STUDY ON GROWTH PERFORMANCE AND SOME ASPECTS OF BIOLOGY OF THAI KOI *Anabas testudineus* (Bloch, 1792)

A Thesis
By

Mahmudul Hasan
Examination Roll No. 06 Fish FBG JJ 12 M
Registration No. 28409
Session: 2000-2001
Semester: January-June 2007

MASTER OF SCIENCE (M. S.)
IN
FISHERIES BIOLOGY AND GENETICS

DEPARTMENT OF FISHERIES BIOLOGY AND GENETICS
BANGLADESH AGRICULTURAL UNIVERSITY
MYMENSINGH

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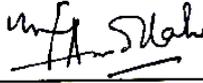**BANGLADESH AGRICULTURAL UNIVERSITY**
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May 2007

DEDICATED

TO

MY BELOVED PARENTS,
NEPHEW MAHID AND

NIECE IKRA

IT-COM

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ABSTRACT

An experiment was carried out to evaluate the effects of different feeds (Suny feed, Mixed feed and Saudi-Bangla fish feed) on the growth, survival and production of Thai koi (*Anabas testudineus*) in nine ponds (81m² each) belongs to "Fisheries Field Laboratory Complex", under the Faculty of Fisheries in Bangladesh Agricultural University, Mymensingh during 21" April to 28th July 06. Here, Suny, mixed and Saudi-Bangla fish feed were considered T1, T2 and T_1 respectively. Two hundred and fifty fries (average length 3.63±0.015 cm and weight 0.90 ± 0.18 g) were cultured 99 days under treatments each having three replications. The net weight gain of fish in T3 (78.90±0.11g) was significantly higher (p<0.05) than that of T2 (76.18 ± 0.04 g) and T_1 (72.67±0.24 g). The productions were 2269, 2374 and 2435 kg/ha/99days in T1, T2 and T3 respectively. Average food conversion ratios (FCR) were 2.166 ± 0.05, 2.40 ± 0.03 and 2.50 ± 0.00 in T1, T2 and T3 respectively. Survival rates of fish were 73, 77 and 78% in T1, T2 and T3 respectively. However, total net profit/ha/99days of T2 (Tk. 206451.85) was significantly higher (p<0.05) than those of T3 (Tk.182928) and T_1 (Tk.164949) respectively. Although, on the basis of observed growth rate and feed utilization by fish, Saudi-Bangla fish feed (T3) showed the best growth performance while Suny feed (T_1) showed the lowest growth performance but in terms of benefit cost ratio (BCR) T2 (1.76) was significantly higher than those of T3 (1.60) and T_1 (1.57). Measured water quality parameters in different treatments during the experimental period were found to be similar and their ranges were within acceptable limit for fish culture. The highest plankton population was recorded in T2. A study was also performed from 23rd January 07 to 15th May'07 to know some biological aspects of the same species. Fecundity of this species varied from 3,965 (total length 9.3 cm, body weight 35.0 g) to 60,500 (total length 14.5 cm, body weight 59.0 g) with mean of all sampling 26,578 ± 1,970. The ovary weight ranged from 1.0 to 12.1 g with mean of 5.36±0.334. The average numbers of eggs/g body and ovary weight were 526 and 4,480 eggs respectively. The gonadosomatic index (GSI) ranged from 2.8 to 19.50 with mean of 10.75 ± 0.583. The ova diameter and sperm-head length varied from 125 to 685 µm with mean of 410.66 ± 7.0 µm and 1.0 to 3.60 um with mean of 2.30 ± 0.08 µm respectively. The condition factor (CF) varied from 0.95 to 1.21 with mean of 1.00 ± 0.003. The regression analysis data showed that the relationship between body weight-fecundity and ovary weight-fecundity were found to be linear and co-efficient of correlation (r) was highly significant (P<0.01). The results of the present studies suggested that mixed feed might be more economic for mass culture of Thai koi (*A. testudineus*) and the fecundity was positively correlated with their body and ovary weight.

LIST OF ABBREVIATIONS

ANOVA = Analysis of variance

& = and

AOAC = Association of Official Analytical Chemists

BAU = Bangladesh Agricultural University

BCR = Benefit Cost Ratio

C = Centigrade or Celsius

CF = Condition Factor

cm = Centimetre

DFID = Department for International Development

DoF = Department of Fisheries

FAO = Food and Agricultural Organization.

FCR = Food Conversion Ratio

g = Gram

GDP = Gross Domestic Product

hr = Hour

ha = Hectare

kg = Kilogram

L = Litre

m = Meter

MAEP = Mymensingh Aquaculture Extension Programme

μm = Micrometer

mg = Milligram

ml = Millilitre

M. S. = Master of Science

mt = Metric ton

% = Percent
PG = Pituitary Gland
PMS = Phenazine methosulfate
ppm = Parts per Million
SE Standard Error
SGR = Specific Growth Rate
Tk. = Taka
UNDP = United Nations Developmental Programme
V = Voltage
wt = Weight
Yr = Year
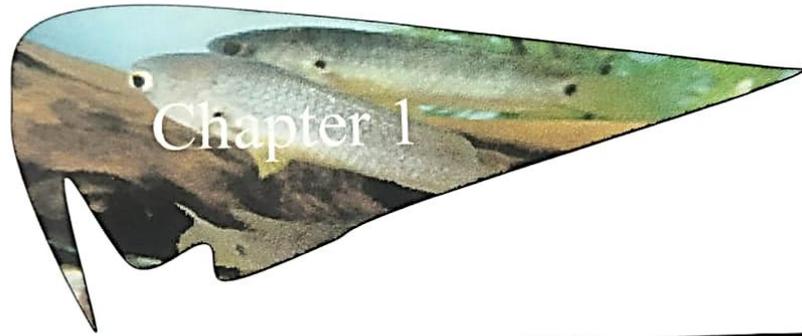
Chapter 1

INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1   General introduction

Bangladesh is a developing country of third world and conceit due to its large aquatic habitat. It is fortunate enough having extensive and huge water resources scattered all over the country in the form of small ponds, beels, lakes, canals, small and large rivers. The country has vast and diversified water resources of 4.34 million ha (Mazid, 2002). It is affluent in terms of globally important wetland ecosystem and associated aquatic biodiversity ranked third in Asia, with approximately 260 indigenous species and 20 exotic species (DoF, 2005). This biological diversity has been endorsed to the world's one of the largest wetlands (Bengal Delta) and some hefty water bodies flowing over the luscious greenery of Bangladesh from the Himalayan mountains into the Bay of Bengal. The inland water resources of the country enfold an area of 4,339,694 ha of which 93% comprise open waters and 7% closed water bodies (DoF, 2005).

In fact, fish and fisheries are extremely important for Bangladesh and these have been an integral part of nutrition, economy, culture and tradition of the people of Bangladesh from time immemorial. Fishing is even older than agriculture itself and always has a major role to play in supply of appetizing and high quality protein food to people. It is also relevant with daily bread of many people, since about 12.8 million people of the country are involved in full time job (DoF, 2005).

Presently fish and fisheries sector contribute 63% of total protein intake, 4.92% to GDP, 23% to agricultural production and 5.77% to foreign export earning of the nation (DoF, 2005).

Since the augmentation of fish production from canals, beels, haors, rivers and estuaries is generally considered to be complicated, we need to depend on pond

aquaculture for escalating production and demandable supply of fish, employment generation and poverty alleviation in rural Bangladesh. Though the population of Bangladesh is increasing geometrically but the resource are not increasing in the same manner. Our per capita annual fish intake is 15.04 kg where demand is 18 kg; this large amount of gap (2.96 kg fish/person/yr) should be fulfilled from our culture fisheries (DoF, 2005).

Therefore, a significant effort to increase fish production should be concentrated on aquaculture. Bangladesh is brought face to face today with the problem of protein calorie malnutrition.

To overcome these problems of protein calorie malnutrition increase of fish production is essential. Prospect of fish farming in Bangladesh is better than those of dairy and poultry farming for its smaller quanta of capital requirement and short term. It is possible to increase animal protein through adoption of small scale aquaculture in the available inland waters as well as in many small sized multipurpose homestead ponds situated in rural areas of Bangladesh. Many potential rural fish farmers and pond owners are poor and they do not have the capability to invest such money for purchasing fish seed, fertilizers and feeds. As a result, their ponds remain derelict. With the exception of the comparatively high investment in carp and shrimp culture, no other fish farming technologies have been developed, especially which could encourage the large group of marginal fish farmers to utilize their small ditches or homestead mini-ponds and other micro compoundments for fish production.

The total fish production of the country during the year 2004-2005 was about 2,215,957 mt of which 1,741,360 mt were produced from inland water (DoF, 2005). In our country sustainable development of aquaculture is essential in order to increase the production. This could be done with many small fishes especially local and Thai koi (*A. testudineus*) based on small scale, low capital investment but with promise of high financial returns.

Among the live fishes koi (*A. testudineus*) is most popular to the people of Bangladesh. A few years ago, a fish was introduced in Bangladesh from Thailand, which was commonly known as "Thai koi". It looks like our local koi. After introducing to our country, within a very short time it occupied a very vital place in our aquaculture. The growth rate and bigger size of Thai koi (*A. testudineus*) made the people enthusiastic to its artificial breeding and culture in Bangladesh. Marginal farmers are very much interested to culture it due to its higher growth rate and better return compared to other species. But proper culture technique and quality feeds for potential growth of Thai koi (*A. testudineus*) are not available.

1.2 Taxonomy and general information about *A. testudineus*.

One of the most celebrated fishes, *A. testudineus* is capable of wandering "cross-country" due to having spiky gill covers propelled by its pectoral fins. *A. testudineus* is exceptionally variable in size and structure. The hind part of the fish twitches violently to propel it forward. Using this method, and when the air is sufficiently humid, it is said to be able to cover several hundred meters/trip.

Climbing perch, climbing bass, kawai, koi, coi, kai, kou are the common names appearing to the species *A. testudineus* which is used for the world wide recognition of this species through this scientific name. But according to Roberts (1989) it may be more than one species currently bearing the similar scientific name *A. testudineus*. Other scientific names manifested in the literature for this species have been unveiled by Riehl and Baensch (1991).

Typically climbing perch are gray to green in color with one dark spot at the caudal base and another just behind the gill plate. The edges of their scales and fins are brightly coloured (Axelrod et al., 1971; Sterba, 1983). The operculum and pre-operculum are both serrated. The single dorsal and anal fins are both long (Sen, 1985). Fin counts are as follows: Dorsal = XVI-XVIII, 8-10, Anal = VIII-XI, 9-11, and Pectoral = 14-15 (Talwar and Jhingran, 1991). The number of vertebrae of Thai koi (*A. testudineus*) is 26 (Noor, 2005). The body is moderately deep, its depth 3 to

3.5 times in standard length. There are 21-29 scales in a lateral line. The mouth is fairly large and the teeth are villiform.

1.3 Distribution

This species naturally occurs in Bangladesh, India, Pakistan, Ceylon, Burma, Srilanka, Thailand, Cochin-China, Tongking, Southern China, Philippines, Polynesia and Malaysia (Axelrod et al., 1971; Jayaram, 1981; Sterba, 1983; Sen, 1985: Talwar and Jhingran, 1991). This species is strictly native for Asia and introduced in Australia and America, but not established in America. It is found in canals, lakes, ponds, swamps and estuaries. It occurs in medium to large rivers, flooded fields and stagnant water bodies including sluggish flowing canals and often found in areas with dense vegetation. It remains buried under the mud during dry season. This freshwater fish is found in the beels, haors, baors, flooded water bodies, ponds, streams and rivers of Bangladesh (Siddiqua et al., 2000).

1. 4 Biological aspects of Thai koi (*A. testudineus*)

Previous studies on different aspects of biology of *A. testudineus* (Bloch) was done very poorly. It is an omnivorous fish (Shafi and Mustafa, 1976). The study of gonadosomatic index (GSI) determines the state of maturity and onset of spawning season. It is often used to follow the reproductive cycle of a species over the year at monthly or less intervals. This index, which assumes that an ovary increases in size with increasing development, compares the mass of the gonad with the total mass of the animal.

To determine the fecundity, it is necessary to know the condition of the female, its ovaries, eggs and the diameter of the egg. For this reason, egg size is important to ascertain the reproductive stage and reproductive pattern of fish. The size of ovarian ova in relation to the weight of the ovaries and size of fish is used to characterize the relative sexual maturity of the fish (Clark, 1934; and Islam and Das, 2006). Sperm plays an important role in breeding. Therefore its sizes are very

important for successful fertilization. In many cases, it was found that egg mature early and sperm mature lately or vice-versa. But for effective breeding eggs and sperms should be mature at the same time.

Fecundity may be defined as the number of ripe mature eggs produced by a brood fish. It is the most important aspect of biology of the fish which must be understood to explain the variations in the level of production as well as to make efforts to increase the amount of harvest. But a few information are available on the fecundity of Thai koi (*A. testudineus*) in Bangladesh. It is important to know the number of eggs, fry and young that could be produced from an individual brood fish for the purpose of better production. In order to raise our knowledge about the biological management of this commercial fish, the present thesis reports will be beneficial for escalating aquaculture practices as well as production of fish in our country.

In fisheries biology, condition factor may be used to detect seasonal variations in the condition of fish, which may vary with food abundance and the average of the stock. Condition factor is quantitative parameter of the well-being state of the fish that will determine present and future population success by its influence on growth, reproduction and survival.

1. 5 Justification of the study

Climbing perch is demandable, small fish in Bangladesh (Bhuiyan, 1964 and Rahman, 1989) having considerable economic importance as food fish. This fish is highly nourishing and remain fresh for prolonged period out of water. It can withstand harsh environmental condition such as low oxygen, random fluctuation in temperature and poor water condition. This species is considered as a valuable item of diet for sick and convalescents. It contains high amount of available iron and copper essentially needed for hemoglobin synthesis (Saha, 1971). In addition, it also contains easily digestible fat of very low melting point and enriched with many of essential amino acids. Due to its other unique feature i.e. faster growth

rate, high market price, deliciousness to eat and cultivability by using supplemental feeds make it popular to adopt in culture by middle-class farmer.

In spite of all these reimbursement, very little initiative has been undertaken in Bangladesh for its commercial aquaculture. Some workers although had previously reported successful business by culturing of the species, but this had not been standardized to be recommended at poor farmers level for commercial production or culture (Akhtaruzzaman, 1988). However, due to cost and availability consideration, it is inevitable that some hand prepared feed (components are available and cheap) will be used as feed for fish culture. But there is very little information on the effects of feeding on the growth and production of *A. testudineus* in our country. Since Thai koi (*A. testudineus*) is a newly exotic species not much work have been done regarding various aspects of its culture.

