press for the study. Scales were examined, the measurements made of the distances from the focus to each ring and to the scale margin with a scale projector at a magnification of 22.5X. All scales were read at least twice, and differences in scale reading either were reconciled or the scales discarded.

3. Time of annulus formation was determined by comparing the extent growth of scale radius between the last annulus and the scale margin. It should be assumed that

annulus formation on the scales of climbing perch takes place somewhere between late November and December. Annulus formation is the effect of decreasing temperature together with lowering water level during the cool season.

4. Annuli or year marks were identified by the interruptions of the ridges (cutting over) in the anterior field. Such area of discontinuous and irregular ridges form dark band, occasionally with gaps between ridges along the lateral field. Annuli are parallel to scale margin and occur in the same relative position on the scales except regenerated or damaged scales of an individual fish. The principal condition of the validity of scales for age determination was based on scale measurements. The study showed that (a) each annulus on the scales was located in the same relative position, (b) the scales increased in length with the number of rings, (c) the distance between outer annuli decrease with age, and (d) the distance between the last annulus and the scale margin increased rapidly during flood season and after lowering period, reaching a maximum in early cool season.

5. Age composition of the climbing perch of the samples composed of the fish age group I 51.63 percent, age group II 40.76 percent, and age group III 7.61 percent. The total number of each age group in the sample decreased continuously with age. The percentage of females is greater than those of males of every year class.

6. The growth study of the climbing perch was computed by many methods. The total length-standard length relationship was determined by the method of least squares to be $TL = 1.2947SL$. The standard length-weight relationship was calculated by the parabolic equation to be $\log W = 3.443 \log SL - 5.3726$. The condition factor is based on the cube law gave an average value of 3.584.

The body-scale relationship was determined by a linear regression of total length on scale radius for 215 climbing perch ranging from 116 mm to 206 mm in length. The regression coefficient was determined by computer yielded an intercept of 69.622 and slope of 0.996. The total length at each annulus was determined by the Lee Method which best fit the available data. The calculated lengths for combined sexes at the first, second and third annuli were 117.54, 154.68 and 168.99 mm respectively.

The average length and weight increments decreased continuously as the fish grew older. The growth rate declined consistently as the fish increased in age and size.

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APPENDIX A

TABLE A-1.--Total length, standard length, weight, annuli, scale radius and sexes of 215 climbing perch taken from Lam Look-Ga, Central Part of Thailand, from July 10, 1969 to May 22, 1970.

TL	SL	W	Age	Annulus			SR	Sex	
				I	II	III		Male	Female
171	139	71	-				80	*	
165	128	64	-				83	*	
142	122	50	1	46			65	*	
145	114	45	2	37	61		68	*	
144	115	50	1	46			75	*	
159	129	54	2	51	70		75	*	
150	119	49	1	55			70	*	
141	123	43	1	50			71	*	
191	164	103	3	44	84	105	117		*
185	160	94	3	41	75	93	101		*
176	163	98	-				98		*
152	130	55	1	62			89	*	
150	128	55	2	39	61		84	*	
148	126	52	1	64			89	*	
149	127	58	1	63			84	*	
148	126	49	1	50			68	*	
146	123	59	1	62			84		*
147	123	51	1	49			73	*	
134	122	44	1	50			75	*	
149	117	50	1	44			63	*	
164	129	68	-				86		*
152	117	54	1	61			85	*	
144	110	45	1	55			79	*	
143	111	50	1	62			83	*	
145	112	44	1	46			69	*	
136	105	46	1	48			74	*	
128	99	30	1	54			64	*	
144	111	50	1	61			84	*	
134	102	43	1	61			84	*	
136	105	46	1	47			68	*	
138	120	44	1	53			79		*
138	106	43	1	51			70	*	
140	107	42	1	60			72	*	
150	110	48	1	51			75	*	
151	130	61	1	59			73		*
152	107	54	1	63			91	*	
152	116	48	1	55			76	*	
154	130	58	1	52			85	*	
157	128	51	1	59			76	*	
133	116	40	1	55			71	*	
133	116	38	1	35			59		*
125	100	40	1	37			65		*

TABLE A-1.--Continued.

TL	SL	W	Age	Annulus			SR	Sex	
				I	II	III		Male	Female
123	100	38	1	48			59		*
138	114	53	1	56			64		*
135	109	50	1	36			55		*
134	102	43	1	42			66		*
143	110	52	1	42			72		*
131	102	46	1	41			68		*
140	110	44	1	48			68		*
133	104	41	1	47			63		*
129	104	40	1	40			52		*
123	94	40	1	40			68		*
130	102	41	1	42			63		*
130	102	42	1	46			60		*
136	110	46	1	40			69		*
130	104	41	1	43			55		*
124	99	38	1	44			62		*
128	102	40	1	44			65		*
133	104	39	1	44			68		*
131	105	36	1	48			64		*
131	114	38	1	41			67		*
127	100	40	1	40			63		*
116	91	29	1	38			58	*	
128	102	41	1	41			62		*
131	113	38	1	45			67		*
139	103	40	1	51			64		*
122	98	35	1	40			58		*
138	101	39	1	50			62		*
127	94	32	1	46			60		*
140	112	47	1	45			70		*
149	115	50	1	49			78		*
142	114	55	1	40			78		*
135	108	47	1	48			78		*
144	116	56	1	49			78		*
146	120	53	1	48			71	*	
131	105	36	1	46			64		*
131	103	46	1	35			59		*
148	119	44	1	42			66		*
132	105	47	1	43			72		*
134	111	48	1	46			64		*
129	102	41	1	32			46		*
137	106	45	1	51			73		*
142	111	48	1	53			77		*
133	105	48	1	43			61		*
133	108	38	1	41			67		*
122	94	32	1	50			69	*	
120	95	29	1	43			59	*	
157	125	90	1	37			91		*
150	120	62	1	70			95		*
162	124	88	2	55	77		109		*
145	113	64	1	38			89		*
162	124	88	-				100		*
160	128	90	1	66			98		*

TABLE A-1.--Continued.

