EVALUATION OF DIETARY INCLUSION OF AZOLLA FOR GROWTH IN QUAIL (*Coturnix coturnix*)

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DECLARATION

I hereby declare that this thesis, entitled **"EVALUATION OF DIETARY INCLUSION OF AZOLLA FOR GROWTH IN QUAIL (*Coturnix coturnix)*"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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Introduction

1. INTRODUCTION

Poultry production occupies a pivotal position in India because of its enormous potential to bring about rapid economic growth in agricultural sector particularly benefiting the weaker section of the society. Poultry industry in India is found to be a rapidly expanding segment in Animal Husbandry sector. India is now endowed with the position of the 3rd largest producer of egg and the 5th largest producer of broilers in the world with production of 2.49 million ton egg and 1.9 million ton poultry meat (Anon, 2007). Poultry population in India has increased from 347.61 to 489.01 million during the period of 1997-2003 with annual growth rate of 5.85 per cent (Anon, 2003a).The value output is Rs112.59 billion from poultry meat and Rs 55.0 billion from eggs during the year 2004-2005(Anon, 2006).

In broiler industry, the size of operation is large and shows the tendency for integration and contract farming. Thus many of the small and marginal farmers were forced out of farming and are in search of an alternative for livelihood. The quail farming is a viable alternative with much potential, and the acceptance of quail farming is getting momentum.

In Kerala, the small, marginal and landless farmers received the quail farming as remunerative and affordable enterprise. The livestock census conducted by the Department of Animal Husbandry, Kerala revealed that the quail population in Kerala has showed substantial increase from 0.39 to 2.9 lakhs in the year 2003 (Anon, 2003b).

The consumer awareness for quality meat demands the quail production in several folds. The preference for the variety and better quality meat recognized the quail meat as a culinary delicacy and as an alternative to chicken meat. In Kerala ayurvedic practitioners recognized the medicinal value of quail meat and meat

products especially for the treatment of chronic respiratory and neurological problems.

The species quail, domesticated by the end of 19th century is identified as a promising species of poultry is now widely used for meat and egg production. The peculiarities like small size, rapid growth and early onset of egg production make quail farming more economical. The low capital investment, quick return and resistance to diseases are unique features of this sector. In developing countries, quail farming offer a viable solution for shortage of animal protein in human diet. The rearing of quails has to be increased multifold in response to the fast and growing demand for quail egg and meat. Quail meat is popular for its high protein quality. It is rich source of trace minerals and vitamins and the cholesterol content is comparatively low to the tune of 57.8 mg per 100 g meat. (Shanaway, 1994).

The major problems associated with the poultry industry are the high price and non availability of feed ingredients. Thereby, the feed cost accounts for more than 70 per cent of total cost of production. The cereal grains are inevitable for feeding poultry, but world grain production shows decreasing trend. The use of animal protein resources in poultry diet is highly expensive. In this situation, greater emphasis has been placed to identify new feed resources to improve the efficiency and economy of poultry production.

The planktonic algae of both marine and fresh water origin are considered to be potential source of feed for meeting the expanding needs of feed ingredients in poultry industry. In developing countries, the aquatic plants have long been used as feed source than leaf proteins and offer greater potential for monogastric animals. Aquatic plants at low level in poultry diet supply a part of total protein. In small avian species like quails, the high density nutrient rich feed sources will be more effective

than conventional feeds. In the present scenario, the search for easily available alternative lead to Azolla that can be used as an ingredient in poultry diets.

The water fern Azolla is a free floating fresh water fern, grows naturally in stagnant water belonging to the family Azollaceae. It is rich in protein, vitamins, trace minerals and carotenoids. Azolla is most promising from the point of view of ease of cultivation and productivity. Experiments conducted in chicken revealed that Azolla feeding improved weight gain in broilers (Basak et al., 2002) and increased egg weight in layers (Khatun et al., 1999).

The studies on feeding value of Azolla in Japanese quail are limited. In the present study an attempt was made to investigate the effect of dried Azolla on the growth pattern of Japanese quails.

Review of literature

Materials and Methods

2. REVIEW OF LITERATURE

2.1 NUTRITIVE VALUE OF AZOLLA

Buckingham *et al.* (1978) studied the chemical composition of *Azolla filliculoides* and observed that it contained 23.42 per cent total protein, 5.05 per cent ether extract (EE), 15.54 per cent ash, 26.58 per cent acid detergent fibre (ADF), 39.16 per cent neutral detergent fibre (NDF), 15.19 per cent cellulose and 9.27 per cent lignin on dry matter basis. The high NDF content in Azolla result in decreased dry matter digestibility. The above researchers reported that the lysine content of Azolla was more than twice (6.45 %) as that in corn (2.76 %) with low methionine value (1.88 per cent). Relative to alfalfa meal major minerals in Azolla were adequate and the calcium and phosphorus ratio were 2:1 Some of the trace minerals in Azolla were higher than in alfalfa; iron 4 times (1 mg/g), copper 3 times (28.05 µg/g) and manganese 22 times higher (771 µg/g) than that in alfalfa.

The *Azolla pinnata* contained 24 to 30 per cent crude protein (CP), 3.0 to 3.4 per cent crude fat, 0.4 to1.0 per cent calcium, 0.5 to 0.9 per cent phosphorus and 10.5 per cent ash, on dry matter basis (Subudhi and Singh ,1978).

Querubin *et al.* (1986) analysed the proximate composition of Azolla and observed that it contained 17.59 to 23.69 per cent crude protein, 1.93 to 2.93 per cent ether extract, 13.19 to16.54 per cent crude fibre, 1.67 to 2.07 per cent calcium and 0.46 to 0.77 per cent total phospherus, on dry matter basis.

Sanginga and Van Hove (1989) analysed the mean protein content of Azolla (28 per cent) and reported that it was comparable to that of legumes like alfalfa. Among various strains, *Azolla microphylla* strain was the best source of aminoacids and *A.fulicoides* was the poorest strain. The amount of essential amino acids (leucine,

lysine, arginine and phenyl alanine plus tyrosine) were found maximal during the linear phase of growth, but the sulfur containing amino acids methionine and cysteine were found less.

Becerra *et al.* (1990) revealed that water plants such as *Azolla filliculoides* were highly productive sources of protein rich biomass and are ideal complement for the low fiber tropical feed resources that are being developed as alternative to cereals in poultry and pig diets.

Ali and Leeson (1995) studied the proximate composition of dried *Azolla pinnata* and reported that it contained 92 per cent dry matter, 16.5 per cent crude protein, 12.5 per cent crude fibre, 1.6 per cent fat, 36.1 per cent total ash, 33.2 per cent NFE, 47.8 per cent NDF, 46.7 per cent ADF, 1.4 per cent calcium, 0.31 per cent phosphorus and 4.38 MJ /kg apparent metabolisable energy value on dry matter basis. The crude protein content of Azolla meal was found to be similar to alfalfa meal but crude fibre is lesser in Azolla than alfalfa meal (314.6 g/kg). It contained 1.5 per cent methionine, 0.9 per cent cystine, 3.8 per cent lysine, 5 per cent arginine, 0.5 per cent tryptophan, 3 per cent tyrosine, 4 per cent threonine, 4 per cent serine, 4.6 per cent phenyl alanine, 8.3 per cent aspartic acid, 9.6 per cent glutamic acid, 4 per cent proline, 5.2 per cent glycine, 5.8 per cent alanine, 5.1 per cent valine, 4.2 per cent isoleucine, 7.7 per cent leucine and 1.6 per cent histidine. These amino acid values of Azolla were comparable with those found in other aquatic plants and alfalfa meal. The apparent digestibility coefficient of aminoacids is lesser in Azolla in comparison with that of snail meal.

Becerra *et al.* (1995) observed 5.6 per cent dry matter, 26.7 per cent crude protein, 11.0 per cent crude fibre, 4.6 per cent ether extract, 0.8 per cent calcium and 0.4 per cent phosphorus and 326 mg / kg of carotene in Azolla.

Ardakani *et al.* (1996) reported 17.67 per cent crude protein, 21.5 per cent crude fibre, 2.49 per cent ether extract, 3.2 per cent calcium, 0.17 per cent phosphorus and 3949 kcal/kg gross energy in Azolla, on dry matter basis.

Khatun *et al*. (1999) analysed the proximate composition of dried *Azolla pinnata* and found that it contained 90.58 per cent dry matter, 28.54 per cent crude protein, 21.98 per cent digestible protein, 12.38 per cent crude fibre, and metabolisable energy value of 7.59 MJ/ kg. The crude protein was similar to that of sesame meal and legume grains. The ME value was comparable to that of duck weed.

Lejune *et al.* (2000) revealed that carotene content of fresh Azolla during the linear phase of growth ranged from 369 to 619 mg / kg dry matter, values comparable to the 451 mg / kg in carrot and 556 mg in spinach per kg dry matter.

Parthasarathy *et al*. (2001a) studied the proximate composition of various species of Azolla and indicated that the content of crude protein, ether extract, crude fibre, NFE and total ash ranged from 24.91 to 27.22 per cent, 2.52 to 3.01 per cent, 13.84 to16.40 per cent, 38.85 to 44.06 per cent and 12.8 to 16.26 per cent, respectively, on dry matter basis. The neutral detergent fibre, ADF, cellulose, hemicellulose and lignin content of *Azolla pinnata* were 43.84, 27.19, 14.28, 16.65 and 8.08 per cent respectively. The ME value of Azolla was 1855 kcal/kg DM. *Azolla microphylla* contained higher levels of calcium (2.11 per cent) and phosphorus (1.08 per cent) compared to other species of Azolla. The concentration of tannin in various species of Azolla is extremely low (0.03 to 0.05 per cent) and insignificant.

Parthasarathy *et al*. (2002) studied the nutritiuve value of *Azolla pinnata* and revealed that it contained 26.02 per cent crude protein, 13.6 per cent crude fibre, 2.37 per cent EE and 45.71 per cent NFE and 12.30 per cent total ash, on dry matter basis.

Azolla is a good source of minerals with 1.24 per cent calcium and 0.72 per cent phosphorus. The apparent and true ME values of *Azolla pinnata* were 1529 and 1855 kcal/kg DM, respectively.

Basak *et al.* (2002) studied the chemical composition of *Azolla pinnata* and reported that the meal contained 25.78 per cent crude protein, 15.71 per cent crude fibre, 3.4 per cent ether extract, 15.76 per cent ash and 30.08 per cent NFE on dry matter basis.

Alalade and Iyayi (2006) estimated that *Azolla pinnata* meal contained 21.4 per cent crude protein12.7 per cent crude fibre, 2.7 per cent ether extract, 16.2 per cent ash and 47.0 per cent NFE on dry matter basis. The mineral content include 1.16 per cent calcium and 1.29 per cent total phosphorus. Amino acid profile revealed that lysine, arginine, isoleucine, leucine phenylalanine, glycine and valine are predominant. However the sulphur containing aminoacids are present in low levels.

Raseena (2006) showed that Azolla contained 23.14 per cent crude protein, 3.50 per cent ether extract, 12.20 per cent crude fibre, 43.66 per cent nitrogen free extract, 17.5 per cent ash, 2.29 per cent calcium and 0.39 per cent phosphorus, on dry matter basis.

Alalade *et al.* (2007) observed that Azolla meal contained 21.4 per cent crude protein, 12.7 per cent crude fibre, 2.7 per cent ether extract, 16.2 per cent ash and 47.0 per cent nitrogen free extract, on dry matter basis.

2.2 BODY WEIGHT

Subudhi and Singh (1978) studied the effect of *Azolla pinnata* in White Leghorn female chicks by including fresh Azolla in diet at levels of 16.0, 12.5 and 5.0 per cent on dry matter basis along with 50, 75 and 100 per cent feed. The result of

the study indicated that the body weight gain in group fed 75 per cent feed with 12.5 per cent Azolla was 518 g and that in birds fed with control diet was 494 g. The birds receiving normal diet with 5 per cent Azolla grew faster than control, obtained a body weight gain of 614 g at 14 weeks of age.