The information on different aspects of biology i.e. gonadosomatic index (GSI), gamete sizes (egg diameter and sperm head-length), fecundity and condition factor of this species is of great importance in fishery research programme as its plays the vital role both in breeding and fisheries management. There is no published information on the biological aspects of Thai koi (*A. testudineus*) in Bangladesh in reference to the variation in the total weight-fecundity and ovary weight-fecundity. A little knowledge exists about its growth performance by using different feeds. Considering these facts, an attempt was made to study the growth performance and different aspects of the biology of Thai koi (*A. testudineus*).

1.6 Objectives

In view of the above, studies were conducted with the following objectives:

➤ To study on growth performance of Thai koi (*A. testudineus*) in ponds with different feeds.

➤ To determine some aspects of biology i.e. gonadosomatic index (GSI), gamete sizes (egg & sperm diameter), fecundity and condition factor of Thai koi (*A. testudineus*).

➤ To know the relationship between body weight-fecundity and ovary weight-fecundity of Thai koi (*A. testudineus*).

Chapter 2

REVIEW OF
LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

Growth performance and biological aspects of Thai koi (*A. testudineus*) are new chapter in our aquaculture at the present context of Bangladesh. Information regarding the experiment is not available. An attempt has been made to present a short review of available literature relating to the present studies.

2.1 Growth and production

Akhteruzzaman (1988) conducted an experiment on the monoculture of *A. testud*ineus (Bloch) under semi-intensive culture system. Fingerlings (average wt. 8 to 9 g) were stocked at a density of 16000/ha in three 0.028 ha size ponds. They were fed daily with a mixture of rice bran, mustard oil cake and fishmeal at a ratio of 3:1:1. Feed was given daily at the rate of 5-6% of the estimated body weight of the stocked fish. After 5 months rearing, the average yield was 450 kg/ha and average survival rate was 78%.

Charoentesprasit et al. (1996) also observed in a 12 weeks study in glass aquaria that, the fry of *A. testudineus* with the initial wt of 0.438 g feeding on isoenergetic diets containing 25, 30 or 35% protein. 30% protein resulted in maximum growth (mortality, live weight gain, body length, specific growth rate) ($P<0.05$). Feed conversion efficiency was not influenced by dietary protein levels

Chareontesprasit et al. (1997) conducted an experiment on climbing perch, *A. testudineus* and were stocked at 3 stocking densities, 100, 200 and 300 fish/m² and fed on diets containing 20, 25 and 30% protein for 12 weeks. Fish stocked at a density of 200/m² and fed on 30% protein showed optimum specific growth rate, length gain, weight gain, protein efficiency ratio, feed cost/unit weight gain and survival rate.

Hossain (2001) carried out an experiment to evaluate the effect of stocking density on the growth, survival and production of pangas (Pangasius hypophthalmus) in stocking densities of 100, 150 and 200 fish/dec. A common supplemental feed containing 30% protein was applied in each pond and significantly higher growth rate was obtained at stocking density of 100 fish/dec.

Doolgindachbaporn et al. (2003) conducted culturing of climbing perch, *A. testudineus* (Bloch) at varying densities. Climbing perch, with mean weight of 0.198 g, were cultured in 50L circular tanks at densities of 55, 77, 99 and 121 fish/m². The fish were fed floating pellet at 30% protein level for 16 weeks. There were significant differences (P<0.05) among the densities in terms of average weight, total weight and mortality rate. Climbing perch, with average weight of 28.9 g, cultured at densities of 10, 20 and 30 fish/m² and fed floating pellets at 32.29% protein level for 12 weeks, showed significant differences (P<0.05) among densities in terms of average weight. However, no significant difference was observed in terms of total weight and mortality rate and the optimal density was found 10 fis/m².

Hossain (2003) carried out an experiment to determine the effect of mixed feeding schedule on the compensatory growth of Thai pangas (Pangasius hypophthalmus) using a commercial feed containing 30% protein. He found the best compensatory growth in a mixed feeding schedule of alternating periods of seven days normal feeding followed by seven days of restricted feeding.

Mahmood (2003) conducted an experiment to find out the suitable PG doses for *A. testudineus* (Bloch). Here, nine different doses were applied in terms of ovulation response, ovulation time, fertilization and hatching rates of eggs. The optimum dose obtained for breeding the fish was 1.2 mg PG/100 g body weight where fertilization rate was 82±2.8% and hatching rate was 71 ±3.7%.

Chandraseksran et al. (2005) conducted a study on the effect of different feeding schedule on the growth of freshwater prawn Macrobrachium lamarrei lamarroides.

They concluded that maximum growth was recorded when the feeding was three times in a day (6 hr frequency). The food conversion efficiency and muscle ratio of the prawn was also higher in 6 hr frequency fed group. However, the condition factor was the maximum in 4 and 8 hr groups.

Noor (2005) carried out an experiment on the growth and morphological composition between local and Thai koi (*A. testudineus*) in Bangladesh. She found that length gain (cm), weight gain (g) and SGR of Thai koi (12.23, 55.83 and 7.92 respectively) were significantly higher (p<0.01) than the local koi (10.77, 26.54 and 7.05 respectively). The survival rate was also significantly higher (p<0.05) in Thai koi (80.67%) than the local koi (62.67%) during the experimental period.

2.2 Economic analysis

Shang and Costa-Pierce (1983) advised the necessity of economic analysis of fish culture operations with a view to finding out different alternatives for ensuring high level of net revenue earning. Economic analysis provides a base not only in the decision making of individual farmer but also in the formulation of aquaculture policies.

A survey conducted by Islam and Dewan (1986) on the resource use and economic return in pond fish culture in 4 districts of Bangladesh indicated that pond fish production in the surveyed areas was based on stocking of fish seed, use of fertilizers and low quality rice bran as feed. The majority of the farmers in Gazipur, Mymensingh, Lakshmipur and Jessore districts reared various species of native and exotic carps and produced 1,700 to 3,889 kg/ha/yr in different locations. They noted that higher yield was not only the factor for higher net return but also price of fish and economic use of both material inputs and labour influenced net return.

Khaleque et al. (1998) assessed the economics of fish production under semi-intensive culture and management in Gazipur Sadar, Kishoreganj and Gaffargaon thana and showed that MAEP fish farmers were producing fish at the rate of 3.2 to 4.5 mt/ha/yr.

Akter (2001) studied the costs, returns and profitability of pangas fish production in Trishal Upazilla, Mymensingh in 2000. It was estimated that per ha gross cost of production of pangas was Tk. 286,952.84 while gross margin and net return were Tk. 300,532.67 and Tk. 259,520.17/ha, respectively.

Khatun (2003) conducted a research on comparative economic analysis of year round pangas culture and alternate rice fish farming in some selected areas of Mymensingh district and observed that per ha total cost and net return were Tk. 79,661 and Tk. 64, 9838, respectively. She also estimated BCR, which was 1.82. The findings indicated that pangas farming was profitable enterprise.

Paul (2005) evaluated a study on profitability of rearing fingerlings and fish in some selected areas of Netrokona. It was estimated that gross cost/ha for fingerling production was Tk.142827, while gross return and net return/ha were Tk 275,123 and Tk. 132,295, respectively.

2.3 Water quality parameters

Water quality parameters are the most important factors, which influence the aquatic production directly or indirectly. Plankton is important food for fish and other aquatic animals. The higher the plankton density in pond waters the higher the productivity of the pond. Some of the research works relevant to the limnological studies of inland water bodies are cited below.

Dewan et al. (1991) worked on food selection, selectivity and dietary overlap among Chinese and Indian Major Carp fry and fingerling grown in extensively managed, rained ponds in Bangladesh and estimated phytoplankton numbers varied from 2×105 to 8×10 cells/L. They also identified 24 genera of phytoplankton during their experimental period.

Wahab et al. (1994) performed the impacts of Thai sarpunti (*Puntius gonionotus*) on the polyculture of native major carps where they identified 24 genera of phytoplankton and 5 genera of zooplankton. They also reported the quantity of phytoplankton in fish pond to range from 20×10^3 to 200×10^3 cells/L.

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Khatun (2005) reported that plankton population varied from 48.61 plus/minus 7.31 $\times 10^3$ to 50.17 plus/minus 7.45 $\times 10^3$ cclls/L during her 165 days experimental period of local sarpunti (*Puntius sarana*) in monoculture and polyculture system

Azim et al. (1995) conducted an experiment in a set of ponds at the Field Laboratory Complex of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh and recorded the mean values of temperature as 26.0°C, pH 7.1 and transparency 36.2 cm.

Wahab et al. (1995) conducted an experiment in nine experimental ponds at Bangladesh Agricultural University campus to find out the suitable water quality parameters. He reported that the water temperature varied between 27.2°C and 32.4°C and Secchi depth between 26 and 50 cm, pH was always around 6.0 and DO was always low and varied between 2.2 and 7.5 mg/L.

Nirod (1997) measured the water quality parameters in nine research ponds of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. He reported the following range of physico-chemical parameters: for temperature 21.8 to 34.10°C, for transparency 25 to 27 cm, for pH 6.5 to 8.5 and for DO 3.40 to 8.79 mg/L.

Kohinoor et al. (1998) studied the water quality parameters in six research ponds of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh and obtained the mean value of water temperature as 27.72 plus/minus 0.01 pH as 7.18 plus/minus 0.06 DO as 4.20 and transparency as 32.5 plus/minus 2.4

Rahman (1999) studied the pond ecology at Mymensingh and found that the value of water temperature ranged from 26.2 to 34.5 deg $\times$ C transparency from 12 to 46.5 cm, total alkalinity from 71 to 175 mg/L, pH from 6.5 to 8.8 and dissolved oxygen from 6 to 8 mg/L.

Kohinoor (2000) conducted an experiment on polyculture of carps with small indigenous fish species and observed water temperature to range from 24.2 to 33.3

°C. transparency from 12 to 50 cm, pH from 6.9 to 8.6 and dissolved oxygen from 2.0 to 7.5 mg/L.

Alim (2005) measured the water temperature to range from 17.30 to 33.50°C, transparency from 17 to 60 cm, pH from 6.2 to 8.9, dissolved oxygen from 1.2 to 8.50 mg/L from the ponds situated in the Bangladesh Agricultural University campus, Mymensingh.

2. 4 Biological aspects

Researchers worked on the biological aspects of different species of fishes. Scant information are available only on its biological aspects which includes the studies on the development and life history (Rahman, 1975), length-weight relationship, fecundity, sex ratio and semi-intensive culture system (Akhtaruzzman, 1988). At the end of 19th century, some scientists worked on the biological aspects of local koi (*A. testudineus*). Here, a short review is given on the related study along with other species.

Shafi and Mustafa (1976) reported that the fecundity of *A. testudineus* varied from 6,478 eggs (for a female with a total length of 9.4 cm and a weight of 38 g) to 44,395 eggs (for a female with average total length of 17.9 cm and a weight of 68.96 g). He also expressed that diameter of the eggs varied from 500 to 900 µm with the average value of 710 µm.

Banu et al. (1985) reported that fecundity of *A. testudineu*s (Bloch) varied from 12,355 eggs (a fish with total length of 12.3 cm and weight of 30.24 g) to 41,820 eggs (a fish with total length of 15.5 cm and weight 66.62 of g). The correlation co-efficient was the highest incase of relationship between fecundity and ovary weight which indicated that fecundity bears a strong relationship with ovary weight.

Banu et al. (1987) revealed that gonad of *A. testudineus* showed peak development in May simultaneously GSI showed higher value in same time. They also denoted

that female mature earlier than the male and monthly change of ova diameter indicated the spawning period of the species.

Islam and Azadi (1989) reported that the absolute fecundity of *Mystus cavasius* varied from 13,425 to 39,404 in the range of 23.2 to 29.2 cm total length.

Islam and Hossain (1990) studied the fecundity and sex-ratio of the common punti, *Puntius stigma* (Cuvier and Valencienns) from the river Padma near Rajshahi in Bangladessh. The fecundity varied from 2,475 (total length 74 mm and body weight 2.85 g) to 14,461 (total length 98 mm and body weight 14.923 g). The relationship between fecundity with total length, standard length, total weight, and gonad length and gonad weight were calculated. The male and female ratio was 1:2.

Kohinoor et al. (1991) reported that a total of 27 female *A.testudineus* were induced bred during the period from March to June. Female fish weighing 29 to 80 g were given single injection of 8-12 mg PG/kg body weight and the male fish weighing 22 to 52 g were given only 4 mg PG/kg body weight.

Banu et al. (1992) measured the fecundity of *Mystus tengara* (Ham.) of Agargaon region of Dhaka and described that the peak spawning period was July and the number of eggs varied from 1,863 to 6,923 with an average of 34466 ± 1407.62.

Alam et al. (1994) studied the fecundity of *Ailia coila* (Hamilton-Buchanan) from the river Padma near Rajshahi city. The fecundity of *Ailia coila* was found to vary from 605 to 1331 with 787 ± 163.
According to Misra (1994), *A. testudineus* (Bloch) matures at a mean size of 14 cm. Seasonal changes in the gonadosomatic index (GSI) and percentage occurrence of different maturing stages indicate that the spawning period of this fish lasts for a period of three months, from May to July. Oocyte distribution in mature fish indicates that *A. testudineus* is a total spawner although a batch of mature oocytes may be released over an extended period of time. Fecundity was linearly related to

body weight (w) and curvilinearly to toatal length (L), and ranged from 435 to 1,482 in fish weighing 36.8 to 42,38 g and 14.6 to 16.7 cm in length.

Das (1998) measured the fecundity of featherback (*Notopterus notopterus*) from two different sources i.e. pond and beel. He evaluated the fecundity of pond fishes ranged from 950 to 2235 with mean of 1425.77 plus/minus 64.92 and the fecundity of beel fishes ranged from 300 to 3680 with the mean of 2002.23 plus/minus 151.13 .

Kabir et al. (1998) estimated the fecundity of pond fishes chapila (*Gudusia chapra*) in the range 25,220 to 154,528 with the average of 72,383. They also found that fecundity increased linearly with the increase in length and weight of the fish.

Alam (2005) performed an experiment on the study of fecundity of *Lepidocephalus guntea* (gutum) of Methamoin haor in Kishoreganj district during March, 2005 to May, 2005. He observed that mean of fecundity and gonadosomatic index (GSI) varied from 10409.53 plus/minus 1121.48 (May) to 20, 667 plus/minus 1497.98 (July) and 15.29 ± 0.96 (April) to 18.68 plus/minus 1.69 (March) respectively. At the end of study, he also reported that mean of ova diameter varied from 0.3 plus/minus 0.01 (May) to 0.338 pm 0.014 (March).

Alam (2005) conducted an experiment on the study of fecundity of Corica soborna (kaski) of Methamoin haor in Kishoreganj district. He disclosed that mean of fecundity and Gonadosomatic Index (GSI) varied from 822 plus/minus 191.43 (August) to 2369.2 plus/minus 241.74 (July) and 4.11 plus/minus 1.59 (April) to 17.54 plus/minus 1.94 (June) respectively. He also concluded that mean of ova diameter varied from 0.16 pm 0.026 (August) to 0.264 plus/minus 0.016 (July).