TL	SL	W	Age	Annulus			SR	Sex	
				I	II	III		Male	Female
152	113	70	1	51			89		*
151	121	80	1	64			97		*
135	108	50	1	65			91	*	
142	110	55	1	62			90	*	
128	100	48	1	50			72	*	
137	105	50	1	59			81		*
137	108	58	1	47			84		*
175	145	126	2	45	81		121		*
161	130	93	-				105		*
146	116	65	1	58			101		*
152	121	80	1	54			96		*
152	123	88	1	68			99		*
154	126	75	1	62			108		*
155	120	82	1	62			93		*
155	121	78	2	51	72		94		*
155	125	70	2	41	61		95		*
167	128	102	2	57	87		101		*
183	146	125	2	57	83		109		*
135	108	59	-				87		*
140	113	58	1	55			90		*
163	126	92	-				100		*
165	127	100	-				97		*
175	140	112	-				100		*
165	128	90	2	45	78		98		*
168	130	100	3	32	63	85	97		*
165	132	92	2	29	84		95		*
174	139	88	2	40	92		105		*
160	124	96	2	59	93		102		*
171	140	82	2	39	80		92	*	
183	152	99	2	41	90		99		*
170	132	106	3	30	58	82	100		*
163	130	90	2	51	75		89		*
167	133	104	2	34	80		100	*	
157	125	100	2	25	78		92	*	
155	122	80	2	33	78		89		*
170	135	102	3	38	68	93	102		*
168	126	95	2	54	81		94	*	
165	130	99	2	25	85		99	*	
168	130	100	2	39	96		101		*
166	134	106	2	35	86		95	*	
183	153	95	2	42	91		110		*
188	156	101	2	43	91		96		*
182	145	105	2	33	94		109		*
164	138	102	3	44	76	102	107		*
165	128	96	2	40	87		94		*
166	134	103	2	37	87		97	*	
162	130	93	2	44	92		100		*
160	125	88	2	35	87		101		*
160	126	90	2	34	81		92		*
150	117	80	2	35	88		96	*	
174	138	104	2	44	90		97		*
174	137	86	2	31	80		94		*

TABLE A-1.--Continued.

TL	SL	W	Age	Annulus			SR	Sex	
				I	II	III		Male	Female
174	142	76	2	45	88		97		*
170	135	98	2	36	86		94		*
170	135	98	2	41	101		110		*
172	130	105	3	43	69	102	109		*
183	145	112	2	45	83		97		*
179	144	89	2	36	87		92		*
165	131	95	2	56	86		90	*	
171	138	69	3	36	56	81	87		*
172	130	100	2	38	92		100		*
165	132	94	2	31	83		101	*	
176	133	115	-				85		*
171	130	90	-				89		*
170	127	95	-				93		*
172	126	100	-				91		*
174	131	100	-				88		*
161	119	82	-				80	*	
167	129	98	2	39	77		88		*
161	120	72	-				82		*
164	132	83	-				90		*
175	133	101	-				99		*
170	130	90	-				97		*
161	122	70	-				91		*
162	120	78	-				89		*
174	131	100	-				98	*	
176	133	94	2	55	84		96		*
172	134	94	2	42	78		100		*
166	122	88	2	49	79		107		*
166	125	94	2	55	91		105		*
180	135	108	2	45	102		111		*
168	122	90	2	54	77		103		*
164	129	86	-				100		*
175	132	103	2	45	75		93		*
175	134	104	2	51	78		90		*
162	126	82	-				92	*	
163	121	86	-				89		*
160	121	75	3	34	61	85	88	*	
157	118	75	1	70			79	*	
167	126	89	-				94		*
168	127	98	3	29	64	93	97		*
160	112	85	1	64			98		*
190	152	150	2	74	96		114		*
206	161	202	3	51	85	108	130		*
190	150	148	2	61	105		114		*
170	135	90	-				94	*	
192	151	148	-				111	*	
190	150	148	2	52	87		107		*
163	129	81	2	28	55		92	*	
204	161	155	-				114		*
202	165	144	3	52	83	107	116		*
190	151	130	2	47	85		99		*
185	150	128	2	40	72		77		*

TABLE A-1.--Continued.

TL	SL	W	Age	Annulus			SR	Sex	
				I	II	III		Male	Female
195	161	154	3	39	76	103	110		*
186	150	138	3	49	74	102	125		*
187	138	138	2	44	73		94		*
190	155	128	2	56	76		95		*
176	140	115	2	52	77		105		*
176	139	120	2	47	77		98		*
180	142	125	2	46	80		110		*
178	142	120	2	47	84		112		*
173	141	118	2	55	89		111		*
171	138	98	2	58	100		108	*	
162	130	93	2	60	95		99		*
176	141	102	2	56	80		102	*	
158	129	80	2	54	99		109	*	
161	128	80	-				88	*	
163	136	84	2	53	97		101	*	
166	130	82	2	52	83		91	*	
156	123	80	2	58	85		93	*	
166	135	83	2	47	82		96	*	
165	130	80	2	56	82		95	*	

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