Querubin *et al.* (1986) conducted feeding trial in broiler chicks with four dietary treatment containing 0, 5, 10 and 15 per cent Azolla meal in diet and observed that body weight gain of the birds was not significantly affected with Azolla meal in broiler diet.

Narayanankutty (1987) reported mean weekly body weight gain of 15.41, 21.27, 27.29, 20.48, 26.29 at second, third, fourth, fifth and sixth week respectively in Japanese quail fed diets containing 26 per cent protein and 2700 kcal of ME per kg.

Das *et al.* (1989) showed a body weight of 119.45g in Japanese quail at sixth week of age, fed with finisher ration having 24 per cent protein and 2800 kcal ME/kg for four to six week of age.

Panda and Mohapatra (1989) stated that Female quails (150-180g) are heavier than males (120-150 g)at five weeks of age. They classified quail chicks 0-3 weeks as starter and 4-5 weeks as grower for efficient and economic feeding depending upon their growth effects.

Mishra *et al.* (1993) observed that Japanese quail fed with diet having 27 per cent crude protein and 2800 kcal of ME per kg, showed a body weight of 143.75g at fifth week of age.

Shrivastav and Johri (1993) observed body weight of 23.0, 59.3, 96.4, 123.3 and 144.6 g at first, second, third, fourth and fifth weeks of age respectively in

Japanese quail fed with ration having 27 per cent crude protein throughout the period of five weeks.

Shanaway (1994) reported weekly weight gain of 13, 25, 27, 21, 17 and 8 g per week at 1 to 6 weeks of age respectively, showing rapid growth from hatching upto the end of three weeks of age and rate of growth is declined thereafter gradually, and reported that the growth in quail is affected by strain, stocking density, nutrient intake, photoperiod and ambient temperature.

Ali and Leeson (1995) observed a body weight gain of 236 g in male broiler chicks with 10 per cent Azolla in feed on digestible protein basis and that of 242 g in birds fed with 8 per cent snail meal on digestible protein basis. The body weight gain was similar to that of control birds fed maize-soyabean basal diet (226.3 g).

Shrivastav *et al.* (1995) observed a body weight of 139.2 g in Japanese quail at six week of age, when grown as sex mixed.

Sarria and Preston (1995) reported a significant increase in growth rate ($p=0.02$) in broiler chick, when soya bean protein was replaced by Azolla up to 15 per cent level. They observed a daily weight gain of 23.0, 29.5, 35.5 when soya bean protein was replaced by *Azolla filicoides* at 0, 10 and 15 per cent level.

The broiler quail line of Ujjwal developed by Central Avian research institute (Anon, 2000) recorded body weight of 170-175 g at five weeks of age.

Parthasarathy *et al*. (2001b) studied the effect on broiler growth by incorporating Azolla meal in feed at 0, 5, 10, 15 and 20 per cent levels on dry matter basis replacing wheat bran and groundnut cake mix. The result of the study indicated that broiler birds receiving 5 per cent Azolla from zero to five weeks of age had a

similar weight gain (1106.00) as that of control (1083.00 g), while the birds on 10, 15 and 20 per cent Azolla diets had significantly lower weight gain (976, 935 and 897 g in the order).

Basak *et al.* (2002) observed a body weight of 1579 and 1637 g in broilers fed 0 and 5 per cent Azolla meal at 6 weeks of age, showing significant improvement in body weight for those fed at 5 per cent level. The body weight at 10, 15 and 20 per cent levels were 976, 935 and 897 g respectively.

Parthasarathy *et al.* (2002) reported a body weight gain of 1803 and 1816 g in broilers fed with basal diet and 5 per cent Azolla diet replacing 2.6 per cent wheat bran and 2.4 per cent fish meal at 8 weeks of age, showing more or less similar body weight with 5 per cent Azolla diets. The addition of higher levels of Azolla at 10, 15 and 20 per cent resulted in significant reduction in body weight gain. The authors observed live weight gain of 1752 g, 1676 and 1650 g respectively with 10, 15 and 20 per cent Azolla.

Dhariwal *et al.* (2004) studied the growth rate and carcass characteristics of two growth selected and one control line of Japanese quail from day old to sixth week of age. The control non selected line showed mean body weights 7.02, 24.55, 50.33, 84.70, 124.58, 141.34, 142.1 g at zero, first, second, third, fourth, five and sixth week of age.

Pillai *et al.* (2004) observed that broiler chicken fed with 5 per cent extra Azolla in diet resulted in substantial increase in bodyweight than those of control diet receiving 100 per cent feed.

Pakhira and Samanta (2005) observed a body weight of 203.83 g in Japanese quail at six weeks, fed with starter ration (27 per cent CP and 2794 kcal of ME / kg)

up to 3 weeks and finisher ration (24 per cent CP. 2814 kcal of ME / kg) for 4-6 weeks.

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Alalade and Iyayi (2006) reported a body weight gain of 95.43, 95.22, 98.62 and 93.44 g per week in egg type chicks fed with Azolla meal at the levels of 0, 5, 10 and 15 per cent, respectively, showing no significant difference in weight gain among different dietary groups.

Raseena (2006) reported mean body weight gain of 37.74, 37.27, 35.51 and 36.76 in layer quails fed dried Azolla at 0, 1.5, 3.0 and 4.5 per cent level during the experimental period of 6 to 26 week, indicating no significant difference in body weight gain when Azolla was included up to 4.5 per cent level.

Alalade *et al.* (2007) investigated the effect of incorporating Azolla meal at levels of 0,5,10 and 15 per cent in diet of growing pullets and observed a body weight of 1516, 1523, 1480 and 1435 g respectively at 18 week of age.

2.3 FEED CONSUMPTION

Narayanankutty (1987) observed a mean daily feed consumption of 8.34, 9.01, 14.09, 16.22 and 19.59 g at second, third, fourth, fifth and sixth week respectively in Japanese quail fed ration containing 26 per cent crude protein and 2700 kcal /kg ME.

Ali and Leeson (1995) observed feed consumption of 318.8 g with 10 per cent Azolla in feed and that of 331.2 g with 8 per cent snail meal in feed on digestible protein basis from zero to fourteen days in male broiler chicken. These values separately were statistically comparable to control birds fed maize soybean basal diet (321.8 g).

Sarria and preston (1995) reported significant increase in feed intake (P=0.09) in broiler chicken, when soya bean protein was replaced by Azolla upto 15 per cent level. The above researchers observed a daily feed intake of 59.0, 58.3 and 67.0 when soya bean protein was replaced by *Azolla filicoides* at 0, 10 and 15 per cent level.

Khatun *et al.* (1999) reported feed consumption of 107.3, 112.6 and 113.6 g/bird/day at 0, 15 and 20 per cent dietary Azolla in laying hen diet on total protein and total amino acid basis, showing significant increase in feed intake with 15 per cent and 20 per cent level, when compared to those fed control diet (107.3 g/bird/day). But feed consumption was statistically comparable among those fed diet containing 15 and 20 per cent Azolla.

Parthasarathy *et al*. (2001b) observed cumulative feed intake of 2170, 2184 and 2196 g, in broiler birds when fed diet containing 5, 10 and 15 per cent Azolla. There was significant reduction in cumulative feed intake in all Azolla fed group than that of control diet (2212g).

Basak *et al.* (2002) found that feed consumption of broiler chicks was statistically comparable with 0, 5, 10 and 15 per cent Azolla meal in diet (981.33, 896.67, 906.67, 913.33 g/bird) at sixth week of age.

Parthasarathy *et al.* (2002) in the study on the effect of feeding Azolla replacing 2.6 percent wheat bran and 2.4 per cent fish meal protein mix in broiler feed, observed a cumulative feed intake of 3925, 3924, 4034, 4018 and 4022 g when fed with 0, 5, 10, 15 and 20 per cent respectively, of Azolla in diet.

Alalade and Iyayi (2006) studied the performance of pullet chick fed with 0, 5, 10 and 15 per cent of Azolla meal in diets and observed that the average weekly

feed intake was similar with 5 per cent Azolla diet to that of control diet. A significant reduction in the average feed intake was observed with 10 and 15 per cent Azolla diet when compared to that of control group.

Alalade *et al.* (2007) conducted a trial to evaluate the effect of incorporating graded levels of Azolla meal in diets of growing pullets and observed that feed intake at 0, 5, 10 and 15 per cent Azolla level were 731, 708, 653 and 659 g /bird / week respectively.

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2.4 FEED CONVERSION RATIO (FCR)

Shrivastav and Panda (1982) observed the feed conversion ratio of 4.41, 4.08 and 3.96 in Japanese quail fed with diet containing 133, 117 and 104 C/P ratio and 2800 kcal of ME/kg at fifth week of age.

Narayanankutty (1987) observed that cumulative feed efficiency in Japanese quail was 4.19 at sixth week of age, fed ration having 26 per cent crude protein and 2700 kcal of ME / kg.

Das *et al.* (1989) showed feed efficiency of 4.37 in Japanese quail at sixth week of age, fed with finisher ration having 24 per cent crude protein and 2800 kcal of ME/ kg.

Ali and Leeson (1995) reported that the feed efficiency was statistically comparable in male broiler chicken fed 10 per cent (1.35) and 8 per cent snail meal (1.36) on digestible protein basis to that of control birds (1.42).

Ardakani *et al.* (1996) investigated the effect of inclusion of Azolla in broiler diets and showed that better FCR was found with 6 per cent fresh Azolla compared with control fed birds.

Khatun *et al.* (1999) reported better feed efficiency in laying hen fed with 5 and 10 per cent Azolla meal in diet. The feed efficiency was significantly improved with 15 and 20 per cent Azolla meal, on digestible protein and digestible amino acid basis.

Parthasarathy *et al.* (2001a) observed a feed efficiency of 2.13, 2.03, 2.34, 2.46 and 2.57 with 0, 5, 10, 15 and 20 per cent Azolla in broiler at five weeks of age, showing better feed efficiency at 0 and 5 per cent level and it became poor towards higher levels of Azolla in diet.

Parthasarathy *et al.* (2002) studied the effect of feeding Azolla replacing 2.6 percent of wheat bran and 2.4 per cent of fish meal protein mix in broiler chick performance and observed that feed and protein efficiency ratios were statistically comparable in basal and 5 per cent Azolla diets, where as significant depression in feed efficiency was observed at higher levels of Azolla.

Basak *et al.* (2002) found that feed conversion ratio was very close to standard (1.87:1) in broilers fed with 0 and 5 per cent Azolla and the feed conversion ratio significantly differed among treatments. The poorest feed conversion ratio was observed for those fed diets containing Azolla at 15 per cent level (2.50).

Pakhira and Samanta (2005) observed a cumulative feed conversion ratio of 4.07 at sixth week of age in Japanese quail fed with starter ration (27 per cent CP and 2794 kcal of ME/ kg) upto 3 week and finisher ration (24 per cent CPand 2814 kcal of ME/ kg) for 4 to 6 week.

Alalade and Iyayi (2006) revealed feed conversion ratio of 3.13, 3.05 2.54, 2.55, and with 0, 5, 10 and 15 levels of Azolla respectively indicating significantly lower feed conversion ratio at higher levels of Azolla (10 and 15 per cent levels) in diet.The control and 5 per cent of Azolla diet group showed comparatively poor FCR.

Raseena (2006) studied the effect of feeding different levels of Azolla in diet of laying quail and the data obtained indicated that the mean cumulative feed efficiency for the quails fed 0, 1.5, 3 and 4.5 per cent Azolla incorporated diets were 0.41, 0.42, 0.45, and 0.43 respectively. All the Azolla fed groups showed numerically higher value of feed conversion ratio per dozen egg than the control group during the period of 7 to 26 weeks of age.