Sarker (2005) reported that fecundity and gonadosomatic index (GSI) of freshwater catfish (*Pseudeutropius atherinoides*) varied from 1092.6 plus/minus 109.22 to 6004.3 plus/minus 1728.03 and 0.95 plus/minus 0.09 to 13.69 plus/minus 0.16 respectively in different months. He also claimed that mean of ova diameter varied from 0.35 plus/minus 0.01 (August) to 0.46 plus/minus 0.01 (June) in his study period.

Islam and Das (2006) conducted an experiment on the study of fecundity of Gulsa *Mystus cavasius* (Hamilton) of Brahmaputra and Kongsa rivers. The fecundity of Brahmaputra river fish ranged from 1250 to 23819 with the mean of 10062 + 704 for the corresponding length of 13.93 ± 0.24 cm, body weight of 24.41 ± 1.08 g and ovary weight of 1.99 ± 0.14 g. Whereas the fecundity of fish collected from the Kongsa river varied from 721 to 44837 with the mean of 11798 1207 for the corresponding length of 15.15 ± 0.24, body weight of 24.88 + 1.09 g and ovary weight of 3.01 ± 0.29 g. The gonadosomatic index (GSI) was calculated to be 8.29 0.47 and 15.63 ± 4.51 respectively for the Brahmaputra and the Kongsa river.

Chapter 3

MATERIALS AND
METHODS

CHAPTER 3

MATERIALS AND METHODS

Based on the objectives given in chapter I the work was designed to be carried out under following two experiments:

Experiment 1. Study on growth performance of Thai koi (*A. testudineus)* in ponds with three different feeds.

Experiment 2. Study on some aspects of biology of Thai koi (*A. testudineus).*

In this chapter, the materials used and experimental methods followed to conduct the above mentioned studies are described chronologically as below:

3.1 Experiment 1: Study on growth performance of Thai koi (*A. testudineus*) in ponds with three different feeds.

3.1.1 Research area

The experiment was carried out for a period of 99 days from 21st April to 28th July, 2006 in nine experimental ponds situated in the "Field Laboratory Complex", of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensigh. The ponds were rectangular in shape, with similar size, depth, basin configuration and bottom type. The surface area of each pond was 81 m² (10.66 mx 7.60 m) with average depth of 1.0 m. The ponds were free from aquatic vegetation and well exposed to sunlight. The ponds were completely independent and no inlet and outlet facilities. All ponds were arbitrarily numbered as pond 1, 2, 3, 4, 5, 6, 7, 8 and 9 for the convenience of the study.

Fig.1. An overview of experimental ponds in "Fisheries Field Laboratory Complex"

3.1.2 Design of experiment

Nine ponds were divided into three treatments (T1, T2 &T3) each having three replications. Ponds were randomly selected to accommodate the relevant treatments. The experimental lay out is shown in Table 1.

Table 1. Layout of the experiment for growth performance of Thai koi (*A. tesudineus*)

Treatment	Replication	Stocking density/treatment (125/dec)	Feed type (Trade name)
T_1	R1	250	Suny feed
	R2	250	
	R3	250	
T_2	R1	250	Mixed feed
	R2	250	
	R3	250	
T_3	R1	250	Saudi-Bangla fish feed
	R2	250	
	R3	250	

Suny feed, mixed feed and Saudi-Bangla fish feed were applied in T1, T2 and T3 respectively twice in a day (0900 and 1700 hr).

3.1.3 Pond preparation

All the ponds were dried during the end of March 2006. At first the bottom and sides of the selected ponds were cleaned. Then the bottom was leveled by scraping of a thin layer of soil where necessary, and let them exposed to sunlight for about 15 days. Embankments were repaired and all ponds were treated with lime at the rate of 5 kg/dec to disinfect the water. Then the ponds were filled up with water to a depth of 1.0 m and after 10 days of liming cowdung at the rate of 20 kg/dec were applied to all the experimental ponds. Netting was done to remove small frog and water bug from the experimental ponds before 3 days of fingerling stocking.

Then the experimental ponds were fenced by nylon net with the help of bamboo sticks to ensure the experimental fishes remain in their respective ponds even if the ponds get inundated due to over raining.

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3.1.4 Collection and stocking of fry

In 21 April 2006, fries were collected from "Brahmaputra Fish Seed Multiplication Farm", Shambhuganj, Mymensingh. Fries were kept inside the polythene bag with proper pro oxygen and the mouth of the polythene was bound tightly by rope. Then the fishes were brought to the field and were transferred to a cistern and were acclimatized for about half an hour. Before releasing the fry to the ponds the initial length and weight of 20 fishes were recorded with the help of measuring scale and a sensitive portable electric balance (DONGIL-15 kg x 50 g). Initial length and weight of fishes were 3.6 ± 0.015 cm and 0.90 ± 0.18 g respectively. Two-hundred and fifty fries were released in each pond.

Fig.2. Picture of 20 days old Fry of Thai koi (*A. testudineus*)

The stocked fries were reared separately according to experimental design for 99 days. As we know this fish species required high amount of protein, three supplemental feeds i.e. Suny feed, mixed feed and Saudi-Bangla fish feed containing 24, 28.49 & 35% protein were used, respectively.

3.1.5.1 Analysis of proximate composition of the feed ingredients

Proximate composition of the feed ingredients were determined following the standard methods given by Association of Official Analytical Chemists (AOAC, 1980) in the Nutrition Laboratory of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. Proximate composition of different feed ingredient is shown in Table 2.

Table 2. Proximate composition of the feed ingredient

Components	Suny feed	Mixed feed	Saudi-Bangla feed
Protein	24%	28.45%	35%
Fat	4.5%	11.15%	5%
Ash	18%	15.15%	16%
Crude protein	6%	5.48%	6.5%
Moisture	11%	13.42%	12%

*NFE-Nitrogen free extract calculated as 100% (moisture + protein + lipid + ash)

3.1.5.2 Feed preparation and feeding

The required quantities of all ingredient mixed with hand (mixed feed) and spread it to the pond surface. The other feeds i.e. Suny feed & Saudi-Bangla fish feed were purchased from Swadeshi Bazar, Mymynsingh Town. The quantities of feed was adjusted every 14 days on the basis of increase in the average body weight of the stocked biomass and were given at the rate of 100, 80, 40, 20, 10, 5, 3 &1% of their body weight respectively.

3.1.6 Sampling procedure

Sampling was done on every fourteen days interval in the morning (09.00 to 10.00 hr). The length and weight were recorded by random sampling of 20 fishes from each pond by using a small seine net. Weight was taken with a spring balance (DONGIL-15 kg x 50 g) and length with a measuring scale. All the data recorded in a note book and finally calculated the average length and weight of fishes according to treatment on each sampling day.

Fig. 3. Picture of Thai koi (*A. testudineus*) at the end of study period.

3.1.7 Other management

Regular cow dung and fertilizer were used at 14 days interval at the rate of 2 kg/dec, 150g urea/dec and 50g TSP/dec respectively. Liming was performed whenever necessary at the rate of 1kg/dec.

3.1.8 Growth parameters

The following parameters were used to evaluate the growth:

i. Length gain (cm) = Average final length – average initial length

ii. Weight gain (g) = Average final weight – average initial weight

iii. Percent gain in length = $\dfrac{\text{Average final length-average initial length}}{\text{Average initial length}} \times 100$

iv. Percent gain in weight = $\dfrac{\text{Average final weight-average initial weight}}{\text{Average initial weight}} \times 100$

The specific growth rate (SGR) is the instantaneous change in weight of fish calculated as the % increase in body weight per day over a given time interval

v. Specific growth rate = $\dfrac{\text{Ln}W_2\text{-Ln}W_1}{T_2 \text{-} T_1} \times 100$

Where,

W_2 = Final live body weight (g) at time T_2

W_1 = Initial live body weight (g) at time T_1

vi. The survival rate was calculated by the following formula =

$$\dfrac{\text{Initial number of fish - final number of fish}}{\text{Initial number of fish}} \times 100$$

vii. The food conversion ratio is expressed by the rate of food consumed to weight gain and was determined for fishes by the following formula (Castel and Tiews, 1980):

$$\text{FCR} = \dfrac{\text{Feed fed (dry matter)}}{\text{Live weight gain}}$$

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3.1.9 Economic analysis

An economic analysis was performed to estimate the net profit from different treatments. The cost of pelleted feed and fish fingerlings are shown in Table 6. The cost of leasing ponds was not included in the total cost. The net return/profit was measured by deducting the gross income from the gross cost/treatment. The benefit cost ratio (BCR) was also measured as a ratio of gross income to gross cost.

A simple economic analysis was performed to estimate the net profit. The approximate cost of each diet was calculated on the basis of Mymensingh local market price (2006) of all ingredients used. The cost of Suny feed was Tk. 19/kg, mixed feed Tk. 20/kg and Saudi-Bangla fish feed Tk. 23/kg. The selling price for Thai koi was estimated as Tk. 200/kg.

3.1.10 Water quality parameters

Physico-chemical parameters like temperature, pH, dissolved oxygen (DO) and transparency of the water of ponds were measured at 14 days interval.

Temperature and dissolved oxygen were measured by a digital DO meter (YSI model 58). Transparency was measured by using a secchi disc and pH with a pH electrode (Jenway, model 3020). Before taking a measurement pH meter was properly adjusted with buffer solution pH-7. On the spot, recording of water temperature (°C), dissolved oxygen (mg/L), pH and transparency (cm) were done between 0900 and 1000 hr.

3.1.10.1 Collection, preservation and enumeration of plankton

Plankton samples were collected fortnightly from experimental ponds. Ten L samples of pond water were collected from different areas and depth of the pond and filtered through a fine mesh (2.5cm) phytoplankton net. Filtered sample was taken into a measuring cylinder and carefully made up to standard volume with distilled water. Using plastic tube, water was siphoned off from the measuring

cylinder and plankton were concerted into 50 ml and preserved using 5% buffered formalin in a small plastic vials for subsequent studies. From each 10 ml preserved sample, 1 ml subsampl was examined using Sedgwick-Rafter cell and binocular microscope (Olympus, BH2).

Counting

The Sedgwick-Rafter counting cell is a special type of slide having a counting chamber which is 5.0 cm long, 2.0 cm wide and 0.1 cm deep; the volume of the chamber is 1 ml. The counting chamber is equally divided into 100 fields, each having a volume of 0.001 ml.

Calculation

Calculation of plankton samples were done by using the following formula (Rahman, 1992).

$$N = \frac{A \times 100 \times C}{V \times F \times L}$$

Where

N = No. of plankton cells or units/L

A = Total no. of plankton counted

 C = Volume of final consternate of the sample in ml.

V= Area of a field = $0.1 cm^3$

F = Number of fields counted

L = Volume of original water in L

3.1.11 Statistical analysis

One way analysis of variance (ANOVA) was used for statistical of the experimental data followed by Duncan's Multiple Range Test to determine the significance of variation among the treatments mean. Standard (error) of treatments means were calculated from the residual mean square in the analysis of variance.

3.2 Experiment 2: Study on some aspects of biology of Thai koi (*A. testudineus*

The fishes which were cultured in experiment 1 were used to know some biological aspects of *A. testudineus*.

3.2.1 Study area

The experiment was conducted for a period of 113 days from 23rd January to 15th May, 2007 collaboratively in "Fish Genetics Laboratory", Department of Fisheries Biology & Genetics under Faculty of Fisheries in Bangladesh Agricultural University and "Genetics Laboratory" of Bangladesh Fisheries Research Institute (BFRI), Mymensingh.
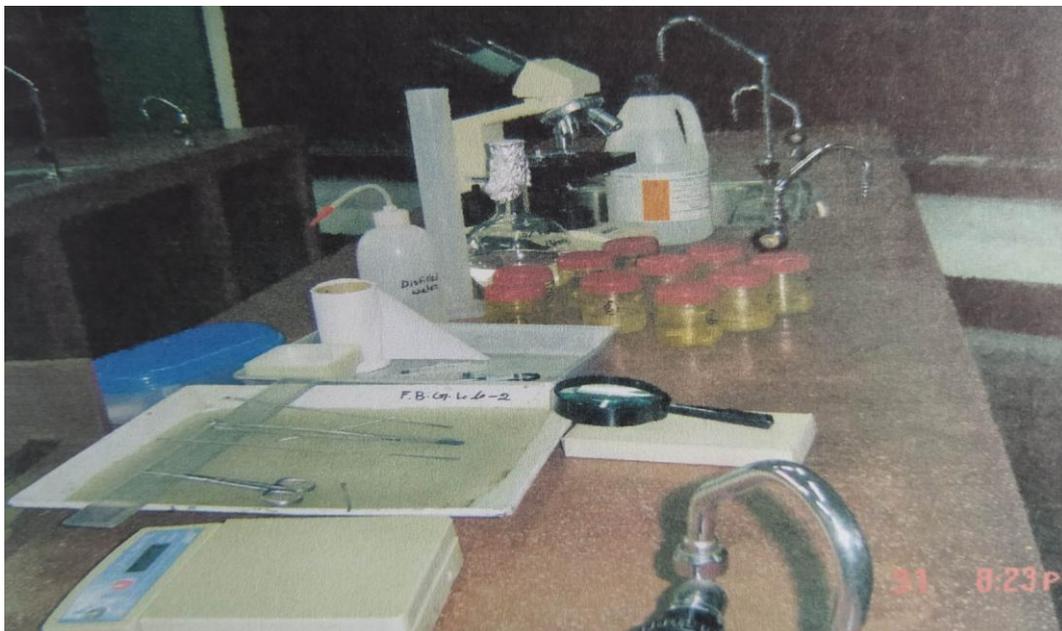
Fig. 4. An overview of instruments and chemicals needed for the biological study of Thai koi (*A. testudineus*).