2.5 CARCASS CHARACTERISTICS

Shrivastav and Panda (1982) reported dressed yield of 88.3, 89.7 and 89.3 per cent in Japanese quail fed with diet containing 133, 117 and 104 C/P ration and 2800 kcal / kg ME. They observed an evisceration yield of 65.6, 65.2 and 66.6 respectively for the above diets.

Choudhari and Mahadevan (1983a) reported that the dressing per cent of Japanese quail was 85.04 with an eviscerated yield of 61.48 per cent. They observed blood per cent of 4.93 at 6 week of age.

Choudhari and Mahadevan (1983b) studied the effect of sex and age on slaughter charecterisics of quail and observed a giblet yield of 7.4 per cent in quail at 6 week of age.

Narayanankutty (1987) observed 88.05 percent dressed yield and 77.85 percent ready to cook yield at six weeks of age in Japanese quail, fed ration having 26 percent crude protein and 2700 kcal of ME / kg. He reported a giblet yield of 7.41 percent. The blood and feather loss were 4.95 and 7 per cent respectively.

Shrivastav and Panda (1987) reported 65.95 per cent dressed yield in Japanese quail at five weeks of age, when fed with a diet having 27 per cent crude protein and 2800 kcal of ME / kg and 0.95 per cent sulphur amino acid in diet.

Samanta and Dey (1991) showed that dressing yield in Japanese quail, fed with ration having 27 per cent crude protein and 2700 kcal of ME/ kg, was 75.5 per cent at seventh week of age. They observed an eviscerated yield of 71.3 per cent and giblet yield of 4.19 per cent.

Mandal *et al. (*1993) observed a mean eviscerated yield of 61.25 per cent in Japanese quail at six week of age. They observe a blood loss of 2.53 per cent and a giblet yield of 7.42 per cent.

Mishra *et al.* (1993) reported that Japanese quail fed with ration having 27 crude protein protein and 2800 kcal of ME / kg, showed an eviscerated yield of 71.16 per cent of at fifth week of age.

Shrivastav *et al*. (1995) observed eviscerated yield of 62.93 per cent and dressed yield of 90.46 per cent in Japanese quail at five weeks of age. They observed a giblet yield of 6.04 per cent.

Mandal *et al*. (1996) observed that dressed yield was 68.75 per cent in Japanese quail fed with ration having 26 per cent crude protein and 2600 kcal of ME / kg. They

observed the heart, liver and gizzard yield of 1.34, 3.59 and 3.81 respectively, at six weeks of age.

Kumararaj (1997) reported a ready to cook yield of 73.20 per cent at six week of age in Japanese quail fed with ration having 26 per cent crude protein and 2700 kcal of ME / kg. He observed giblet yield 8.16 per cent. Blood and feather loss was 1.60 and 5.20 per cent respectively.

Basak *et al.* (2002) in a study observed that broiler chicken fed 5 per cent Azolla in diet showed best average dressing percentage (72.16), while that was statistically comparable in other treatment groups (69.38, 68.24 and 68.78 at 0, 10 and 15 per cent dietary Azolla respectively). The mean giblet yield was highest in 15 per cent level and lowest in 0 and 5 per cent level.

Parthasarathy *et al.* (2002) reported that broiler chicken fed with 5 per cent Azolla diet had significantly higher dressing percentage (69.66) and it was decreased with 10,15 and 20 per cent level of Azolla in diet (65.76, 65.38, 65.19) than those fed control diet (67.79).

Sengar *et al*. (2003) observed a dressed yield of 85.50 per cent and eviscerated yield of 71.85 per cent in meat line Japanese quail fed with ration containing crude protein 19.56 percent, at 5 week of age.

Dhariwal *et al.* (2004) studied the growth rate from day old to sixth week of age, carcass characteristics of two selected and one control line of Japanese quail, showed a dressed yield of 73.65 per cent and eviscerated yield 61.90 per cent at six week of age in non selected control lines. The above authors observed 8.37 per cent giblet yield.

Pakhira and Samanta (2005) observed dressing percentage of 69.88 at sixth week in Japanese quail fed with ration having 27 per cent CP and 2794 kcal of ME/ kg for 0-3 week and 24 per cent CP, 2814 kcal of ME for 4-6 weeks of age. They observed a giblet yield of 8.29 per cent.

Raseena (2006) studied the effect of feeding different levels of Azolla in diet of laying quail and observed dressed yield of 83.09, 83.73, 81.57 and 83.63 with diet containing Azolla at levels 0, 1.5, 3.0, 4.5 per cent respectively, at twenty six weeks of age. She reported the ready to cook yield as 58.07, 59.71, 57.99 and 60.07 per cent with dietary groups 0, 1.5, 3 and 4.5 per cent Azolla.

2.6 SERUM PARAMETERS

2.6.1 Serum Cholesterol

Joshi and Bhuvanesh (1987) observed serum cholesterol value of 242 mg per dl in Japanese quail at fifth week of age.

Nirupama *et al.* (1995) observed a blood cholesterol level of 173.91 mg per cent in Japanese quails at five weeks of age.

Manjumdar *et al.* (1996) found that the serum cholesterol level in cage reared meat line female broiler quail ranged from 320.57 to 369.44 mg per dl.

Kumar (1997) observed 181.14mg per cent plasma cholesterol at six weeks of age in Japanese quail fed ration containing 24 per cent crude protein and 2725 kcal of ME / kg.

Ozbey et al. (2004) reported the total serum cholesterol in Japanese quail at 18-24^{0}C as 212.04 mg / dl and was increased significantly to 219.08 mg / dl at 35^{0}C.

Pakhira and Samanta (2005) observed 186.5 and 200mg per cent of serum cholesterol in male and female respectively in Japanese quail, fed with starter ration (27 per cent CP and 2794 kcal of ME / kg) up to 3 week and finisher ration (24 per cent CP and 2814 kcal of ME / kg) for 4-6 week.

Asrani *et al.* (2006) observed that serum cholesterol was 151.90 mg /dl in Japanese quail fed with chick mash, at 28 day of age.

Lonkar (2006) observed a total serum cholesterol of 181.73 mg / dl in broiler chicken at six weeks of age.

Preethymol (2006) observed serum total cholesterol 190.33 mg/dl in layer quail at twenty sixth week of age.

Raseena (2006) reported serum total cholesterol of 167.92, 147.79, 140.35 mg/dl and 113.99 mg per dl in Japanese quail layer fed with diet containing Azolla at 0, 1.5, 3 and 4.5 per cent level, at twenty sixth week of age, showing significant reduction at 3.0 and 4.5 percent level than control diet fed quails.

Simi (2007) observed a total serum cholesterol of 175.89 mg / dl in broiler chicken at six weeks of age.

2.6.2 Serum Total Protein

Joshi and Bhuvanesh (1987) observed that serum protein in Japanese quail was 5 g /dl at five weeks of age.

Narayanankutty (1987) reported that serum protein in Japanese quail was 6.02 g /dl at six weeks of age, when rat ion having 26 per cent crude protein and 2700 kcal of ME per kg was fed.

Mandal *et al.* (1996) reported a serum total protein of 4.00 g /dl in Japanese quail fed with ration containing 26 per cent crude protein and 2600 kcal / kg ME.

Ozbey et al. (2004) reported that Japanese quail reared at constant temperature of 35^0C up to 14 weeks of age had a total protein level of 4.39 g /dl. While it was significantly higher (5.06 g /dl) at temperature 18-24^0C.

Pakhira and Samanta (2005) reported that serum protein was 3.6 in male at 4.5 mg per cent in female Japanese quail fed with starter ration (27 per cent crude protein and 2794 kcal of ME /kg) up to 3 week and finisher ration (24 per cent crude protein 2814 kcal of ME / kg for 4-6 week.

Sheena (2005) observed 5.15 g percent serum protein at 26 weeks of age in layer quail fed ration having 22 per cent crude protein, 1.03 per cent lysine and .037 per cent methionine.

Asrani *et al.* (2006) observed that serum total protein in quail chick fed with chick mash was 4.02 g /dl at 28 days of age.

Preethymol (2006) reported a serum total protein of 6.83 g percent in layer Japanese quail at twenty sixth week of age.

Raseena (2006) observed serum total protein of 3.29, 2.97, 3.37 and 3.02g/dl in Japanese quail layer fed with diet containing Azolla at 0, 1.5, 3 and 4.5 per cent level, at twenty sixth weeks of age.

2.6.3 Serum Uric Acid

Mandal *et al.* (1996) observed that serum uric acid was 6.74 g / dl in Japanese quail fed with ration having 26 per cent crude protein and 2600 kcal of ME / kg.

Nazifi and Asasi (2001) reported that serum uric acid in adult Japanese quail was 35mmol /litre at 9 week of age.

Raseena (2006) observed the serum uric acid of 3.10, 3.27, 3.31 and 3.27 respectively with 0, 1.5, 3 and 4.5 per cent Azolla meal in diet of layer quail at twenty sixth week of age. The values were statistically comparable among different treatments.

2.6.4 Serum Creatinine

Asrani *et al.* (2006) reported serum creatinine of 1.2 mg /dl in Japanese quail fed with chick mash, at 28 day of age.

Raseena (2006) observed serum creatinine of 0.37, 0.28, 0.38 and 0.43 in Japanese quail with diet containing Azolla at levels 0, 1.5, 3 and 4.5 respectively at twenty sixth weeks of age

2.7 MEAT CHOLESTEROL

Kumar (1997) reported meat cholesterol of 179.54 mg / dl at six week of age in Japanese quail, fed on ration having 24 per cent crude protein and 2725 kcal of ME / kg.

Basak *et al.* (2002) reported that abdominal fat was not significantly affected by different dietary levels of Azolla in broilers.

Lonkar (2006) reported 54.07 and 111.09 mg per cent of total breast and thigh meat cholesterol respectively in broilers at six weeks of age.

Simi (2007) and observed thigh meat cholesterol of 113.08 mg per cent in broilers at six weeks of age.

2.8 LIVABILITY

Khatun *et al.* (1999) in their study with laying hen revealed that there was no mortality in any treatments of Azolla, indicating that Azolla meal has no deleterious effect on livability.

Basak *et al.* (2002) observed cent per cent survivability in broiler chicks when they were fed with Azolla at different levels, during the experimental period from 7 to 42 days of age.

Parthasarathy *et al.* (2002) reported that feeding of Azolla at a level of 20 per cent did not show any adverse effect on the livability of broilers.

Alalade *et al.* (2006) reported that there is no mortality at different dietary treatments of Azolla in egg type chicks.

2.9 ECONOMICS

Singh and Subudhi (1978) suggested that about 20 to 25 per cent of commercial feed could be replaced by fresh Azolla in poultry feed.

Bacerra *et al.* (1995) studied the effect of replacing whole boiled soya bean in diets of growing duck and the economic analysis revealed that fresh Azolla can partially replace whole soya bean upto a level of 20 per cent of total crude protein in diet of fattening ducks with lowest feed cost.

Jayaraman *et al.* (1995) observed 24 per cent reduction in feed cost in the integrated fish-duck-azolla farming system.

Ardakani *et al.* (1996) investigated the effect of inclusion of Azolla in broiler diets and studied the economics and showed that the cost of live weight gain production in the treatments containing 6 and 8 per cent fresh Azolla were lower than control group.

Parthasarathy *et al.* (2001b) studied the economics of utilizing Azolla in broiler ration at different levels of 0, 5, 10, 15 and 20 per cent by replacing a protein mix. The result of this study indicated that the feed cost per kg was decreased from Rs. 5.62 to 4.80 as levels of Azolla was increased from 0 to 20 per cent. The return over feed cost was found to be better at 5 per cent Azolla fed group.

Basak *et al.* (2002) observed that the cost per broiler was higher in control group than the Azolla fed group. While the profit per broiler was higher in 5 per cent Azolla group which was comparable to control group, while the profit per broiler is significantly lower in10 and 15 per cent Azolla groups.

Results

4. RESULTS

The results of experiment carried out to study the effect of dietary inclusion of dried Azolla on performance of Japanese quail is presented in this chapter.

4.1 NUTRITIVE VALUE OF AZOLLA

The proximate analysis of dried Azolla (Table 3) showed that it contained 88.80 per cent dry matter, 25.46 per cent crude protein, 2.66 per cent ether extract, 14.80 per cent crude fiber, 41.58 per cent nitrogen free extract and 15.5 per cent total ash. The dried Azolla contained 2.25 per cent calcium and 0.40 per cent total phosphorus. The calculated value of metabolisable energy value of dried Azolla was 1807 kcal/ kg.

4.2 BODY WEIGHT

The week wise mean body weight of quails is presented in Table 4 and is represented graphically in Fig.1. The day-old mean body weight of quail chicks in the groups T1, T2, T3 and T4 were 7.53, 7.59, 7.41 and 7.50 g respectively with an overall mean of 7.53 g. The statistical analysis of data revealed that the day old body weight was comparable among dietary groups.

At the end of first week, the mean body weight in groups T1, T2, T3 and T4 fed 0, 2.5, 5.0 and 7.5 per cent Azolla were 26.30, 24.52, 24.53 and 23.32 g respectively with an overall mean of 24.67 g. The quails fed control diet showed significantly higher mean body weight than Azolla fed groups ($P \leq 0.05$). However, in

Table 3.Chemical composition of dried Azolla, per cent (on dry matter basis)

Sl. no.	Components	Composition (%)
1	Dry matter	88.80
2	Crude protein	25.46
3	Ether extract	2.66
4	Crude fibre	14.80
5	NFE	41.58
6	Total ash	15.50
7	Calcium	2.25
8	Phosphorus	0.40
9	ME (kcal / kg)*	1807

* Calculated value

Table 4. Weekly mean body weight (g) of Japanese quails from day old to six weeks of age as influenced by dried Azolla in quail rations.

Age in weeks	Azolla levels (%) in experimental diets				Overall mean
	T_1 (0 %)	T_2 (2.5 %)	T_3 (5.0 %)	T_4 (7.5 %)	
Day old	7.53 ± 0.04	7.59 ± 0.06	7.41 ± 0.06	7.50 ± 0.06	7.53 ± 0.03
I	26.30^{a} ± 0.54	24.52^{b} ± 0.47	24.53^{b} ± 0.57	23.32^{b} ± 0.57	24.67 ± 0.28
II	63.46^{a} ± 1.08	59.49^{b} ± 0.96	58.88^{b} ± 0.99	56.02^{c} ± 1.00	59.46 ± 0.54
III	98.99^{a} ± 1.47	89.94^{b} ± 1.34	88.68^{b} ± 1.39	86.50^{b} ± 1.52	91.03 ± 0.79
IV	138.96^{a} ± 1.82	137.09^{ab} ± 1.66	135.25^{ab} ± 1.77	133.50^{b} ± 1.56	136.19 ± 0.86
V	162.40^{a} ± 2.26	159.47^{ab} ± 1.83	155.61^{bc} ± 1.82	151.73^{c} ± 1.57	157.28 ± 0.98
VI	177.16^{a} ± 3.17	175.42^{ab} ± 2.66	169.81^{bc} ± 2.27	164.07^{c} ± 1.76	171.61 ± 1.30

Mean values bearing the different superscript within a row differ significantly ($P \leq 0.05$)

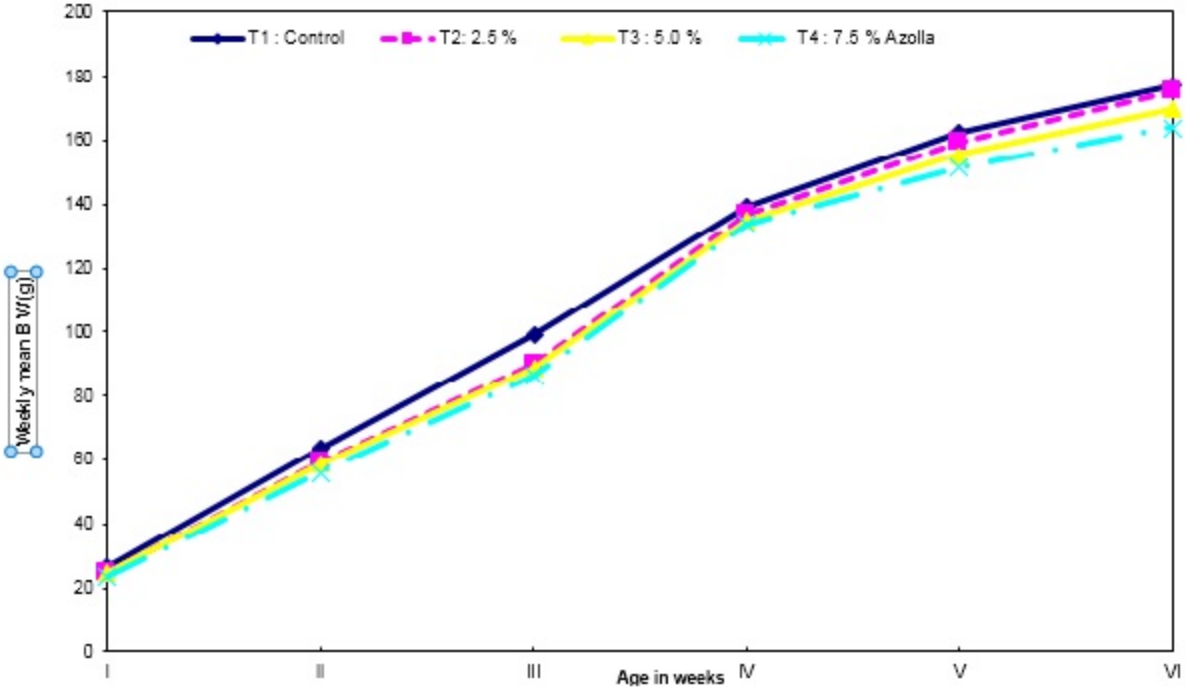

Fig.1 Weekly mean body weight (g) of quails from1 to 6weeks of age as influenced by inclusion of dried Azolla in quail diets

Azolla fed groups, there was no significant difference in body weight among dietary groups T2, T3 and T4.

At the end of second week, the mean body weights were 63.46, 59.49 58.88 and 56.02 g for treatment groups T1, T2, T3 and T4 respectively with an over all mean of 59.46 g, showing significantly lower body weight in all dietary groups fed Azolla in comparison with that of control group ($P \leq 0.05$). In Azolla fed groups, there was significantly lower body weight in quails fed 7.5 per cent Azolla (T4) in comparison with the groups (T2 and T3) fed 2.5 and 5.0 per cent Azolla ($P \leq 0.05$).

At third week of age, the mean body weights were 98.99, 89.94, 88.68, and 86.50 g for dietary groups T1, T2, T3 and T4 respectively with an over all mean of 91.03 g. The data recorded at third week revealed significantly lower body weight in all dietary groups fed Azolla in comparison with the control group T1($P \leq 0.05$).

The mean body weight recorded at the end of fourth week of age in treatment groups T1, T2, T3 and T4 were 138.96, 137.09, 135.25 and133.50 g respectively with an overall mean of 136.19 g. The statistical analysis revealed significantly lower body weight with quails fed diet (T4) containig 7.5 per cent Azolla in comparison with the control group ($P \leq 0.05$). The mean body weight of quails fed 2.5 and 5.0 per cent Azolla was intermediary and was statistically comparable with that of control group so also with the group fed 7.5 per cent Azolla (T4).

At the end of fifth week, the mean body weight recorded were 162.40, 159.47, 155.61 and 151.73 g for groups T1, T2, T3 and T4 respectively with an over all mean of 157.28 g. The mean body weight of quails fed 5.0 and 7.5 per cent Azolla was significantly lower than that of control group ($P \leq 0.05$). The highest body weight observed in the control group was statistically comparable with quails fed 2.5 per cent Azolla. The lowest mean body weight was observed with T4 at the end of fifth week,

while the low body weights recorded in groups T3 and T4 were statistically comparable.

The mean body weight at sixth week of age in groups T1, T2, T3 and T4 were 177.16, 175.42, 169.81 and 164.07 g respectively with an overall mean of 171.61 g. The statistical analysis of data on mean body weight at sixth week of age showed the same trend of results observed in the fifth week. The mean body weight of quails fed 5.0 and 7.5 percent Azolla was significantly lower than that of control group ($P \leq 0.05$). The highest mean body weight observed with the control group (177.16 g) was statistically comparable with quails fed 2.5 per cent Azolla (T2). The mean body weight observed with group T4 was the lowest but it was statistically comparable with group T3.

4.3 BODY WEIGHT GAIN

The mean weekly body weight gain of quails as influenced by dietary inclusion of dried Azolla is given in Table 5 and is represented graphically in Fig. 2. The mean body weight gain at the end of first week of age for groups T1, T2, T3 and T4 were 18.78, 17.03, 16.98 and 15.83 g with an overall mean of 17.15 g. Statistical analysis of data on mean body weight gain at the end of first of week of age showed significant difference among the groups ($P \leq 0.05$). Significant reduction in mean body weight gain was observed only in group T4 compared to control group. The body weight gain in groups T1, T2 and T3 were statistically comparable.

The mean body weight gain at the end of second week of age for groups T1, T2, T3 and T4 were 37.18, 34.95, 34.38 and 32.73 g respectively with an overall mean of 34.81 g. Statistical analysis of data on mean body weight gain at the end of second week showed the same trend observed in the first week.

Table 5. Weekly mean body weight gain (g) from day old to six weeks of age in Japanese Quails fed dried Azolla.

Age in weeks	Azolla levels (%) in Experimental Diets				Overall mean
	T_1 (0 %)	T_2 (2.5 %)	T_3 (5.0 %)	T_4 (7.5 %)	
I	18.78^{a} ± 1.06	17.03^{ab} ± 0.64	16.98^{ab} ± 0.73	15.83^{b} ± 1.01	17.15 ± 0.48
II	37.18^{a} ± 0.41	34.95^{ab} ± 1.37	34.38^{ab} ± 1.16	32.73^{b} ± 0.88	34.81 ± 0.61
III	35.53^{a} ± 0.67	30.43^{b} ± 0.75	29.83^{b} ± 0.77	30.50^{b} ± 0.83	31.57 ± 0.68
IV	39.90^{b} ± 0.61	47.15^{a} ± 2.22	46.58^{a} ± 1.58	46.98^{a} ± 1.14	45.16 ± 1.03
V	23.50 ± 3.19	22.40 ± 1.01	20.40 ± 0.36	18.25 ± 0.71	21.14 ± 0.93
VI	14.75 ± 1.58	15.88 ± 3.00	14.23 ± 2.57	12.28 ± 0.66	14.28 ± 1.02
Cumulative (5^{th} wk)	154.87^{a} ± 2.22	151.88^{a} ± 3.39	148.20^{ab} ± 1.70	144.23^{b} ± 1.95	149.79 ± 1.49
Cumulative (6^{th} wk)	169.63^{a} ± 0.97	167.84^{a} ± 3.10	162.40^{ab} ± 2.05	156.57^{b} ± 2.57	164.11 ± 1.68

Mean values bearing the different superscript within a row differ significantly ($P \leq 0.05$)