3.2.2 Source of collection

Ten gravid female and male fishes of *A. testudineus* were collected from the pond of "Fisheries Field Laboratory Complex" of Bangladesh Agricultural University, Mymensingh at 14 days interval for subsequent studies. Eye observation and common experience were exercised to ensure collection of gravid specimens. The breeders were selected on the basis of external features of their abdomen, vent and pectoral fins. The pectoral fins of female are soft in this breeding season. Their enlarged abdomens with a soft (during the breeding season) enable them to be identified correctly. The body shape of male usually slim and pectoral fin slightly rough.
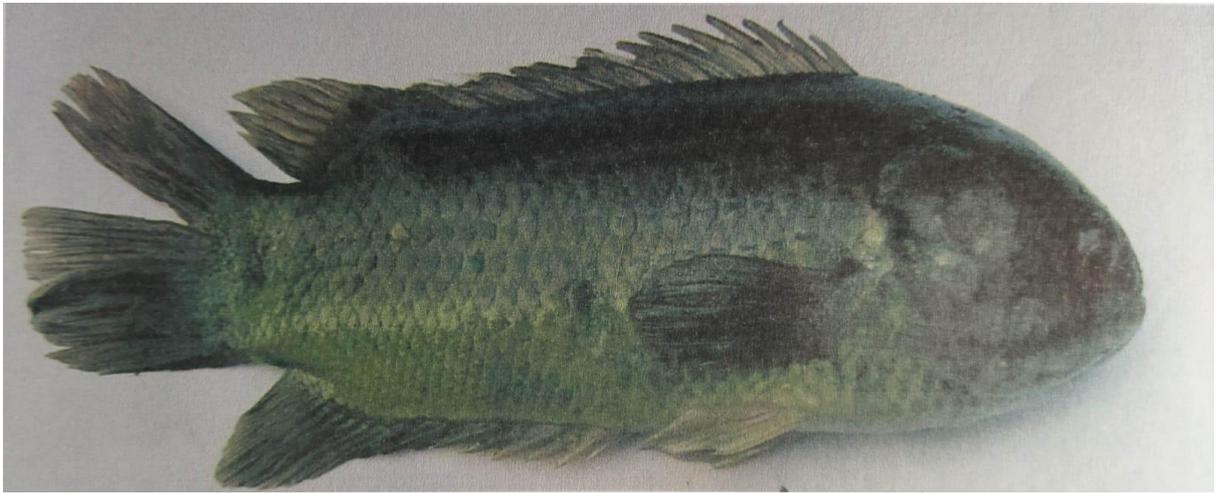
Fig. 5. Gravid female of Thai koi (*A. testudineus*)
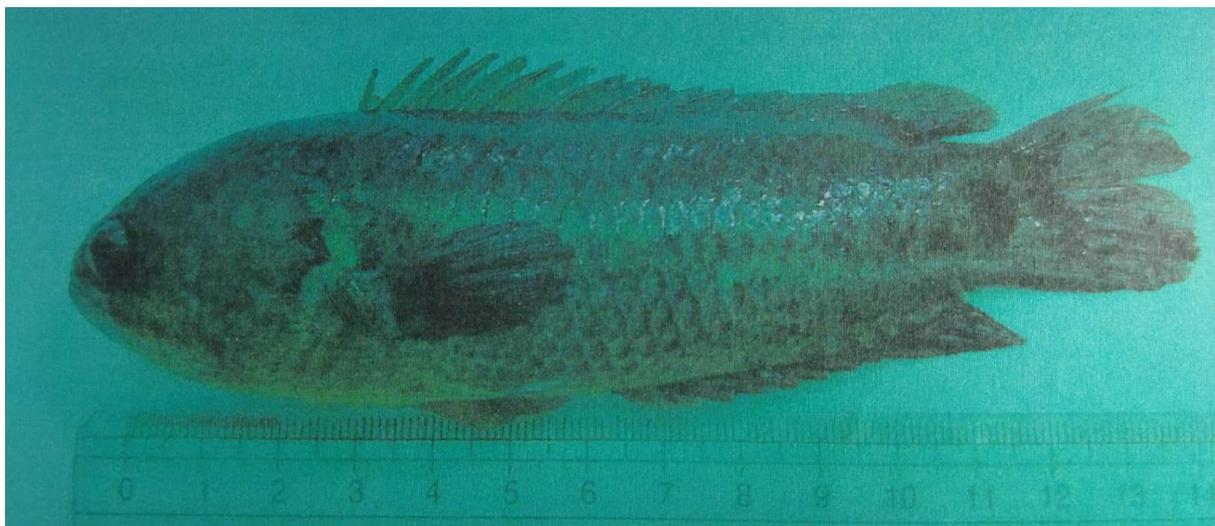
Fig. 6. Mature male of Thai koi (*A. testudineus*)

3.2.3 Collection of gametes (egg and sperm)

First, the fishes were killed by piercing a pin on the head and kept on a tray. Then the fishes were dissected out by a scissors. Starting from anus to lower jaw and the belly was opened. The whole mass (stomach, intestine and the ovary) were removed carefully and placed on a petridish. Ovary was washed and cleaned with distilled water. Weights and length of the ovary were taken and colour of the ovary was observed and recorded. Ovary was then kept into boiling water for 10 minutes and finally ovary was collected from the boiling water and preserved in 10% buffered formalin for fecundity study.

Fig. 7. Display of selected ovaries from the gravid female of Thai koi (*A. testudineus)*
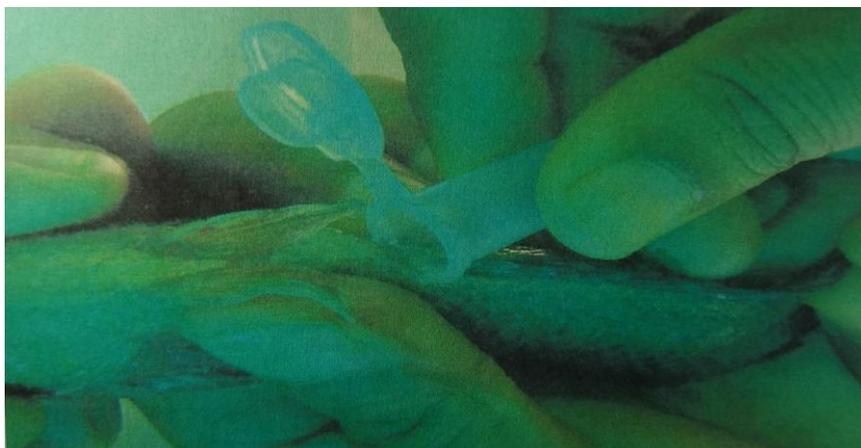
Fig. 8. Collection of sperm

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At first excess moisture was removed as consistently as possible from the surface of the fish with blotting paper. Then eyes of mature male were covered by hand. Sperm was collected from male in an eppendorf tube containing 10% formalin by gentle pressure of the lower region of caudal fin to the vent. Diameter of eggs and length of sperm-head length were measured (eggs at 10×10 & sperm at 40×10 on a slide) by a compound microscope, using the method of Amy (1983) and Rahman et al. (2003).

3.2.4 Calculation of gonadosomatic index (GSI)

Gonadosomatic index (GSI) is the % of gonad weight to the total weight of the fish. The Gonadosomatic index (GSI) of the collected fish was calculated for each of the female separately.

Gonadosomatic index (GSI) was calculated by using the following formula

$$GSI = \frac{GSI\ Weight\ of\ ovary}{Weight\ of\ fish} \times 100\ (Nikolsky, 1963)$$

3.2.5 Measurement of ovarian weight, ova diameter and sperm-head length

The preserved ovary of each fish was taken from the 10% formalin and washed with water. Excess moisture was removed as much as possible from the surface of the ovaries with blotting paper. Then the ovary was weighed to the nearest gram by an electric balance. The measured 0.1g eggs were placed on a petridish which contain a little amount of water. Then the eggs were separated from each other by using soft brush. Diameter of the eggs was measured from each of the anterior, central and posterior portions of the ovaries of the individual fishes in micrometer. The eggs were selected randomly and were put on the micrometer and the measurement was recorded along with the longest axis by moving the eggs with a fine needle whenever necessary. The extra moisture of the eggs was removed with blotting paper and the weight was recorded randomly.

Fig. 9. An overview of the collected ovary

The preserved sperm was placed on the slide and covered by a cover slip. Then the slide was placed under a compound microscope and measured the sperm-head length by adjusting different magnification. During the experimental period, diameters of eggs and sperm-head length were measured at 10 x 10 and 10 ×40 magnification respectively.

3.2.6 Method of fecundity estimation

There are several methods for the estimation of fecundity of fish. The most accurate method of enumeration of fish eggs i.e. fecundity, is probably by actual count. This method i.e., direct counting was found to be more time consuming and rather impossible in case of fishes which were highly fecund. When the actual counting of eggs is impracticable, approximate fecundity may be obtained by one of the following methods as outlined by Lagler, (1956).

(i) Volumetric method

(ii) Gravimetric method and

 (iii) Van Bayer method

Gravimetric method seemed to offer the best possibility of minimizing error due to its sample and easy sampling techniques. The gravimetric or weight method has been successfully used by Doha and Hye (1970), Shafi et al. (1978), Dewan and Doha (1979), Mustafa et al. (1980) and Islam et al. (2006). The eggs in the sample were counted. The number of eggs of the samples multiplied by the total weight of both parts of the ovaries which gave the total number of the eggs of a particular fish. In this way fecundity of fishes were obtained by using the following formula:

$$F = \frac{N \times Gonad\ weight}{Sample\ weight}$$

Where F is the fecundity and N is the number of eggs in sample.

Fig. 10. Counting of eggs

3.2. 7 Condition factor

When considering an individual fish, the value of 'q' in the equation W = qLb was used as an index of well-being or condition factor (CF) of fish by using the following equation:

$$CF = W/L^b$$

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Here,

W =weight of fish in g

L=Length of fish in cm

b =Calculated exponent value.

Condition factors calculated from monthly samples for example, may be used to detect seasonal variations in the condition of fish, which may vary with food abundance and the average reproductive stage of fish.

3.2.8 Data processing

The relationship of different parameters such as month wise body weight-fecundity and ovary weight-fecundity were estimated as simple linear relationship with the help of Micro Excel Program. Co-efficient of correlation (r) and regression co-efficient (b) were also determined.

Chapter 4

RESULTS

CHAPTER 4

RESULTS

4.1 Experiment 1. Study on growth performance of Thai koi (*A. testudineus*) in ponds with three different feeds

The results as obtained in the present study are presented under the following headings:

4.1.1 Growth performance of fish

Growth performance of *A. testudineus* in terms of length gain, weight gain, SGR (%/day), food conversion ratio (FCR), survival rate (%) and production (kg/ha/ 99 days) during the experimentation is shown in Table 3.

4.1.1.1 Length

The mean final length of Thai koi (*A. testudineus*) varied among the three treatments. The mean final lengths of Thai koi (*A. testudineus*) were 14.82 ± 0.01, 15.20 ± 0.01 and 15.99 ± 0.01 cm in T1, T2 and T3 respectively (Table 3). The highest length was found in T3 (15.99 ± 0.01 cm) and the lowest length in T1 (14.82 ± 0.01 cm).

The mean length gain of Thai koi (*A. testudineus*) were 11.19 ± 0.90, 11.57 ± 0.01 and 12.36 ± 0.05 cm in T1, T2 and T3 respectively (Table 3). The highest length gain was obtained in T3 (12.36 ± 0.05 cm) which was significantly ($p<0.05$) higher than that of T2 (11.57 ± 0.01 cm) and T1 (11.19 ± 0.09 cm). Fortnightly variation of length and weight of Thai koi (*A. testudineus*) is shown in Appendix 1.

4.1.1.2 Weight

The mean final weight of Thai koi (*A. testudineus*) were 73.50 ± 0.24, 77.08 ± 0.04 and 79.80 ± 0.11 g in T1, T2 and T3 respectively (Table 3). The highest final

weight was 79.80 ± 0.11 g in T3 and the lowest was 73.50 ± 0.24 g in T1. Fortnightly increases of weight (g) of Thai koi (*A. testudineus*) in different treatments are shown in Fig. 11.
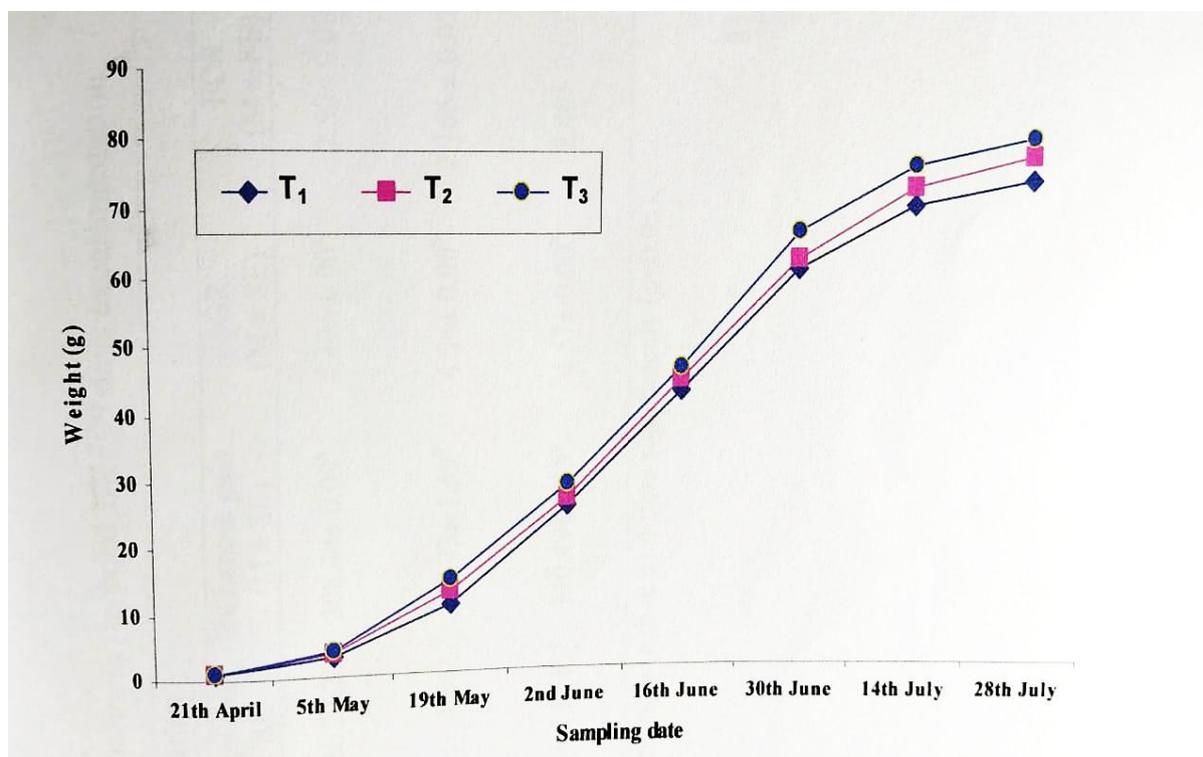
Fig. 11. Fortnightly variation of body weight (g) during 99 days experimental period

Mean weight gain and % weight gain of Thai koi (*A. testudineus*) varied significantly (p<0.05) among the three treatments. Mean final weight gain were 72.67 ± 0.24, 76.18 ± 0.04 and 78.90 ± 0.11g and % weight gain were 8075.18 ± 27.26, 8464.81 ± 4.64 and 8766.66 ± 12.83 g in T1, T2 and T3 respectively. The highest weight gain and % of weight were found in T3 which were significantly higher (p<0.05) than those of T2 and T1.