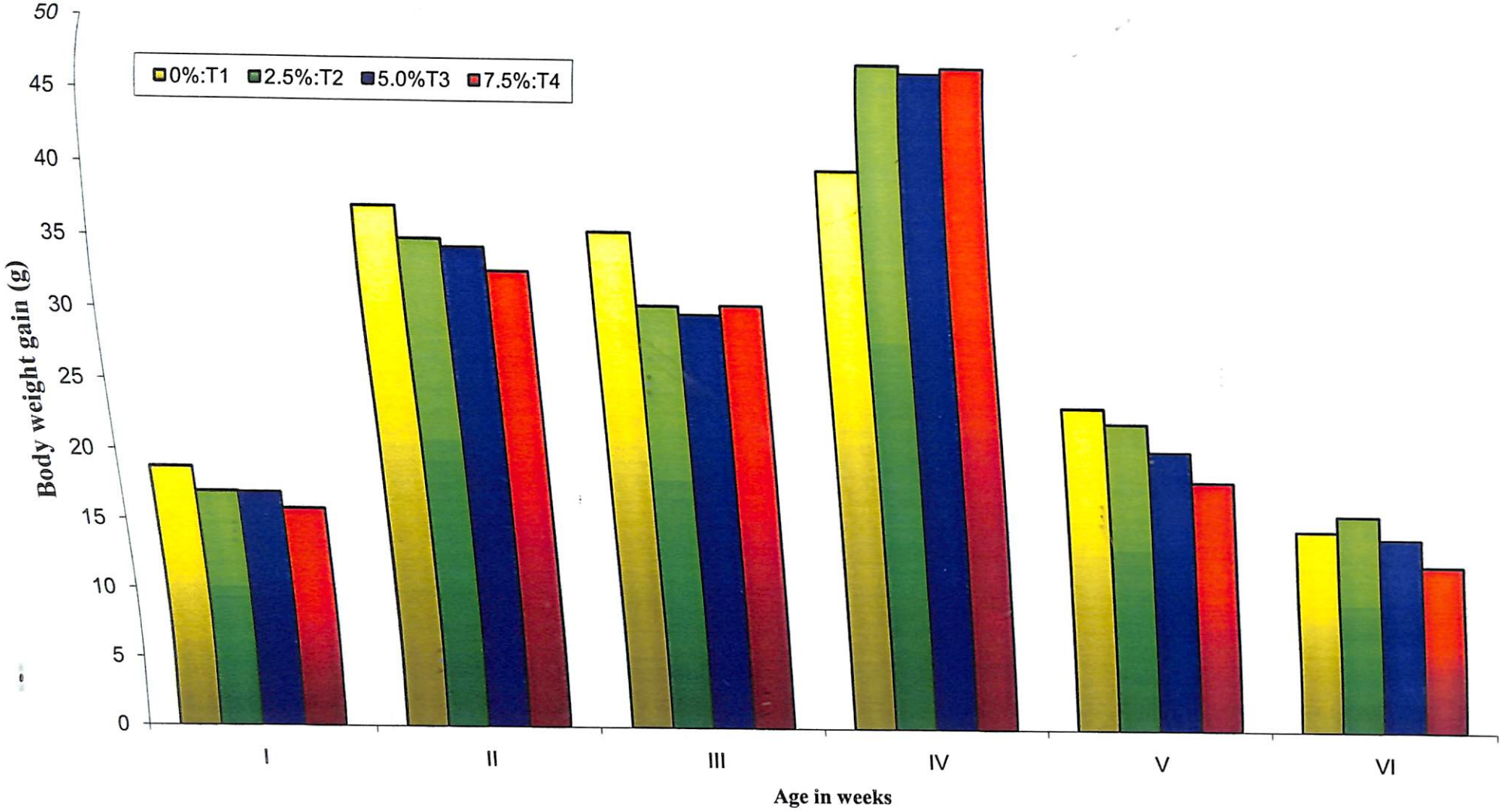

Fig.2 Mean weekly weigt gain (g) of Japanese quails as influenced by dietary inclusion of dried Azolla from 1 to 6 weeks of age

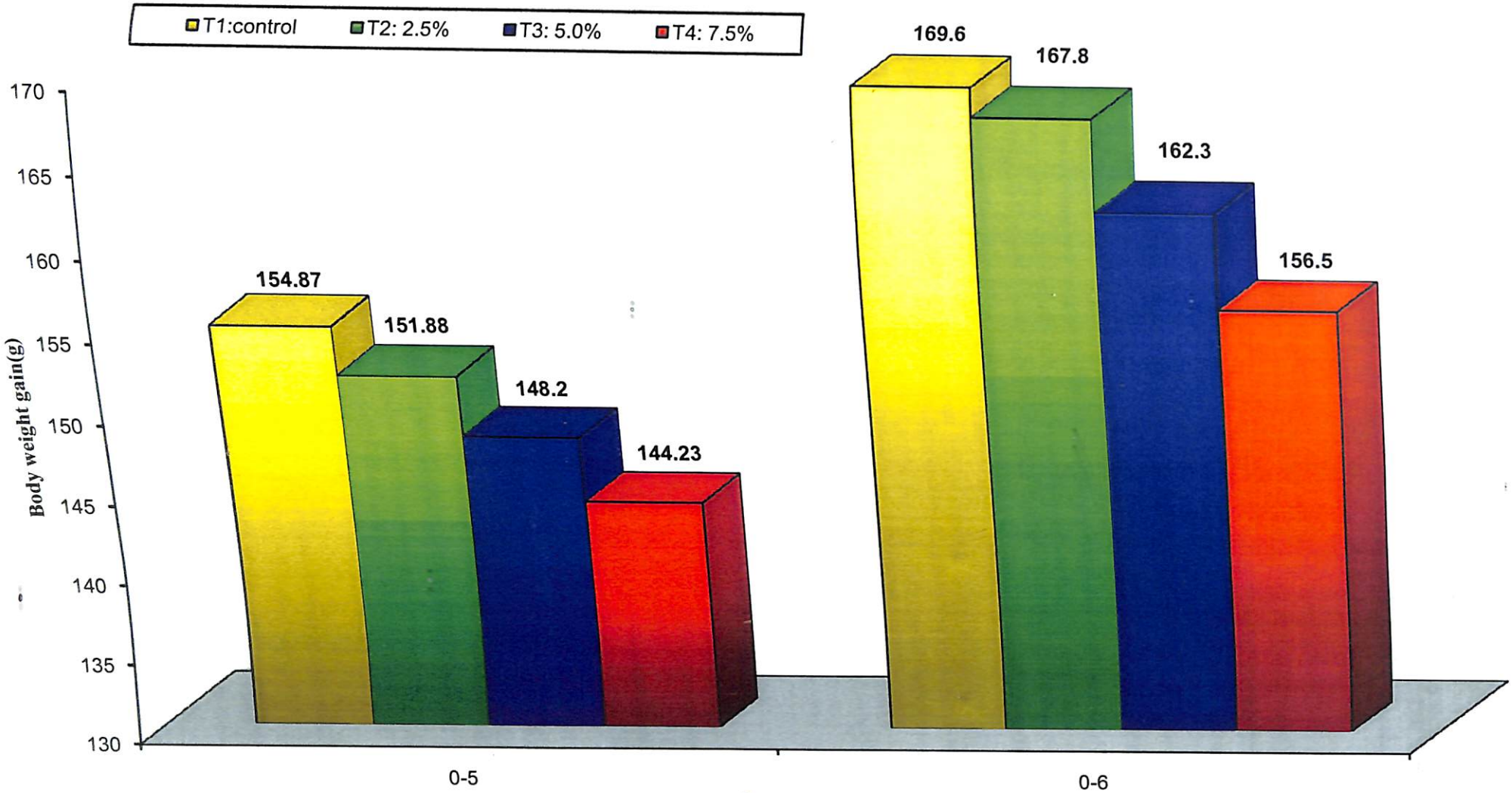

Fig.3 Mean cumulative body weight gain (g) during 0- 5 and 0- 6 weeks of age as influenced by dietary inclusion of dried Azolla in japanese quail

The mean body weight gain at the end of third week of age for groups T1, T2, T3 and T4 were 35.53, 30.43, 29.83 and 30.50 g respectively with an over all mean of 31.57 g, showed significant depression in all Azolla fed groups. The highest mean body weight gain observed in control group (35.53g) and the lowest in group T4.While all groups fed Azolla were statistically comparable among each other.

The analysis of data on mean body weight gain at the end of fourth week of age showed significant depression in control than all other Azolla fed groups ($P \leq 0.05$). The highest mean body weight gain observed with T4 group was statistically comparable with T2 and T3 groups.

The mean body weight gain at the end of fifth week of age for the quails in different dietary levels of Azolla for groups T1, T2, T3 and T4 were 23.50, 22.40, 20.40 and 18.25 g respectively with an over all mean of 21.14 g. The mean body weight gain at the end of sixth week of age for groups T1, T2, T3 and T4 were 14.75, 15.88, 14.23 and 12.28 g respectively with an over all mean of 14.28 g. There was no significant difference between dietary groups T1, T2, T3 and T4 at five and six weeks of age.

The cumulative body weight gain of quails as influenced by dietary inclusion of dried Azolla for 0 to 5 and 0 to 6 week are represented graphically in Fig.3. The mean values at fifth week of age was 154.87, 151.88, 148.20 and 144.23 g and that at the sixth week was 169.63 167.84, 162.40 and 156.57 g in groups T1, T2, and T3 and T4 respectively. At both these ages, it was significantly lower with quails fed 7.5 per cent Azolla than that of control group

4.4 MEAN DAILY FEED CONSUMPTION

The mean daily feed intake in Japanese quail fed dried Azolla, is presented in Table 6 and is represented graphically in Fig. 4. The data on feed intake in first and

Table 6. Mean daily feed consumption (g) of Japanese Quails from day old to six weeks of age as influenced by dried Azolla in quail rations.

Age in weeks	Azolla levels (%) in Experimental Diets				Overall mean
	T_1 (0 %)	T_2 (2.5 %)	T_3 (5.0 %)	T_4 (7.5 %)	
I	5.70 ± 0.32	5.51 ± 0.14	5.65 ± 0.16	5.30 ± 0.15	5.54 ± 0.10
II	12.37 ± 0.38	12.11 ± 0.36	11.86 ± 0.13	11.73 ± 0.09	12.02 ± 0.14
III	13.64^{a} ± 0.27	12.29^{b} ± 0.20	12.27^{b} ± 0.22	11.94^{b} ± 0.12	12.53 ± 0.19
IV	21.01^{b} ± 0.59	24.60^{a} ± 0.30	24.16^{a} ± 0.43	24.78^{a} ± 0.34	23.64 ± 0.44
V	26.12^{a} ± 0 41	24.41^{b} ± 0.32	25.98^{a} ± 0.14	26.28^{a} ± 0.58	25.70 ± 0.26
VI	27.63 ± 0.48	27.16 ± 0.33	26.25 ± 0.42	27.25 ± 0.52	27.07 ± 0.24
Cumulative (5^{th} wk)	551.81 ± 6.5	552.44 ± 3.39	559.44 ± 5.06	560.21 ± 3.83	555.97 ± 2.37
Cumulative (6^{th} wk)	745.33 ± 7.37	742.55 ± 2.64	743.13 ± 2.74	750.87 ± 5.53	745.47 ± 2.39

Mean values bearing the different superscript within a row differ significantly ($P \leq 0.05$)

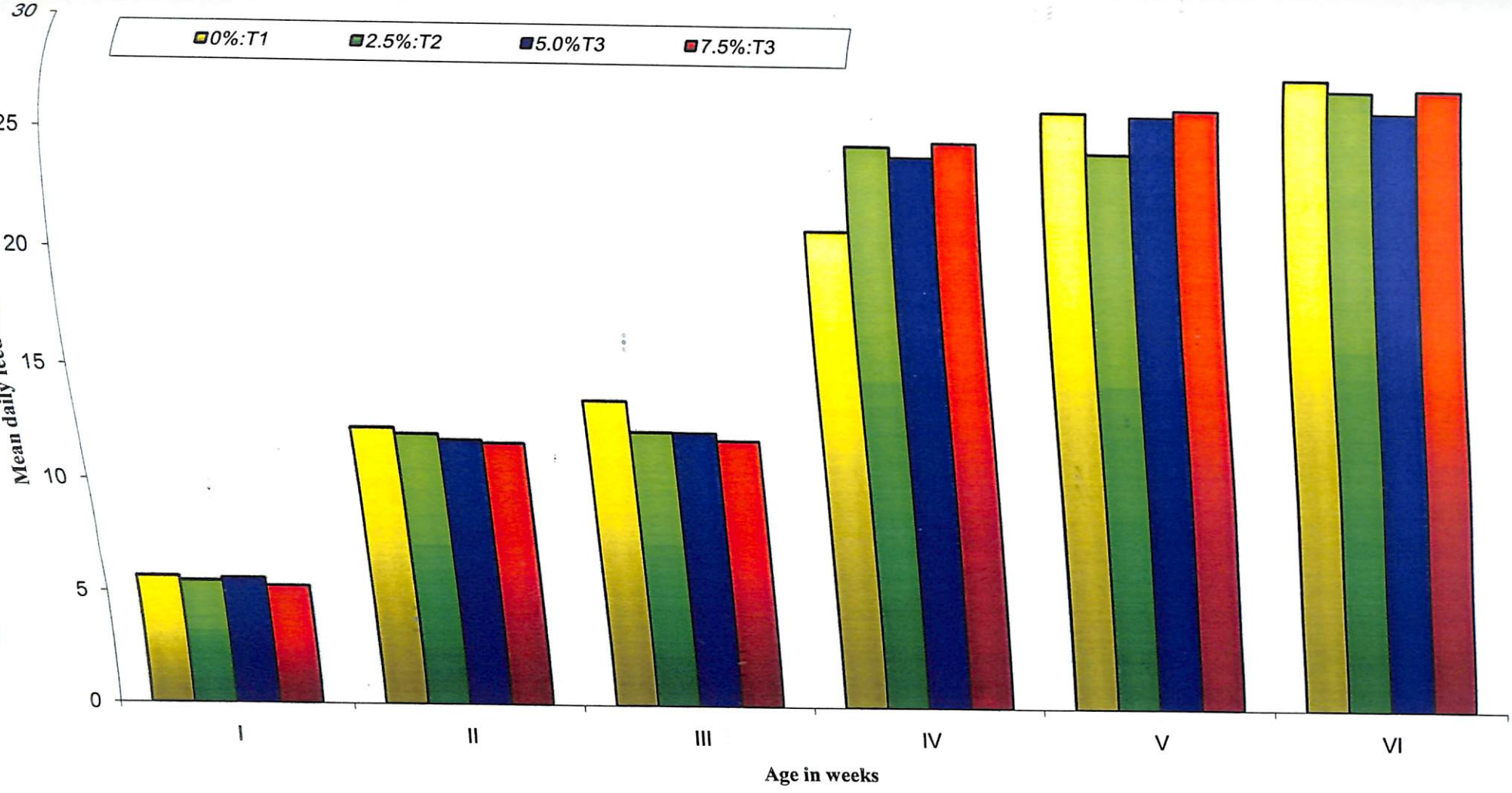

Fig. 4 Week wise daily feed intake (g) of Japanese quail as influenced by dietary inclusion of dried Azolla from 1 to 6 weeks of age

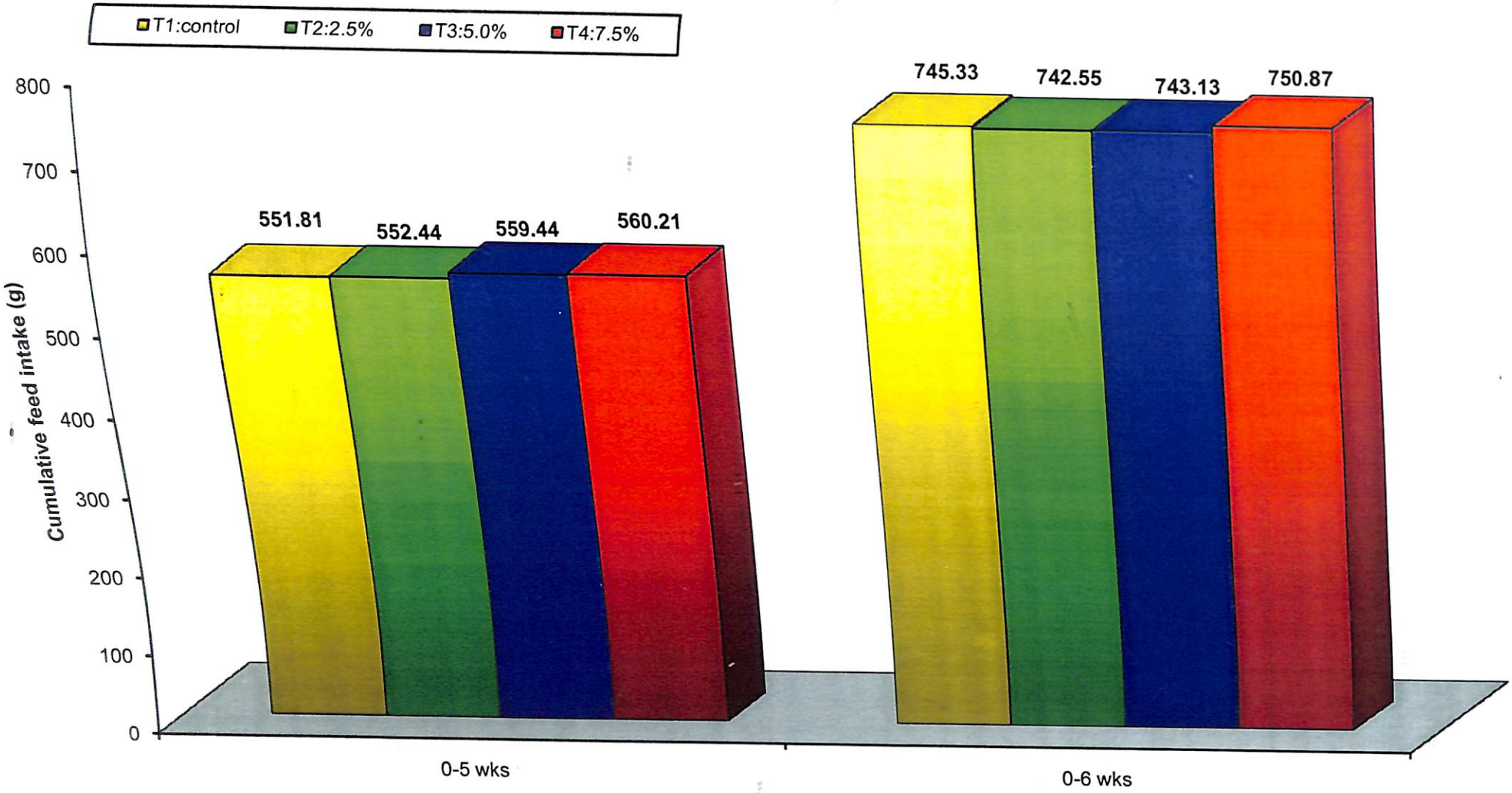

Fig.5 Mean cumulative feed intake during 0- 5 and 0-6 weeks in Japanese quail as influenced by dietary inclusion of dried Azolla

second week of age did not reveal significant difference between the dietary groups. The mean value recorded in first week for the dietary groups T1, T2, T3 and T4 were 5.70, 5.51, 5.65, and 5.30 g respectively with an over all mean of 5.54 g. During second week of age the mean feed intake values were12.37, 12.11, 11.86 and 11.73g in dietary groups T1, T2, T3 and T4 respectively with an over all mean of 12.02 g.

At third week of age, the feed intake was decreased significantly with all levels of Azolla in comparison with control diet ($P \leq 0.05$). The highest feed intake was observed with control group (13.64 g). The lowest feed intake was observed in T4 group, while T2, T3 and T4 were statistically comparable. The mean values were 13.64, 12.29, and 12.27, 11.94 g among groups T1, T2, and T3 and T4 with an over all mean of 12.53 g.

On the contrary, at fourth week of age, the feed intake was significantly higher with all levels of Azolla in comparison with the control diet ($P \leq 0.05$). The mean values were 21.01, 24.60, 24.16 and 24.78 g among T1, T2, and T3 and T4 with an over all mean of 23.64 g. The feed intake among the Azolla fed groups T2, T3 and T4 were statistically comparable each other.

At fifth week of age, the mean feed intake were 26.12, 24.41, 25.98 and 26.28 g in dietary groups T1, T2, and T3 and T4 respectively with an over all mean of 25.70 g, showing significantly low feed intake in the group fed 2.5 percent Azolla in comparison with all other diets ($P \leq 0.05$).

At sixth week of age, feed intake in all dietary groups was statistically comparable among each other. The mean values were 27.63, 27.16, 26.25 and 27.25 g respectively with an overall mean of 27.70 g. The cumulative feed intake of quails as influenced by dietary inclusion of dried Azolla for 0 to 5 and 0 to 6 week are represented graphically in Fig.5. The mean values for 0 to5 weeks was 551.81,

552.44, 559.44 and 560.21 g The mean values recorded t for 0 to 6 weeks was 745.33, 742.55, 743.13 and 750.87 g in groups T1, T2, T3 and T4 respectively, was statistically comparable among each other.

4.5 FEED CONVERSION RATIO

The data on weekly mean feed conversion ratio of quails as influenced by dietary inclusion of dried Azolla is given in Table 7 and is represented graphically in Fig. 6. The data on feed conversion ratio revealed significant difference among dietary groups only at fifth week of age ($P \leq 0.05$).

The overall feed efficiency without considering treatment effect were 2.28, 2.43, 2.79, 3.67, 8.75 and 14.28 at first, second, third, fourth, fifth and sixth weeks respectively. The feed efficiency at first, second, third and fourth weeks were statistically comparable in all four groups. The mean value recorded for dietary groups T1, T2, T3 and T4 for first week of age were 2.15, 2.27, 2.34 and 2.37 respectively with an over all mean of 2.28. During second week of age the FCR values were 2.33, 2.43, 2.43 and 2.51 among dietary groups T1, T2, T3 and T4 respectively with an over all mean of 2.43.

The mean feed conversion ratio in quail chicks among dietary groups T1, T2, T3 and T4 at the end of third week of age were 2.70, 2.83, 2.89 and 2.75 respectively with an overall mean of 2.79.The mean values for fourth week of age were 3.69, 3.67, 3.64 and 3.70 among dietary groups, T1, T2, T3 and T4 with an over all mean of 3.67.