Table 3. Growth and survival rate of Thai koi (*A. testudineus*) in pond after 99 days experimentation

Treatment	Parameters						
	Weight gain (g) (M ± SE)	Length gain (cm) (M ± SE)	% Weight gain (M ± SE)	% Length gain (M ± SE)	SGR (M ± SE)	FCR (M ± SE)	Survival rate (%) (M ± SE)
T_1	72.67± 0.24[a]	11.19± 0.90[a]	8075.18± 27.26[a]	308.44± 0.09[a]	4.49± 0.00[a]	2.50± 0.03[c]	73.00± 0.57[a]
T_2	76.18± 0.04[b]	11.57± 0.01[b]	8464.81± 4.64[b]	318.73± 1.59[b]	4.54± 0.00[b]	2.166 ± 0.05[a]	77.00± 1.00[b]
T_3	78.90± 0.11[c]	12.36± 0.05[c]	8766.66± 12.83[c]	340.49± 0.15[c]	4.57± 0.00[c]	2.40± 0.03[b]	78.33± 1.20[b]

Values of the parameter in each column with different superscripts (a, b & c) differs significantly ($p < 0.05$).

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4.1.1.3 Specific growth rate (SGR)

The final specific growth rates (SGR) of Thai koi (*A. testudineus*) in different treatments were 4.49 ± 0.00, 4.54 ± 0.00 and 4.57 ± 0.00 in T1, T2 and T3 respectively (Table 3). The highest SGR was recorded in T3 (4.57 ± 0.00) and the lowest SGR recorded in T1 (4.49 ± 0.00).

4.1.1.4 Survival rate

The survival rates (%) of Thai koi (*A. testudineus*) in different treatments were 73, 77 and 78% in treatment T1, T2 and T3 respectively. The highest survival rate was found in T3 (78%) and the lowest in T1 (73%) (Table 3).

4.1.1.5 Food conservation ratio (FCR)

The average food conversion ratios (FCR) in different treatments were 2.50 ± 0.03, 2.16 ± 0.05 and 2.40 ± 0.03 in T1, T2 and T3 respectively (Table 3). The highest FCR was found in T1 (2.50 ± 0.03) and the lowest FCR was in T2 (2.166 ± 0.05).

4.1.1.6 Production of fish

Gross production of Thai koi (*A. testudineus*) were (kg/treatment) 18.38, 19.23 and 19.73 in T1, T2 and T3 respectively and total production (kg/ha) were 2269.13, 2374.04 and 2435.80 in T1, T2 and T3 respectively after 99 days culture period (Table 4). There were significant variations in production among the treatments. The production of T3 ($p<0.05$) was significantly higher than that of T2 and T1.
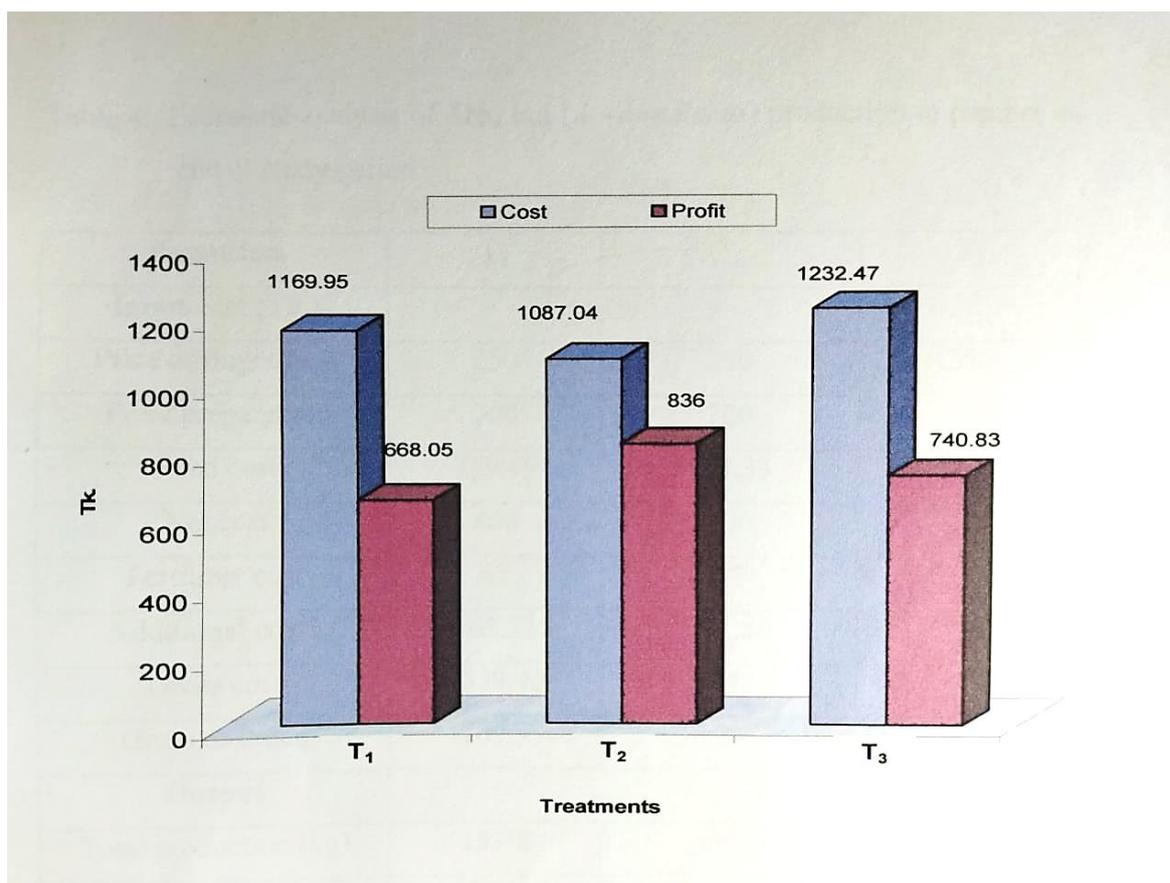
Fig. 12.Showing cost and profit (Tk./dec) in different treatments

4.1.1.7 Economic analysis

The main theme of this section is to calculate cost, returns and profitability of fish production as obtained from different treatments. The cost and income calculated for different treatments are presented in Table 4.

The cost items e.g. fingerling cost, pond repairing and development cost etc. and returns from the treatments e.g. gross income, net income, benefit-cost ratio (BCR) etc. are discussed below:

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Table 4. Economic analysis of Thai koi (*A. testudineus*) production in pond at the end of study period

Parameters	T_1	T_2	T_3
Input cost (Tk.)			
Price of fingerlings	250	250	250
Pond preparation	700	700	700
Feed cost	759.49	608.33	894.47
Net cost	400	400	400
Fertilizer cost	67	67	67
Additional cost*	163.23	151.89	173.36
Gross cost	2339.90	2174.07	2464.94
Gross cost/dec	1169.95	1087	1232.47
Output			
Total production (kg)	18.38	19.23	19.73
Gross income	3676	3846	3946.60
Gross income/dec	1838	1923	1973.3
Net profit (Tk.)	1336.09[a]	1672.26[c]	1481.72[b]
Net profit/dec	668.05[a]	836[c]	740.83[b]
Total production (kg/ha)	2269.13[a]	2374.04[b]	2435.80[c]
Net profit (Tk./ha)	164949.38[a]	206451.85[c]	182928.39[b]
BCR	1.57[a]	1.76[c]	1.60[b]

Values of the parameter in each rows with different superscripts (a ,b\&c) differs significantly ($p < 0.05$)

*An additional 7.5% on the top of the total raw materials costs towards manufacturing, marketing expenses and operating marginal was included of the ADCP (1983).

4.1.1.8 Gross cost

The total average cost of fingerling was Tk. 250/treatment (Table 4). Here, price of each fingerling was considered Tk. 1.00. The price of suny feed was Tk. 19/kg, mixed feed Tk. 20/kg and Saudi Bangla fish feed Tk. 23/kg. The average total quantity of feed required were 39.97 kg, 43.41 kg and 36.77 kg/treatment with average of Tk. 759.49, Tk. 608.33 and Tk. 894.47 in T1,T2 and T3 respectively. The feed costs required in different treatments are shown in Table 4. Pond preaparing was similar to all the treatments. The average gross cost of pond repairing was Tk. 700 for all treatments. Gross cost of each treatment was calculated by the addition of all input cost for individual treatment. The average gross cost were Tk. 2339.90, Tk. 2174.07 and Tk. 2464.94/treatment for T1,T2and T3 respectively.

 (Table 4).

4.1.1.9 Gross income

Gross income was the value of total fish produced. It was calculated by multiplying the total quantity of production by their respective unit quantity market price. The net profit/ha were Tk. 164949.38, Tk. 206451.85 and Tk. 182928.39 for T1,T2 and T3 respectively.

4.1.1.10 Net income

Net incomes from fish production in different treatments were calculated by deducting gross cost from the gross income. The average total net profit was Tk. 164949.38, Tk. 206451.85 and Tk. 182928.39 in T1, T2 and T3 respectively (Table 4). The net income or profit was significantly higher ($p < 0.05$) T2 in followed by T3 and T 1

4.1.1.11 Benefit-cost ratio (BCR)

BCR for each treatment was determined as the ratio of gross income to gross cost. The BCR in T1, T2 and T_2 were 1.57, 1.76 and 1.60 respectively (Table 4). The benefit-cost ratio was different in the treatments. The highest BCR was found in T2 (1.76) and the lowest BCR was found in T_1 (1.57).

4.1.2 Water quality parameters

The water quality parameters are recorded from the different ponds under three different treatments are shown in Table 5.

4.1.2.1 Temperature (°c)

The water temperature was found to be similar in different ponds. The average water temperature were $27.75 \pm 0.0°C$, $27.75 \pm 0.02°C$ and $27.79 \pm 0.05°C$ in T1, T2 and T3 respectively (Table 5). The ranges of water temperature were $24.55 \pm 0.08°C$ to $30.35 \pm 0.02°C$ in T_1, $24.55 \pm 0.02°C$ to $30.45 \pm 0.33°C$ in T2 and $24.88 + 0.11°C$ to $29.95 \pm 0.20°C$ in T3. The highest water temperature $(30.45 \pm 0.33)°C$ was observed in T_2 on 14th July and the lowest value was recorded in T2 $(24.55 \pm 0.02)°C$ on 2nd June. Fortnightly variation of water qualities in different treatments are shown in Appendix 2.

4.1.2.2 Transparency (cm)

Water transparency was found to vary from one pond to another and also from one month to another. The mean water transparency were 34.71 ± 0.251, 23.44 ± 0.39 and 27.28 ± 0.01 cm in T1, T2 and T3 respectively (Table 5). The ranges of water transparency were 14.66 ± 2.60 cm to 53.33 ± 0.88 cm in T1, 9.33 ± 1.6 cm to 37.33 ± 1.2 cm in T2 and 16 ± 0.57 cm to 41 ± 0.57 cm in T3. The highest transparency was recorded as 53.33 ± 0.88 cm in T_1 on 28th July and the lowest was recorded as 9.33 ± 1.6 cm in T2 on 16th June.

Table 5. Fortnightly variation of water quality in ponds during 99 days experimental period.

Water quality parameters	T_1 (M± SE)	T_2 (M± SE)	T_3 (M± SE)
Temperature (°c)	27.75 ± 0.0^{a}	27.75 ± 0.02^{a}	27.79 ± 0.05^{a}
Dissolved oxygen (mg/L)	$5.99 \pm .006^{a}$	$6.06 \pm .019^{b}$	6.08 ± 0.02^{b}
pH	8.05 ± 0.12^{a}	8.04 ± 0.16^{a}	$8.06 \pm .004^{a}$
Transparency (cm)	$34.71 \pm .251^{c}$	$23.44 \pm .399^{a}$	27.28 ± 0.01^{b}
Plankton (cells/L)	$36.5 \pm 10.50 \times 10^{5\,a}$	$40.2 \pm 12.30 \times 10^{5\,c}$	$36.8 \pm 12.0 \times 10^{5\,b}$

Values of the parameter in each rows with different superscripts (a, b & c) differs significantly ($p<0.05$).

4.1.2.3 pH

The pH was found to vary in all ponds throughout the study period. The observed average pH were 8.05 ± 0.12, 8.04 ± 0.16 and 8.06 ± 0.00 in T1, T2 and T3 respectively and the variation was significantly different ($p<0.05$) from each other (Table 5). The ranges of pH were 7.7 ± 10.02 to 8.30 ± 0.11 in T1, 7.83 ± 0.03 to 8.23 ± 0.03 in T2 and 7.7 ± 0.00 to 8.3 ± 0.00 in T3. The highest pH was found as 8.3 ± 0.00 in T3 on 5th May and the lowest as 7.7 ± 0.00 in T3 on 30th June.

4.1.2.4 Dissolved oxygen (mg/L)

Dissolved oxygen concentration in all ponds showed an irregular pattern of fluctuation from the beginning to the end of the experiment without any definite monthly trend. The mean dissolved oxygen concentrations were 5.99 ± 0.00, 6.06 ± 0.019 and 6.08 ± 0.00 mg/L in T1, T2 and T3 respectively. The dissolved oxygen varied from 5.02 ± 0.04 mg/L to 7.4 ± 0.01 mg/L in T1, $4.95 \pm .00$ mg/L to 7.39 mg/L in T_2 and 7.7 ± 0.0 mg/L to 8.30 ± 0.00 mg/L in T3. The highest dissolved

oxygen was observed as 7.79± 0.33 mg/L in Ton 2nd June and the lowest as 4.96 ± 0.01 mg/L in Ta on 30th June.

4.1.2.5 Plankton population.

The plankton population varied from 35.50 x 10 to 36.55 ×10 cells/L with an average of 36.5 ± 10.50×10 cells/L in T_1 39.0×10 to 42.0×10 cells/L with an average of 40.2 ± 12.30×105 cells/L in T_2 and 38.50×105 to 36.87×10 cells/L with an average of 36.8 ± 12.0 × 105 cells/L in T3. The highest abundance of plankton population was observed in pond 4, 5 and 6 under T2 (40.2 ± 12.30 ×10 cells/L) and the lowest abundance of plankton population was observed in pond 1, 2 and 3 underT_1 (36.5± 10.50× 10 cells/L).

4.2 Experiment 2. Study on some aspects of biology of Thai koi (*A. testudineus*)

4.2.1 Morphology of experimental fish

The female fishes which were collected for this experiment was elongated with swollen abdomen. It is comparatively larger in size, fairly deep and wide body shaped. Its body colour is whitish to pale. Scales were normal. It appeared black spot both on caudal base and operculum. Matured female was clearly identified from male by their swollen abdomen.

On the other hand, male of Thai koi (*A. testudineus*) is slightly elongated than the female. Its body color is little brighter than the female.

4.2.2 Gonadosomatic index (GSI)

Gonadosomatic index (GSI) showed gradual increase in pre-spawning period and then decrease in post-spawning period. In the present study, the highest value of GSI was recorded in 17th April average of 19.50 ± 0.54 with ranges from 14.77 to 20.77 and the lowest value was recorded in 23th January average of (3.96 ± 0.19) with ranges from 2.8 to 4.7

 (Table 6).
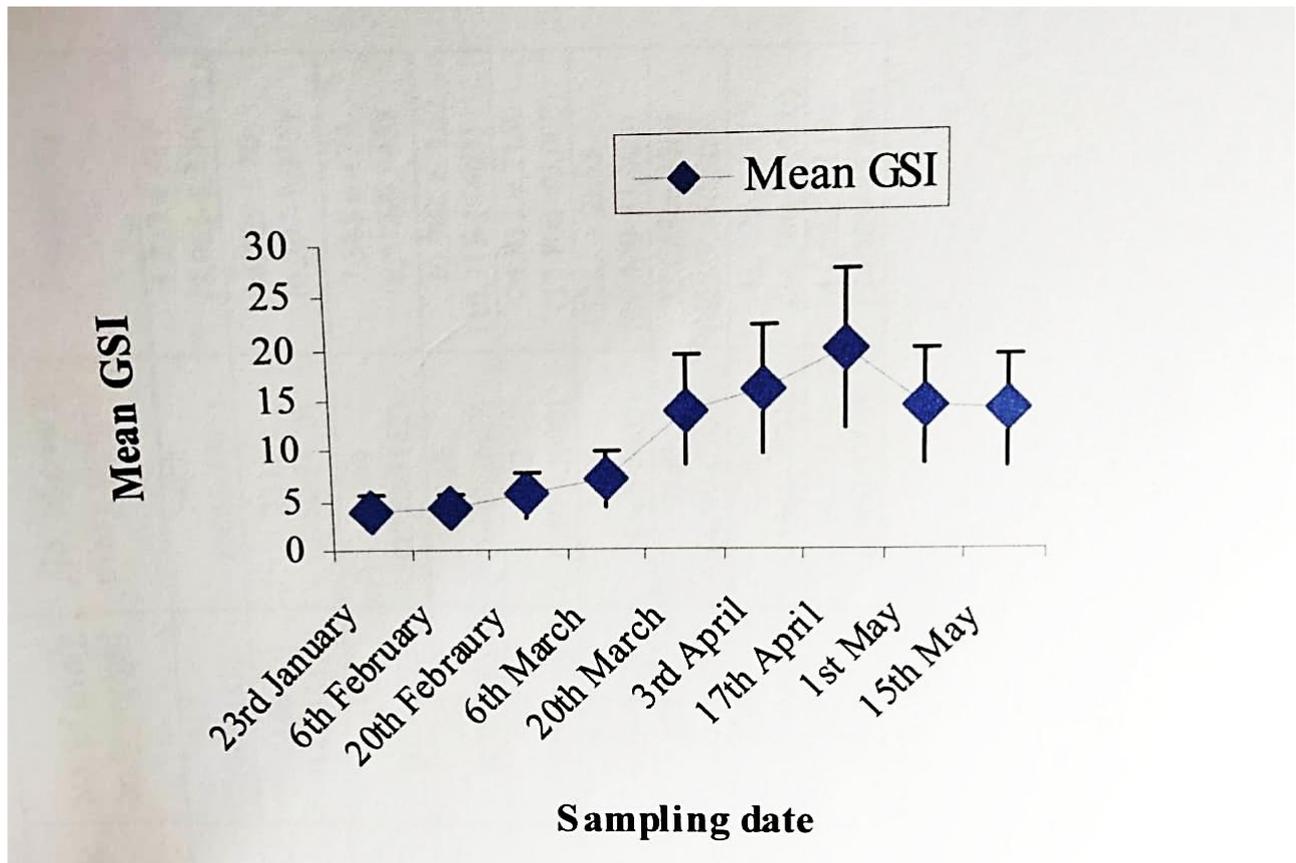
Fig. 13. Variation of gonadosomatic index (GSI) in different sampling date of *A. testudineus*.

4.2.3 Gamete sizes (egg diameter and sperm-head length)

The highest average ova diameter was recorded 654.10 ± 6.37 µm with ranged from 628.0 to 685.0 µm in 17th April and the lowest average ova diameter was recorded 139.70 ± 3.14 µm with ranged from 125 to 155 µm in 23rd January.

Simultaneously, the highest sperm-head length was found in 17th April average of 3.18 ± 0.08 µm with ranged from 2.72 to 3.60 µm and the lowest average sperm-head length was 1.18 ± 0.05 µm with ranged from 1.01 to 1.30 µm in 23rd January.

Comparison between egg diameter and sperm-head length with their corresponding body weight is shown in Fig. 14.

Table 6. Total length, body weight, condition factor, ovary weight, gonadosomatic index (GSI), estimated fecundity and ova diameter of Thai koi (*A. testudineus*). Ten fishes were examined for each sampling in each parameter. Mean ± SE with ranges in parameters

Sampling date	Average total length (cm)	Average body weight (g)	Condition factor	Ovary weight (g)	Gonadosomatic index (GSI)	No. of ova/g body weight	No. of ova/g ovary weight	Fecundity
23rd January	11.31 ± 0.321 (9.3-12.4)	41.56 ± 1.13 (35-45)	1.0014 ± 0.007 (0.95-1.03)	1.64 ± 0.11 (1.0-2.1)	3.96 ± 0.19 (2.8-4.7)	137 (100-183)	3487 (2666-3965)	5,722 ± 437 (3,965-8,250)
6th February	12.84 ± 0.89 (12.1-13.6)	44.99 ± 0.31 (44-47)	1.0001 ± 0.003 (0.99-1.02)	1.987 ± 0.2 (1.9-2.1)	4.10 ± 0.32 (1.31-4.61)	146 (143-155)	3314 (3250-3400)	6,585 ± 80 (6,207-7,035)
20th February	13.8 ± 0.16 (13-14.5)	45.57 ± 0.31 (44-47)	1.0000 ± 0.002 (0.99-1.01)	2.45 ± 0.6 (2.1-2.7)	5.47 ± 0.15 (4.8-6.25)	162 (148-171)	3009 (2720-3162)	7,388 ± 177 (6,532-7,943)
6th March	14.26 ± .12 (13.5-14.8)	45.34 ± 0.24 (44-46.3)	1.0000 ± 0.001 (0.99-1.01)	3.12 ± 0.3 (2.99-3.22)	6.89 ± 0.06 (6.64-7.23)	242 (229-258)	3509 (3449-3600)	10,982 ± 150 (10,315-11463)
20th March	14.38 ± 0.35 (11.7-16)	46.37 ± 2.69 (25.6-60)	1.0039 ± 0.028 (0.91-1.21)	6.34 ± 0.51 (4.1-10)	13.7 ± 0.67 (9.73-16.66)	587 (389-800)	4252 (3900-5000)	26,837 ± 2150 (18,800-40,000)
3rd April	15.02 ± 0.28 (13.2-16.3)	56.22 ± 3.44 (37.3-77.5)	1.005 ± 0.12 (0.95-1.08)	8.9 ± 0.67 (5-11)	15.72 ± 0.63 (11.72-17.9)	810 (639-940)	5178 (4500-5900)	45283 ± 2655 (29,500-53,000)
17th April	14.09 ± 0.14 (13.2-14.5)	52.4 ± 1.46 (44-59)	1.001 ± 0.011 (0.91-1.05)	10.22 ± 0.51 (6.5-12.1)	19.50 ± 0.54 (14.77-20.7)	991 (902-1040)	5140 (4797-6300)	52,088 ± 2066 (40,950-60,500)
1st May	14.39 ± 0.16 (13.9-15.5)	49.08 ± 0.59 (45.2-50.6)	1.005 ± 0.101 (0.94-1.04)	6.825 ± 0.20 (5.5-7.5)	13.91 ± 0.36 (11.4-15.2)	869 (706-980)	6,262 (5569-7031)	42,700 ± 1415 (34,100-49,600)
15th May	14.43 ± 0.12 (13.9-15.1)	49.98 ± 0.66 (48-53.5)	1.0004 ± 0.008 (0.97-1.06)	6.75 ± 0.20 (5.5-7.4)	13.53 ± 0.47 (11.4-15.4)	792 (426-951)	6,171 (6000-6300)	41,623 ± 1175 (34,100-45,880)
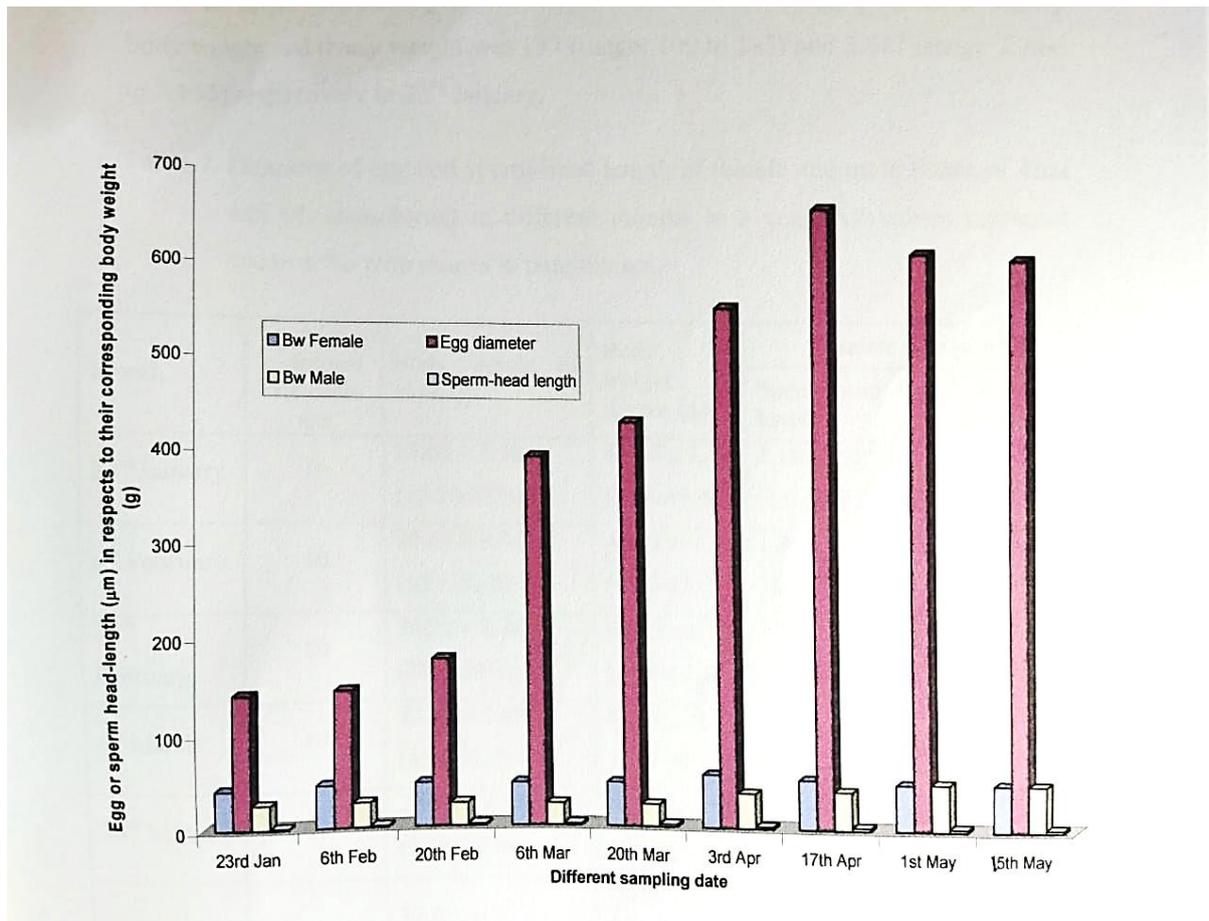
Fig.14. Comparision of egg diameter and sperm-head (µm) length with their corresponding body weight (g)

4.2.4 Fecundity

The highest fecundity estimation ranged from 40,950 to 60,500 with a mean of 52,088 ± 2066 in 17th April for the corresponding body weight from 44 to 59 g with a mean of 52.4 ± 1.46 g and total length from 13.2 to 14.5 cm with a mean of 14.09 ± 0.14 cm. The lowest fecundity was estimated ranged from 3,965 to 8,250 with a mean of 5,722 ± 437 in 23rd January for the corresponding body weight from 35 to 45 g with a mean of 42.56 ± 1.13 g and total length from 9.3 to 12.4 cm with a mean of 11.32 ± 0.32 cm. The highest average number of eggs/g of body and ovary weight were 991 with ranged from 902 to 1,040 and 5,140 with ranged from

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4,797 to 6,300 respectively in 17th April. The lowest average number of eggs/g to 3,965) respectively in 23rd January.

Table 7. Diameter of egg and sperm-head length of female and male fishes of Thai mean ± SE with ranges in parentheses. koi (*A. testudineus*) in different months in a year. All values represent