The mean feed efficiency at fifth week of age were 8.24, 7.69, 8.94 and 10.12 in groups T1, T2, T3 and T4 respectively showing significantly ($P \leq 0.05$) lower value

Table 7. Mean feed efficiency of Japanese Quails from day old to six weeks of age as influenced by dried Azolla in quail rations

Age in weeks	Azolla levels (%) in Experimental Diets				Overall mean
	T_1 (0 %)	T_2 (2.5 %)	T_3 (5.0 %)	T_4 (7.5 %)	
I	2.15 ± 0.17	2.27 ± 0.06	2.34 ± 0.10	2.37 ± 0.12	2.28 ± 0.06
II	2.33 ± 0.08	2.43 ± 0.11	2.43 ± 0.07	2.51 ± 0.05	2.43 ± 0.04
III	2.70 ± 0.08	2.83 ± 0.06	2.89 ± 0.06	2.75 ± 0.07	2.79 ± 0.04
IV	3.69 ± 0.08	3.67 ± 0.14	3.64 ± 0.08	3.70 ± 0.13	3.67 ± 0.05
V	8.24^{ab} ± 1.16	7.69^{b} ± 0.39	8.94^{ab} ± 0.11	10.12a ± 0.30	8.75 ± 0.37
VI	13.67 ± 1.80	13.78 ± 3.33	13.96 ± 1.93	15.70 ± 0.89	14.28 ± 0.99
Cumulative (5^{th} wk)	3.56^{b} ± 0.07	3.63^{b} ± 0.09	3.77^{b} ± 0.02	3.88^{a} ± 0.04	3.71 ± 0.04
Cumulative (6^{th} wk)	4.40^{b} ± 0.05	4.43^{b} ± 0.07	4.58^{b} ± 0.05	4.80^{a} ± 0.07	4.55 ± 0.05

Mean values bearing the different superscript within a row differ significantly ($P \leq 0.05$

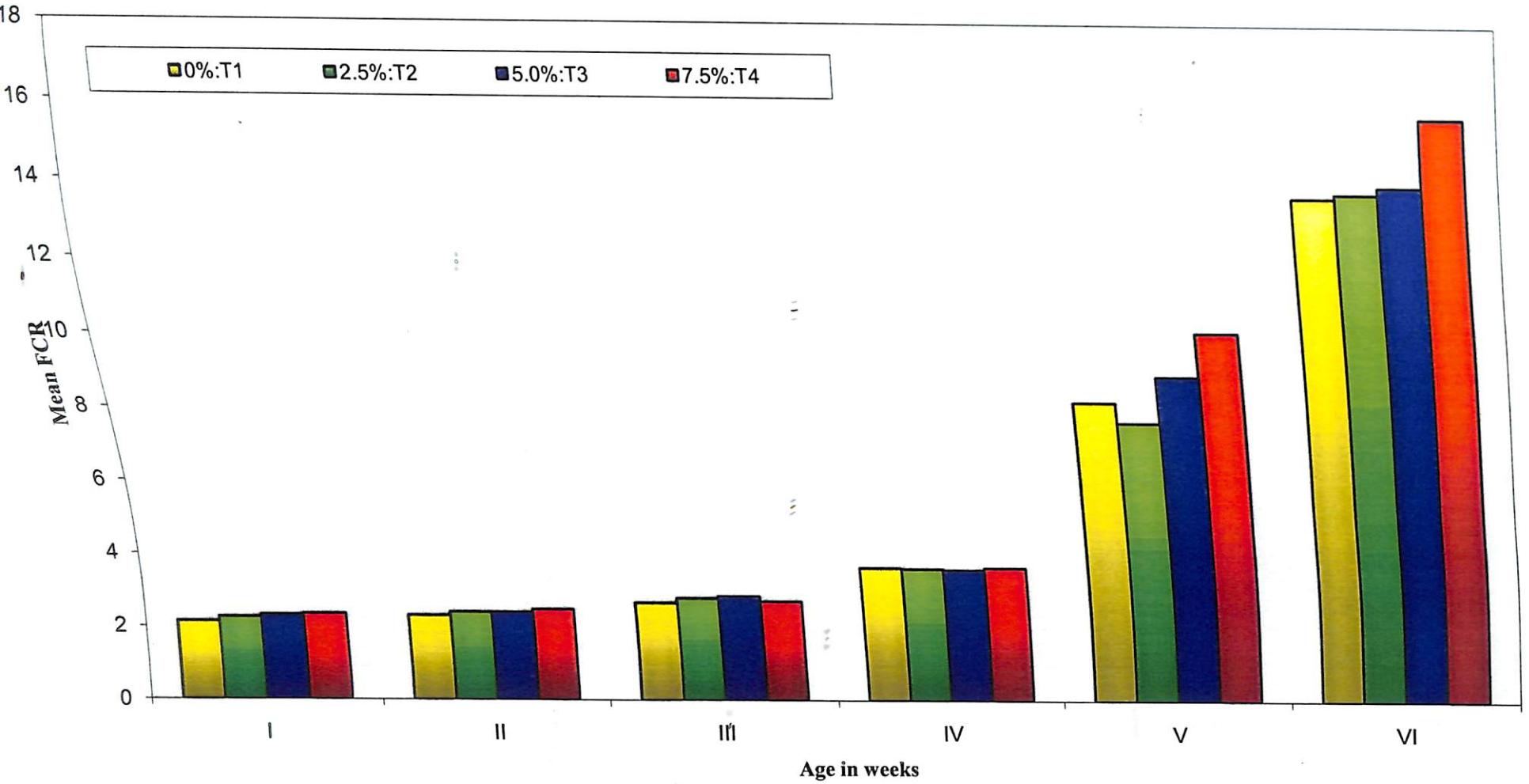

Fig. 6 Weekly FCR from 1 to 6 weeks of age in Japanese quail as influenced by inclusion of dried Azolla in quail diets

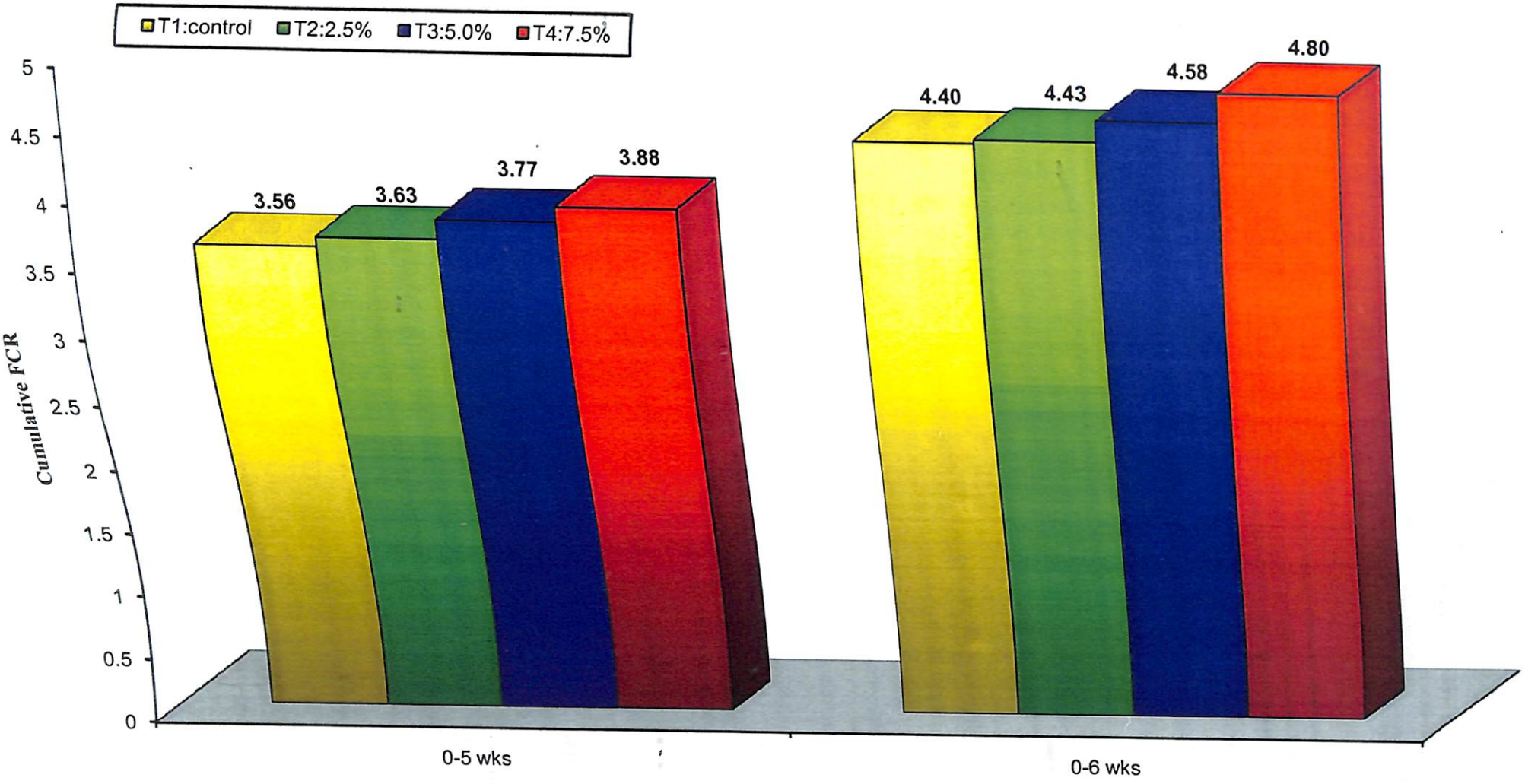

Fig.7 Mean cumulative FCR at 0- 5 and during 0- 6 weeks as influenced by dietary inclusion of dried Azolla in Japanese quail

in the group T2 fed 2.5 percent Azolla than that observed in T4 group and the groups T1, T3 and T4 were statistically comparable.

The mean feed conversion ratio in quail among dietary groups viz, T1, T2, T3 and T4 at the end of sixth week of age were 13.67, 13.78, 13.96 and 15.70 with an overall mean of 14.28 without significant difference among dietary groups.

The cumulative FCR of quails as influenced by dietary inclusion of dried Azolla for 0 to 5 and 0 to 6 week are represented graphically in Fig.7. The mean values for 0-5 weeks were 3.56, 3.63, 3.77 and 3.88 ,but a higher values of 4.40, 4.43, 4.58 and 4.80 was recorded for 0-6 weeks of age in groups T1, T2, T3 and T4 respectively. The mean value observed with quails fed 7.5 per cent Azolla was significantly higher than that in other groups ($P \leq 0.05$).

4.5 PROCESSING YIELD AND LOSSES

The mean processing yield and losses recorded in quails slaughtered at six weeks of age, fed diet with different levels of Azolla is presented in Table 8.

The dressed yield in various dietary groups was 92.86, 91.73, 92.55 and 92.16 per cent respectively with an overall mean of 92.32 per cent. The statistical analysis of data did not reveal significant difference among dietary groups. The per cent eviscerated yield and ready to cook yield of quails at sixth week of age as influenced by dietary inclusion of dried Azolla is represented graphically in Fig.8.The eviscerated yield obtained in dietary groups T1, T2, T3 and T4 were 67.2, 70.5, 72.3 and 70.2 per cent showing significantly higher yield with the group fed 5.0 per cent Azolla than the control group ($P \leq 0.05$).

Table 8. Processing yields and losses in Japanese quail at six weeks of age as influenced by dried Azolla in quail rations

Sl. No	Parameter (%)	Azolla levels (%) in Experimental Diets				Overall mean
		T_1 (0 %)	T_2 (2.5 %)	T_3 (5.0 %)	T_4 (7.5 %)	
1.	Dressed yield	92.86 ± 0.44	91.73 ± 0.36	92.55 ± 0.50	92.16 ± 0.41	92.32 ± 0.22
2.	Eviscerated yield	67.2^{b} ± 1.4	70.5^{ab} ± 4.7	72.3^{a} ± 1.8	70.2^{ab} ± 4.8	70.12 ± 4.26
3.	R-to-C yield	71.14^{b} ± 1.44	75.45^{ab} ± 1.66	76.78^{a} ± 0.72	74.53^{ab} ± 1.76	74.47 ± 0.79
4.	Giblets	4.08^{b} ± 0.15	4.81^{a} ± 0.26	4.40^{ab} ± 0.19	4.23^{ab} ± 0.19	4.38 ± 0.11
5.	Liver	1.76 ± 0.13	2.13 ± 0.21	1.65 ± 0.16	1.74 ± 0.20	1.82 ± 0.09
6.	Heart	0.74 ± 0.07	0.86 ± 0.06	0.85 ± 0.05	0.83 ± 0.07	0.82 ± 0.03
7.	Gizard	1.58^{b} ± 0.06	1.83^{ab} ± 0.08	1.90^{a} ± 0.11	1.69^{ab} ± 0.09	1.75 ± 0.05
8.	Blood loss	3.49 ± 0.34	3.56 ± 0.33	3.50 ± 0.48	3.95 ± 0.18	3.63 ± 0.17
9.	Feathers	3.9 ± 0.44	4.7 ± 0.36	4.1 ± 0.50	4.0 ± 0.40	4.12 ± 0.22

Mean values bearing the different superscript within a row differ significantly ($P \leq 0.05$)