Month	No. of fish examined for each sex	Body weight of male (g)	Body weight of female (g)	Gamete size (µm)	
				Sperm-head length	Egg diameter
23rd January	10	25.68 ± 2.78 (15.50-37.0)	41.56 ± 1.13 (35.0-45.0)	1.18 ± 0.05 (1.0-1.30)	139.70 ± 3.14 (125-155)
6th February	10	25.65 ± 2.37 (15.0-38.0)	44.99 ± 0.31 (44.0-47.0)	1.36 ± 0.03 (1.30-1.50)	143.40 ± 0.94 (140-150)
20th February	10	24.22 ± 2.28 (10.0-34.0)	45.57 ± 0.31 (44.0-47.0)	1.73± 0.04 (1.50-1.95)	176.40 ± 2.78 (160-190)
6th March	10	23.45 ± 1.88 (15.0-32.0)	45.34 ± 0.24 (44.0-46.30)	1.98 ± 0.03 (1.86-2.20)	393.30 ± 14.27 (300-450)
20th March	10	23.71 ± 2.55 (7.30-29.0)	46.37 ± 2.69 (25.60-60.0)	2.78 ± 0.17 (1.86-3.50)	430.80 ± 9.72 (390-500)
3rd April	10	37.0 ± 1.75 (30-45)	56.22 ± 3.44 (37.30-77.50)	2.45 ± 0.11 (2.0-3.0)	551.20 ± 7.21 (525-590)
17th April	10	40.59 ± 1.71 (36.70-50.0)	52.40 ± 1.46 (44.0-59.0)	3.18 ± 0.08 (2.97-3.60)	654.10 ± 6.37 (628-685)
1st May	10	49.85 ± 2.32 (40.0 – 62.0)	49.08 ± 0.59 (45.20-50.60)	3.02 ± 0.03 (2.90-3.20)	607 ± 7.37 (555-635)
15th May	10	49.49 ± 2.30 (13-14.80)	49.98 ± 0.66 (48-53.50)	2.99 ± 0.2 (2.90-3.90)	600.10 ± 7.56 (550-625)
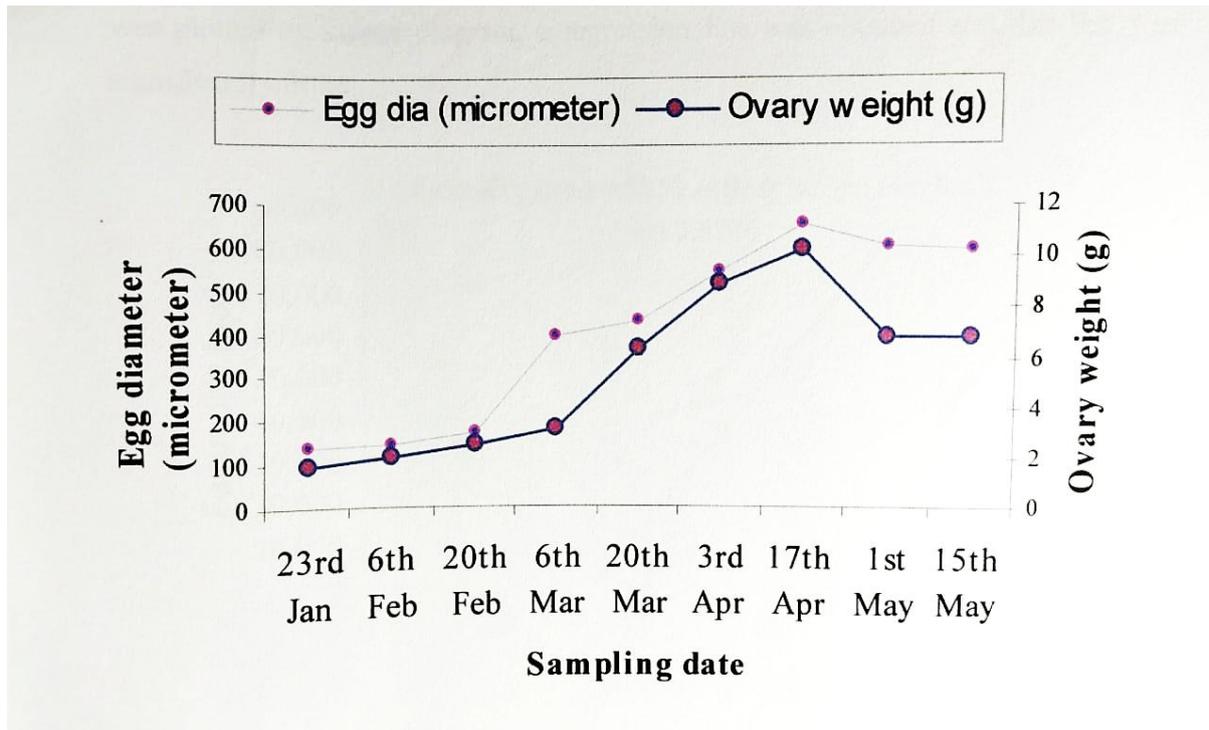
Fig. 15. Variation of ovary weight (g) and egg diameter (μm) of Thai koi (*A. testudineus*) in different sampling date

4.2.5 Condition factor (CF)

The overall condition factor (CF) of all sampling date was similar. The highest average CF was in 1.005 ± 0.12 in 3rd April with ranged from 0.95 to 1.08 and the lowest was 1.0000 ± 0.002 in 20th February with ranged with 0.99 to 1.01.

4.2.6 Fecundity and body weight relationship

The fecundity of the fish was increasing with the increase of body weight following the equation of

Fecundity = 1952.16 (body weight) - 67043.

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The value of co-efficient correlation (r) was 0.6746 (p<0.01). When this equation was plotted on scatter diagram, a regression line was obtained and this line was significantly fitted.
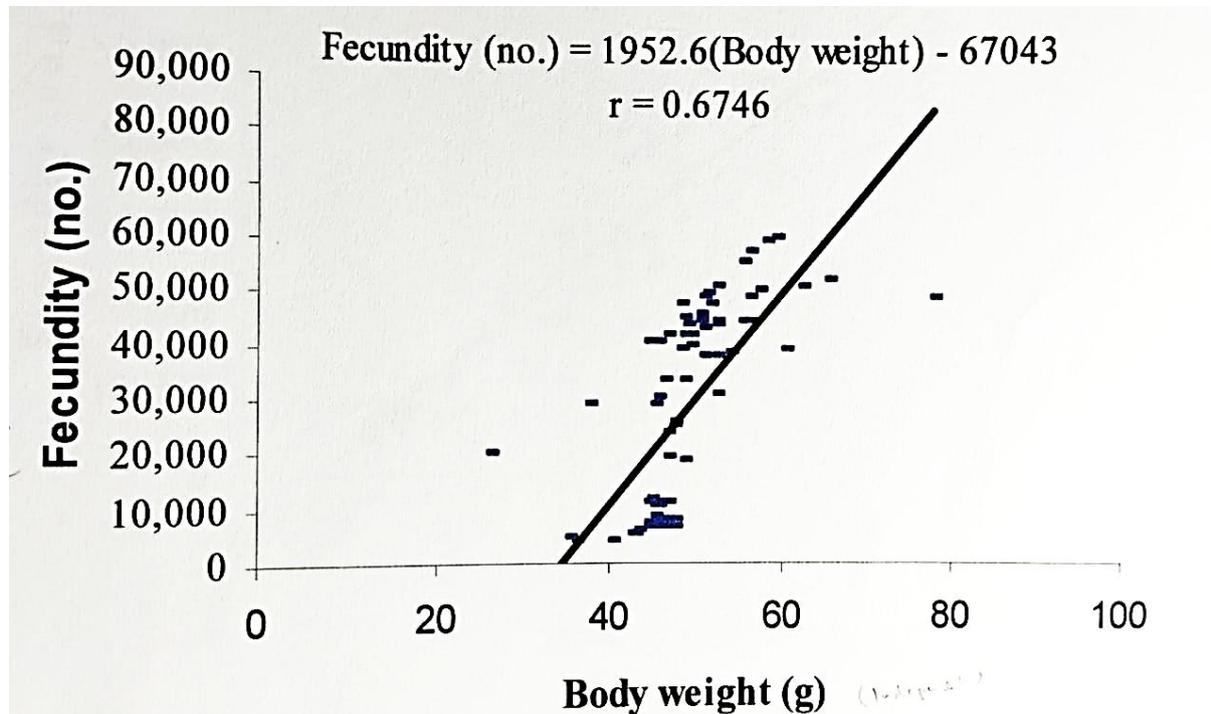
Fig. 16. Linear relationship between body weight (g) and fecundity of Thai koi (*A. testudineus*)

4.2.7 Fecundity and ovary weight relationship

The fecundity of the fish was increasing with the increase of ovary weight following the equation

Fecundity = 5863.6 weight - 5484.7.

The value of co-efficient correlation (r) (p<0.01) was 0.0.960. When this equation was plotted on a scatter diagram, a straight line was obtained and the regression line was significantly fitted (Fig. 17).
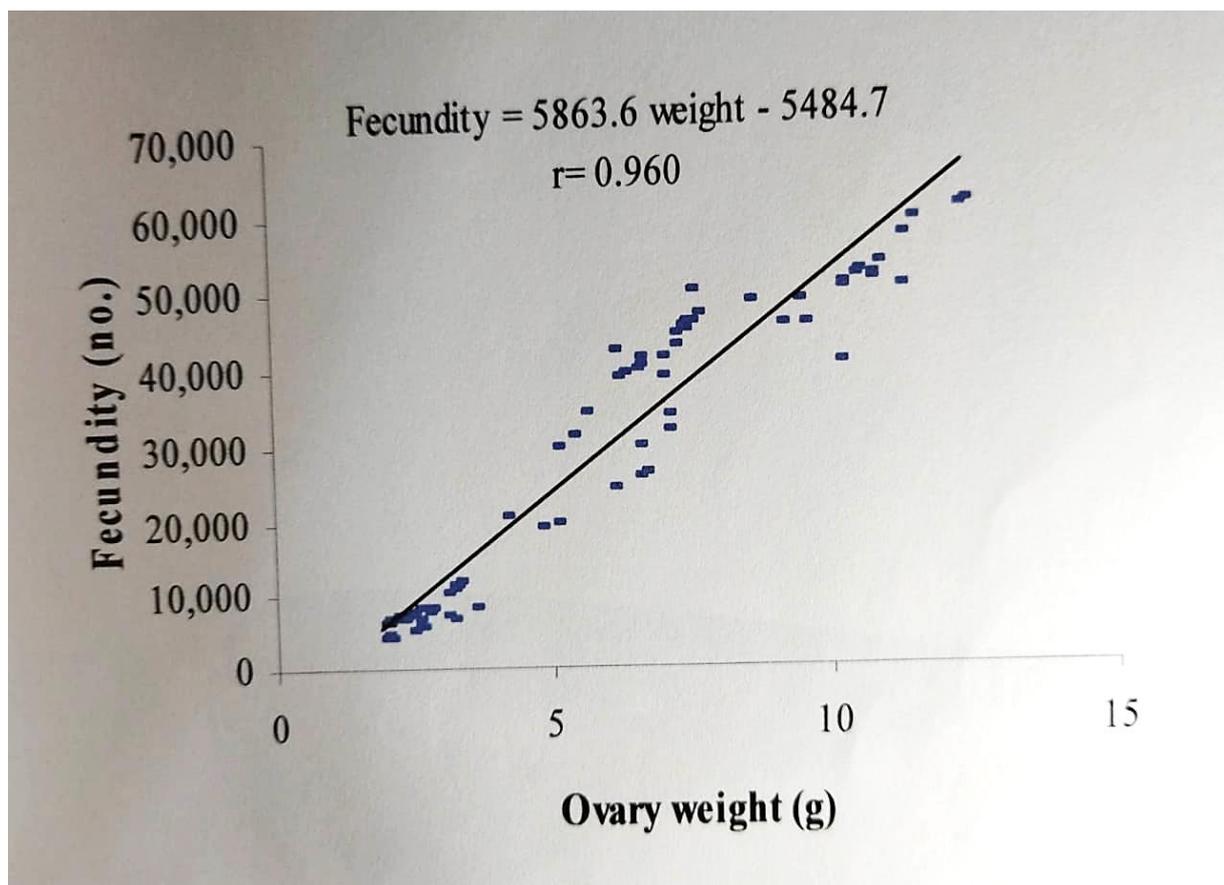
Fig. 17. Linear relationship between ovary weight (g) and fecundity of Thai koi (*A. testudineus*)

Chapter 5

DISCUSSION

CHAPTER 5

DISCUSSION

Experiment 1. Study on growth performance of Thai koi (*A. testudineus*) in ponds with three different feeds

In the present study, the average final length were obtained 14.82 plus/minus 0.01 , 15.10 plus/minus 0.01 and 15.99 plus/minus 0.01 cm in T1, T2 and T3 respectively. The final average weight were obtained 73.5 plus/minus 0.24, 77.08 plus/minus 0.04 and 79.8 plus/minus 0.11 * g in T1,T2and T3 respectively for 99 days experiment with applying Suny feed, mixed feed (prepared) and Saudi-Bangla fish feed in those treatments respectively. Noor (2005) revealed that Thai koi (*A. testudineus*) obtained average length of 14.66 ± 0.38 cm and weight of 57.22 plus/minus 2.93 g for 50 days experiment by applying hand made feed which contained 38% protein. Akhteruzzaman (1988) found 32.47 to 40.45 g weight in local koi during 5 months experimental period and the feed was compound as rice bran, mustard oilcake and fish meal at a ratio of 3:1:1. The growth of present finding is lower than that of Noor (2005) due to lower % of protein (24, 38.45 and 35% in T1,T2 and T3 respectively) were used in present experiment.

The SGR (%/day) as recorded in the present study were 4.49, 4.54 and 4.57 in T1 T2 and T3 respectively with feeding 24, 28.45 and 35% protein containing feed which was lower to 7.92 achieved by Noor (2005) and also lower to 8.09 to 9.21 obtained by Samad et al. (2004) for shingi (*Heteropneustes fossilis*) with similar protein level (27.75 to 32.24%). This may be associated with different percentage of protein and different species of fish. The food conversion ratios (FCR) were 2.5 plus/minus 0.03 2.166 plus/minus 0.05 and 2.4 plus/minus 0.03 in T1,T2 and T3 respectively. Hossain et al. (1994) reported that FCR of *Puntius gonionotus* varied from 1.74 to 2.29 for fed feed containing different levels of mustard oilcake and seasame meals. Azad (2006) found that FCR were 2.40, 2.22 and 2.07 while feeding frequencies were once/day, two times/day and three

times/day respectively with the feeding of pelleted feed (Quality Fish Feed Ltd; 30% protein) polyculture of pangas (*Pangasius hypophthalmus*) and silver carp (*Hypophthalmichthys molitrix*) in nine earthen ponds of 135 days experimental period. In the present study result is similar with Azad (2006) but is slightly higher than those of Hossain et al. (1994) due to different environmental condition, different species and different type of feeds. The survival rates of Thai koi (*A. testudineus*) were 73, 77 and 78% in T1, T2 and T3 respectively. Similar types of survival rates were obtained by Noor (2005), who stated survival rate of Thai koi (*A. testudineus)* to be 81.67% in her 50 days experimentation in BAU ponds. Azad (2006) also reported that the survival rates of pangasiid catfish (*Pangasius hypophthalmus*) were 95.2, 96.0 and 96.8% and the survival rates of silver carp (*Hypophthalmichthys molitrix*) were 83.2, 85.2 & 86.0% in polyculture system in ponds for 135 days experimental period. The result of present study is similar with the findings of Noor (2005) and lower than that of Azad (2006). It might be due to the different culture systems, different species and different water quality condition. The total production (kg/ha) of Thai koi (*A. testudineus*) were 2269.13, 2374.04 and 2435.80 kg/ha/99 days in T1, T2 and T3 respectively during the experimental period. The overall production of T3 (2435.80 kg) was significantly ($p < 0.05$) higher than those of T2 and T1. Due to higher % of protein (35%) of Saudi-Bangla fish feed the production of T3 was significantly higher than of T_2 and T_1. The lower production was found in T_1, which might be due to lower survival rate of fish. Kohinoor et al. (1993) obtained *P. gonionotus* production of 2384 kg/ha/6 months for fertilized pond along with supplemental feeding and 2129.72 kg/ha/6 months with supplemental feeding only. The production of the present study is almost similar with the result of Kohinoor et al. (1993).

The cost of pond repairing, maintenance and fingerlings were the same for each treatment but there were significant ($p < 0.05$) variation among the treatments in relation to production and profit. The input cost was highest in T3 due to higher expenditure of feed in T3 than the other treatments. The net

profits obtained were 164949.38, 206451.85 and 182928.39 Tk./ha/99 days in T1, T2 and T3 respectively. Net profit (Tk./dec) of the present study were 668.05. 836.0 and 740.83 in T1, T2 and T3 respectively. Akter (2001) recorded the benefit of Tk. 1050.69/dec from pangas farming after 10 to12 months culture and Haque (2003) obtained a net profit of Tk. 846.32/dec in 105 days in polyculture system of Thai pangas and silver carp. The result of the present study agrees with the result of Haque (2003) but is lower than that of Akter (2001) due to higher market price and higher production of Thai koi (*A. testudineus*). The benefit cost ratios (BCR) of the present study were 1.57, 1.76 and 1.60 in T1, T2 and T3 respectively. Akter (2001) recorded BCR of 1.90 in case of Thai pangas culture. The results of the present study are lower than that of Akter (2001) due to different species, different stocking density and higher production of Thai pangas. But, in this experiment among the treatments, T_2 showed the highest BCR than those of T_1 and T3. It might be due to lower input cost and comparatively better production than the other treatments on the basis of economic analysis.

In the present study, the average temperatures (°C) were 27.75 ± 0.0, 27.75 ± 0.02 and 27.79 ± 0.05 °C in T1, T2 and T3 respectively. There was no significant ($p < 0.05$) variation among the treatments and those values were within acceptable range for fish culture throughout the experimentation. Similar results were found by Aminul (1996); Wahab et al. (1995); Boyd (1982) and Swingle (1967). The average dissolved oxygen were 5.99 ± 0.006, 6.06 ± 0.19 and 6.08 ± 0.02 (mg/L) in T1, T2 and T3 respectively. The average value of T_1 is significantly ($p < 0.05$) lower than those of T2 and T3. It might be due to high organic decomposition from supplied feed and higher oxygen consumption by fish than the rest two treatments. Similar results were reported by Wahab et al. (1995). The average values of transparency were 34.71 ± 0.25, 23.44 ± 0.399 and 27.28 ± 0.01 cm T1, T2 and T3 respectively and the average values of plankton population were $36.5 \pm 10.50 \times 105$, $40.2 \pm 12.30 \times 10$ and $36.8 \pm 12.0 \times 105$ (cells/L) in T1, T2 and T3 respectively. The mean values of

water transparency (cm) differed significantly ($p < 0.05$) different from each other and T2 (23.44 ± 0.399) showed lower than the other treatments due to higher plankton population (cells/L) in T2. On the contrary, T2 ($40.2 \pm 12.30 \times 10'$) showed the highest plankton (cells/L) than those of T_1 and T3. Similar results were found by Rahman (1992), Reid and wood (1976). It might be due to excreata of Thai koi (*A. testudineus*) and fertilization effect of uneaten mixed feed. Khatun (2005) unveiled that plankton population varied from 48.61 plus/minus $7.31 * 10^\wedge 3$ to 50.17 plus/minus $7.45 * 10^\wedge 3$ cells/L during her 165 days experimental period of local sarpunti (*Puntius sarana*) in monoculture and polyculture system. The findings of the present study was slightly lower than that of Khatun (2005) due to different environment and different seasonal variation. However, fish fed mixed feed might be considered the best since net profit was the highest in this treatment compared to others.

**Experiment 2. Study on some aspects of biology of Thai koi (*A. testudineus)*

Thai koi (*A. testudineus*) was comparatively larger than the local koi. Its body colour was whitish to pale and contained numerous black spots. Similar observations were reported by Noor (2005) which support the results of present finding. The average GSI value of the present study was 13.72 ± 0.415 (range: 11.4 to 15.4) in May and 17.61 ± 0.585 (range: 11.72 to 20.7) in April. Although local koi (*A. testudineus*) showed maximum GSI in May (Banu et al., 1987), but Thai koi (*A. testudineus*) showed maximum GSI in April. It might be due to different strain, size of body, feed type and other environmental causes. Sarkar (2005) revealed that highest average value of GSI of catfishes (*Pseudeutropius atherinoides*) was 16.12 ± 3.26 (range: 11.24 to 20.11) in May. Here, the results of the present study is little higher than the findings of Sarkar (2005) which might be due to different species and different maturing stages of the species. Present study showed that average ova diameter of *A. testudineus* varied from 139.70 ± 3.14 to 654.10 ± 6.37 µm with average value of 410.66 7.0 which was similar to Shafi and Mustafa (1976). Shafi and Mustafa (1976) reported that diameter of eggs of *A. testudineus* varied from 500 to 900 µm with the average value of 710 µm. Sarker (2005) reported that the ova diameter of P. atherinoides varied from 340 to 470 µm in Methamaion haor in Kishoreganj district. It might be due to environmental differences, different species and degree of maturation. The average sperm-head length of Thai koi (*A. testudineus*) varied from 1.0 to 3.60 µm with average value of 2.30 µm. Rahman et al. (2003) reported that the average value of sperm-head length of *Labeo calbasu* was 3.35 ± 0.32 µm which was higher than the present findings. It might be due to species variation and the lager size of *L. calbasu*.

In the present study, the fecundity of Thai koi (*A. testudineus*) varied from 3,965 eggs (a fish with total length of 9.3 cm and weight of 35.0 g) to 60,500 (a fish with total length of 14.5 cm and weight of 59.0 g). Shafi and Mustafa (1976) reported the fecundity *A. testudineus* (Bloch) to vary from 6,478 eggs (a fish with total length of 9.4 cm and weight of 38 g) to 44,395 eggs (a fish with total length of 17.9 cm and weight of 114 g). Khan and Mukhopadhay (1972) found a range of 10,002 eggs to 36,477 eggs in same species measuring 9.9 to 16.9 cm in length. Banu et al. (1985) reported that fecundity of *A. testudineus* varied from 12,355 (a fish with total length of 12.3 cm and weight of 30.24 g) to 41,820 eggs (a fish with total length of 15.5 cm and weight of 66.62 g). However, present findings agree with the findings of above mentioned authors. Faruq et al. (1998) reported that the average number of eggs/g body and ovary weight of *Heteropneustis fossilis* were 181 and 873 respectively. In the present study, the results of eggs/g body and ovary weight were 562.22 and 4480.22 respectively which is higher than the findings of Faruq et al. (1998). It might be due to the different species and different times of the year. Fecundity also varied with seasons, climatic conditions, environmental habitat, nutritional status and genetic potential (Bromage et al., 1992; Nakarj and Hossain, 1987). Condition factor of Thai koi (*A. testudineus*) varied from 0.95 to 1.05. Faruq et al. (1998) reported that condition factor of *H. fossilis* (Bloch) varied from 0.59 to 0.79. This deviation occurred due to variation in size, time, species, overall feeding and habitat condition. Here, those values proclaimed that health condition of experimental fishes were good. The fecundity depends on the weight of a fish. The relationships of fecundity with the body weight closely approximate a straight line. Body weight and fecundity of *A. testudineus* were found to maintain a positive correlation (r = 0.6746). Fecundity was observed to increase with the increase of body weight. The value of correlation coefficient (r = 0.6746) was indicative of strong relationship between fecundity and body weight of fish. The relationship between body weight and fecundity has also been observed in other fishes by Islam et al. (2006) in *M. cavasius*,

Faruq et al. (1998) in *H. fossilis* and Doha et al. (1970) in *Tenualosa ilisha.* The fecundity of fish species depends on the weight of ovary. The correlation coefficient between ovary weight-fecundity of *A. testudineus* was 0.960. It was observed that fecundity increase with the increase of ovary weight. Similar strong relationship was established by Islam et al. (2006) in *M. cavasius* and Azadi et al. (1987) in *M. vittatus*. However, this experiment should be conducted all the year round for more information of biological aspects including the identifying of peak spawning period of this species.

Chapter 6

SUMMARY AND CONCLUSION

CHAPTER 6

SUMMARY AND CONCLUSION

The works reported in the preceding chapters were conducted with Thai koi, *A. testudineus* (Bloch, 1792) to investigate the growth performance of three types of feeds (Suny, Mixed and Saudi-Bangla fish feed) as supplemental feed and to know some biological aspects of the same species. A 99 days pond trial was conducted with Thai koi in nine experimental ponds of "Field Laboratory Complex", Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh during 21st April to 28th July'06. Another experiment of 113 days was performed to know some biological aspects jointly in the "Fish Genetics Laboratory" of Department of Fisheries Biology and Genetics under Faculty of Fisheries, Bangladesh Agricultural University and "Genetics Laboratory" of Bangladesh Fisheries Research Institute (BFRI), Mymensingh during 23rd January to 15th May'07.

The fish were fed twice daily. The amount of feed was adjusted at 14 days interval as the rate of 100, 80, 40, 20, 10, 5, 3 and 1% of their body weight respectively. Each treatment had three replications with 250 fishes/replicate and suny, mixed and Saudi-Bangla fish feed were used in T1, T2 and T3 respectively. On the basis of observed growth rate and food utilization, Saudi-Bangla fish feed (T_{3}) showed the highest growth performance while Suny feed (T_{1}) showed the lowest. The average growth increased in terms of weight gain were 72.67 plus/minus 0.24, 76.18 plus/minus 0.04 and 78.90 ±0.11 g in T_{1} T_{2} and I_{3} respectively. The survival rate of T_{3} was significantly ($p < 0.05$) higher followed by T_{2} and T_{1} Net productions were 2269.13, 2374.04 and 2435.80 kg/ha/99 days in T_{1} T_{2} and T_{3} respectively. In terms of economic analysis, T_{2} showed the highest profit (Tk/ha/99 days) followed by T_{3} and T_{1}

However from the above discussion, it can be concluded that T_{3} (Saudi-Bangla fish feed) showed highest production but T_{2} (mixed feed) showed highest net profit than the other treatments. So, mixed feed might be considered the best since it showed

highest net profit compared to others. Use of mixed feed, therefore, may be recommended for mass culture of Thai koi (*A. testudineus*).

Another experiment was conducted to know some biological aspects i.e. fecundity, gamete sizes (egg and sperm diameter), gonadosomatic index (GSI), condition factor, the relationship between body weight-fecundity and ovary weight-fecundity of same species. The study indicated that *A. testudineus* was not a highly fecund fish. Fecundity of this species varied from 3,965 (total length 9.3 cm, body weight 35.0 g) to 60,500 (total length 14.5 cm, body weight 59.0 g) with mean of 26578 ± 1970. The egg diameter and sperm-head length varied from 125 to 685 μm with mean of 410.66 ± 7.0 μm and 1.0 to 3.60 μm with mean of 2.30 ± 0.08 μm respectively. The average gonadosomatic index (GSI) was 10.75 ± 0.377 with the lowest average of 3.96 ± 0.19 (range: 2.8 to 4.7) in January and the highest average of 17.61 0.585 (range: 11.72 to 20.7) in April. The final average value of condition factor (CF) was 1.0019 ± 0.003 which indicated that fishes were in good condition i.e. not so much fatty or lean. The coefficient of correlation (r) of body weight-fecundity (r = 0.6746) and ovary weight-fecundity (r=0.960) indicated that fecundity of a fish could be well defined by the ovary weight-fecundity relationship.

The information gathered through the present experimentation may be used for better management of fishery resources especially for acceleration of aquaculture production.

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APPENDICES

Appendix 1. Lenflh and weight of Thai koi (*Anabas testudineus*) in ponds during the experimental period in three different treatments

Treatment	Parameters	Initial 20ʰ April	1st sampling 5ᵗʰ May	2nd sampling 19ᵗʰ May	3rd sampling 2nd June	4th sampling 16ᵗʰ June	5th sampling 30ᵗʰ June	6th sampling 14ᵗʰ July	7th sampling 28ᵗʰ July
T₁	Length (cm) (M±SE)	3.63 ± 0.015	5.78 ± .00	7.01 ± 0.01	9.65 ± 0.02	11.31 ± 0.01	13.87 ± 0.00	13.91 ± 0.00	14.82 ± .01
	Weight (g) (M±SE)	0.90 ± 0.18	3.14± 0.33	10.45 ± 0.02	25.06 ± 0.11	42.51± 0.27	60.80±0.20	70.16± 0.09	73.5 ± 0.24
T₂	Length (cm) (M±SE)	3.63 ± 0.015	5.12 ± 0.00	8.13 ± 0.00	10.15 ± 0.02	13.15 ± 0.00	14.35 ± 0.01	14.99 ± 0.00	15.20 ± 0.01
	Weight (g) (M±SE)	0.90 ± 0.18	3.7 ± 0.16	12.62 ± 0.15	26.39 ± 0.19	44.55 ± 0.24	62.54 ± 0.24	73.05 ± 0.03	77.08 ± 0.04
T₃	Length (cm) (M±SE)	3.63 ± 0.015	5.45 ± 0.16	8.87 ± .00	10.05 ± 0.02	13.45 ± 0.12	14.79 ± 0.01	15.35 ± 0.02	15.99 ± 0.01
	Weight (g) (M±SE)	0.90 ± 0.18	3.86 ± 0.32	14.33 ± 0.03	28.45 ± 0.00	46.24 ± 0.02	66.75 ± 0.08	76.22 ± 0.10	79.80 ± 0.11

Appendix 2. Fortnightly variation of Physico-chemical condition of water in the ponds during the experimental period in three different treatments.

Treatment	Parameters	Initial sampling (21st April)	1st sampling (5th May)	2nd sampling (19th May)	3rd sampling (2nd June)	4th sampling (16th June)	5th sampling (30th June)	6th sampling (14th July)	7th sampling (28th July)
T1	Average temperature (°C) (M ± SE)	26.95±.02	26.5 ± .09	26.85±.23	24.55±.08	29.65±.08	30.35±.02	29.3±.05	27.9±.05
	Average DO (mg/L) (M ± SE)	6.07±.02	6.86±.02	6.22±.06	7.4±.01	5.65±.30	5.02±.04	5.23±.01	5.6±.02
	Average pH (M ± SE)	7.95±.02	8.18±.01	8.2±.00	8.25±.02	7.9±.00	7.76±.03	7.85±.02	8.3±.11
	Transparency (cm) (M ± SE)	27±1.5	38.33±.88	32.66±1.45	27.66±1.45	14.66±2.60	41.0±.57	45.33±	53.33±
T2	Average temperature (°C) (M ± SE)	27.00±.00	26.95±.02	26.7±.05	24.55±.02	28.2±.80	30.35±.02	30.45±.33	27.8±.88
	Average DO (mg/L) (M ± SE)	5.97±.04	6.8±.00	6.36±.03	7.39±.00	6.26±.10	4.95±.00	5.2±.00	5.61±.004
	Average pH (M ± SE)	8.1±.05	8.23±.03	8.2±.15	8.13±.03	8.1±.00	7.93±.08	7.83±.03	7.83±.03
	Transparency (cm) (M ± SE)	29±.57	24.66±.33	17.66±.33	15.33±.33	9.33±1.6	27±.57	30±1.1	37.33±1.2
T3	Average temperature(°C) (M ± SE)	27.00±.05	26.9±.00	26.65±.02	24.8±.11	29.45±.08	29.95±.20	29.9±.23	27.7±.17
	Average DO (mg/L) (M ± SE)	5.87±.12	6.81±.00	6.17±.01	7.79±.33	6.25±.05	4.96±.01	5.17±.00	5.66±.03
	Average pH (M ± SE)	8.13±.03	8.3±.00	8.25±.02	8.2±.00	8.1±.05	7.7±.00	7.83±.03	8.0±.05
	Transparency (cm) (M ± SE)	29±1.00	27±.57	23.33±.88	21±.57	16±.57	30.33±.30	32±.57	41±.57