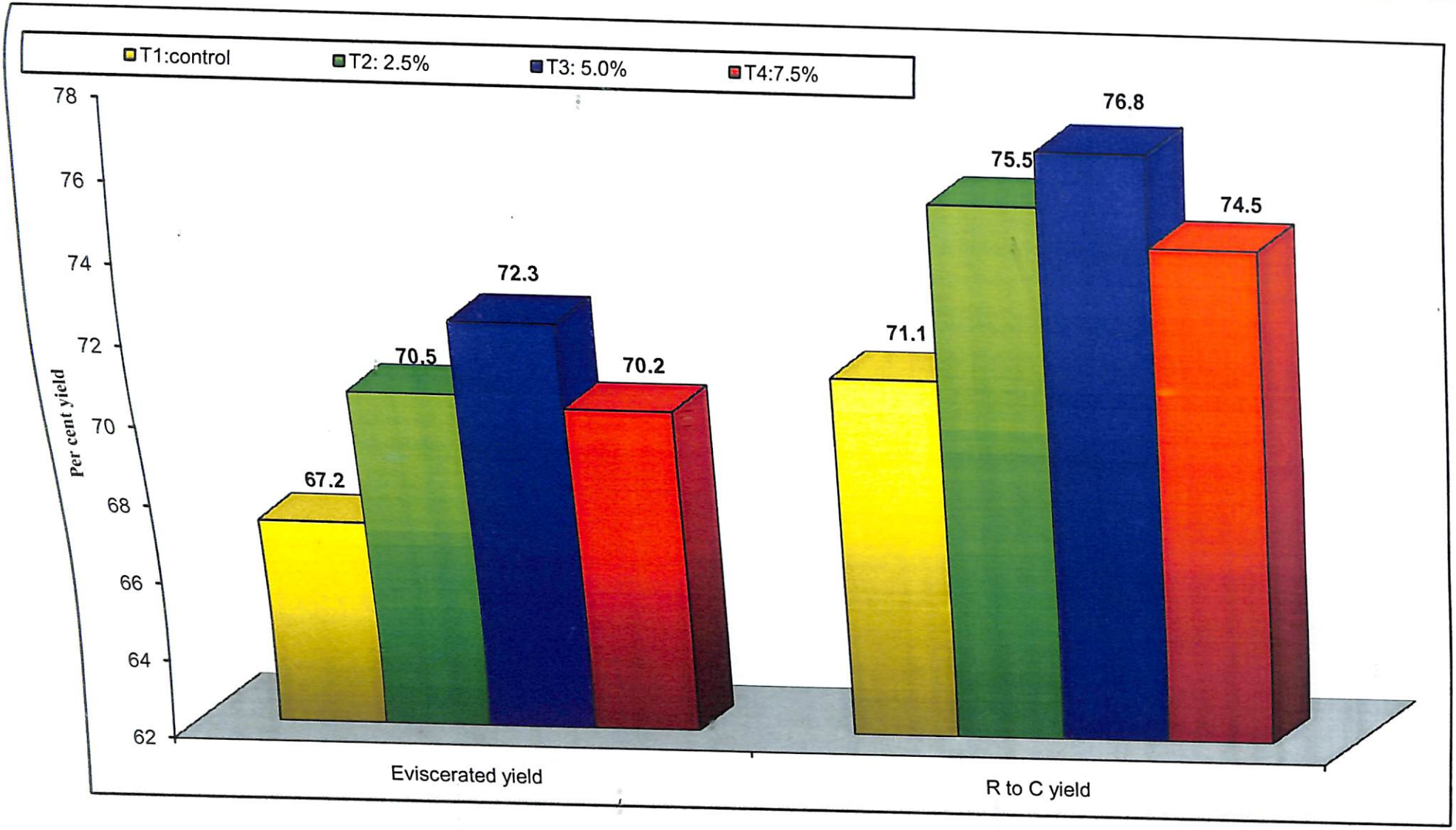

Fig.8 Per cent Eviscerated and R to C yield in Japanese quail at six week of age as in fluenced by dietary inclusion of dried Azolla

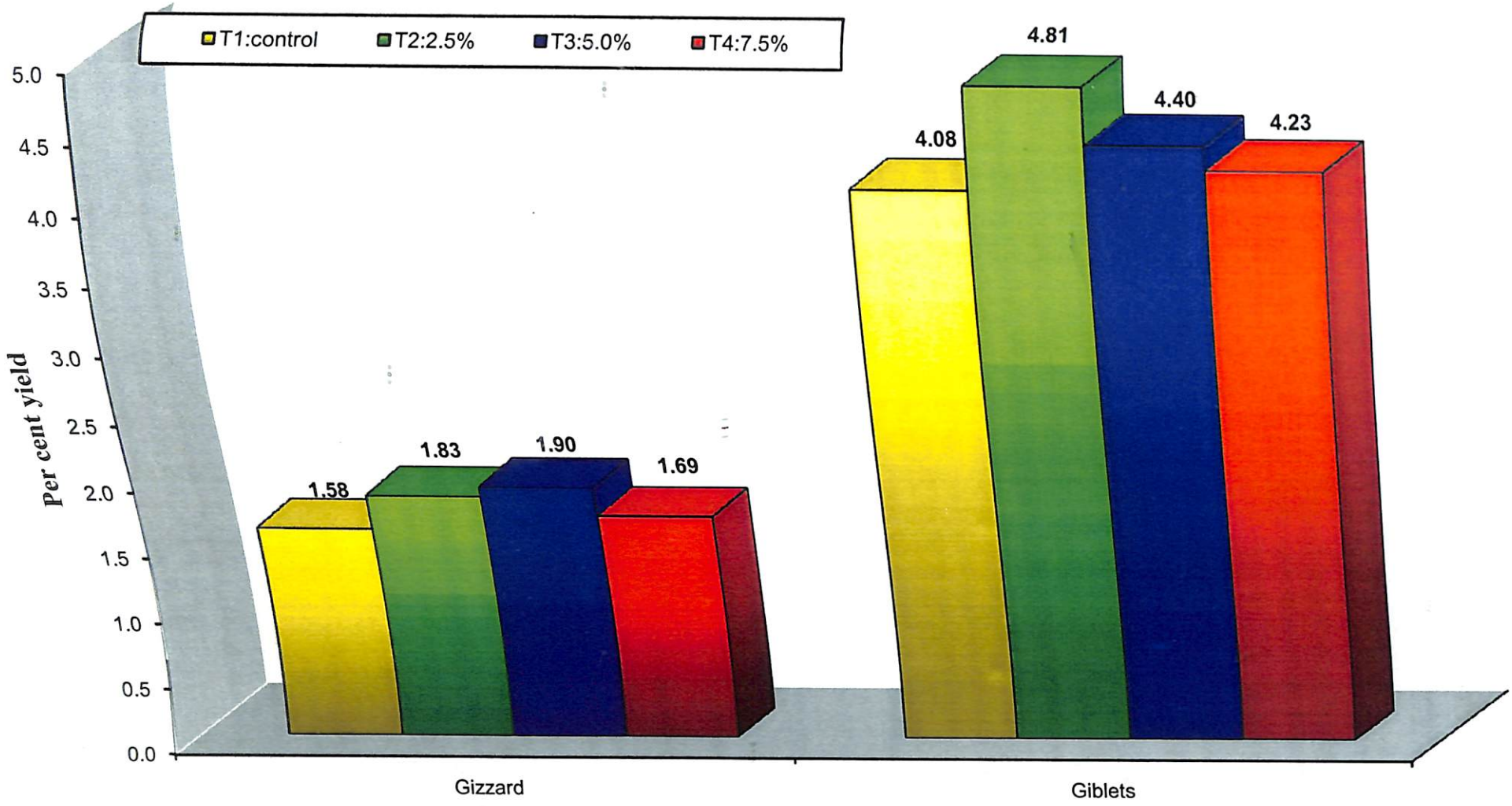

Fig.9 Per cent gizzard and giblets yield in Japanese quail at six weeks of age as influenced by dietary inclusion of dried Azolla

The Ready to cook yield (R to C yield) in dietary groups T1, T2, T3 and T4 were 71.14, 75.45, 76.78 and 74.53 per cent respectively with an overall mean of 74.47 per cent. The R-to-C yield per cent was significantly higher with the group fed diet containing 5.0 percent Azolla than control diet ($P \leq 0.05$). The dietary groups T2, T3 and T4 were in a homogenous group and T1, T2 and T4 formed another homogenous group.

The per cent giblets and gizzard yield at sixth week of age as influenced by dietary inclusion of dried Azolla is represented graphically in Fig.9.The giblet yield recorded for the dietary groups T1, T2, T3 and T4 were 4.08, 4.81, 4.40 and 4.23 per cent respectively with an overall mean of 4.38 per cent with significantly higher value in diet containing 2.5 percent Azolla than control group. The dietary groups T1, T3 and T4 formed homogenous group. The gizzard percent were significantly higher in diet containing 5.0 percent Azolla than control group, while the T1, T2 and T4 formed homogenous group. The mean values of gizzard were 1.58, 1.83, 1.90 and 1.69 per cent in dietary groups T1, T2, T3 and T4 respectively with an over all mean of 1.75 per cent.

The blood loss was comparable among the different dietary groups T1, T2, T3 and T4 and the mean value were 3.49, 3.56, 3.50 and 3.95 per cent respectively with an overall mean of 3.63 per cent.

The feather loss in different dietary groups T1, T2, T3 and T4 were 3.9, 4.7, 4.1and 4.0 per cent respectively with an overall mean of 4.12 per cent. The data did not reveal significant difference between groups.

4.7 SERUM PARAMETERS

The mean serum parameters estimated at the end of sixth week of age is set out in Table 9 and is represented graphically in Fig. 10. The statistical analysis of the data on serum total protein, creatinine and uric acid did not reveal any significant difference between the groups. But the statistical analysis of the mean serum total cholesterol values revealed significant differences among the groups ($P \leq 0.05$).

4.7.1 Serum Total Protein

The mean serum total protein levels at sixth week of age were 3.01, 3.15, 3.06 and 3.00 g per dl respectively with an over all mean of 3.06 g per dl.

4.7.2 Serum Total Cholesterol

The serum total cholesterol levels at the end of sixth week of age for groups T1, T2, T3 and T4 were 187.78, 176.12, 163.88 and 159.50 mg per dl respectively for groups T1, T2, T3 and T4 with an overall mean of 171.84 mg per dl. Significantly higher values were obtained with control group than T4 group. It showed a decreasing trend in groups T2 and T3, and a significant reduction was observed in diet containing 7.5 percent Azolla.

4.7.3 Serum Creatinine and Uric Acid

The mean serum creatinine values were 2.00, 2.13, 2.13 and 2.00 mg / dl in dietary groups T1, T2, T3 and T4 respectively with an over all mean of 2.06 mg / dl. The mean serum uric acid values were 2.00, 2.00, 2.13 and 2.38 mg /dl in dietary groups T1, T2, T3 and T4 respectively with an over all mean of 2.13 mg / dl. Statistical analysis revealed no significant difference.

Table 9. Mean serum profile of Japanese Quails at six weeks of age as influenced by dried Azolla in quail rations.

Sl. No	Serum Parameters	Azolla levels (%) in Experimental Diets				Overall mean
		T_1 (0 %)	T_2 (2.5 %)	T_3 (5.0 %)	T_4 (7.5 %)	
1.	Total protein (g/dl)	3.01 ± 0.17	3.15 ± 0.21	3.06 ± 0.30	3.00 ± 0.16	3.06 ± 0.10
2.	Creatinine (mg/dl)	2.00 ± 0 41	2.13 ± 0.35	2.13 ± 0.35	2.00 ± 0.27	2.06 ± 0.16
3.	Total cholesterol (mg/dl)	187.78^{a} ± 4.33	176.12^{ab} ± 3.73	163.88^{bc} ± 6.35	159.50^{c} ± 4.32	171.84 3.02
4.	Uric acid (mg/dl),	2.00 ± 0.27	2.00 ± 0.27	2.13 ± 0.23	2.38 ± 0.38	2.13 ± 0.14

Mean values bearing the different superscript within a row differ significantly ($P \leq 0.05$)

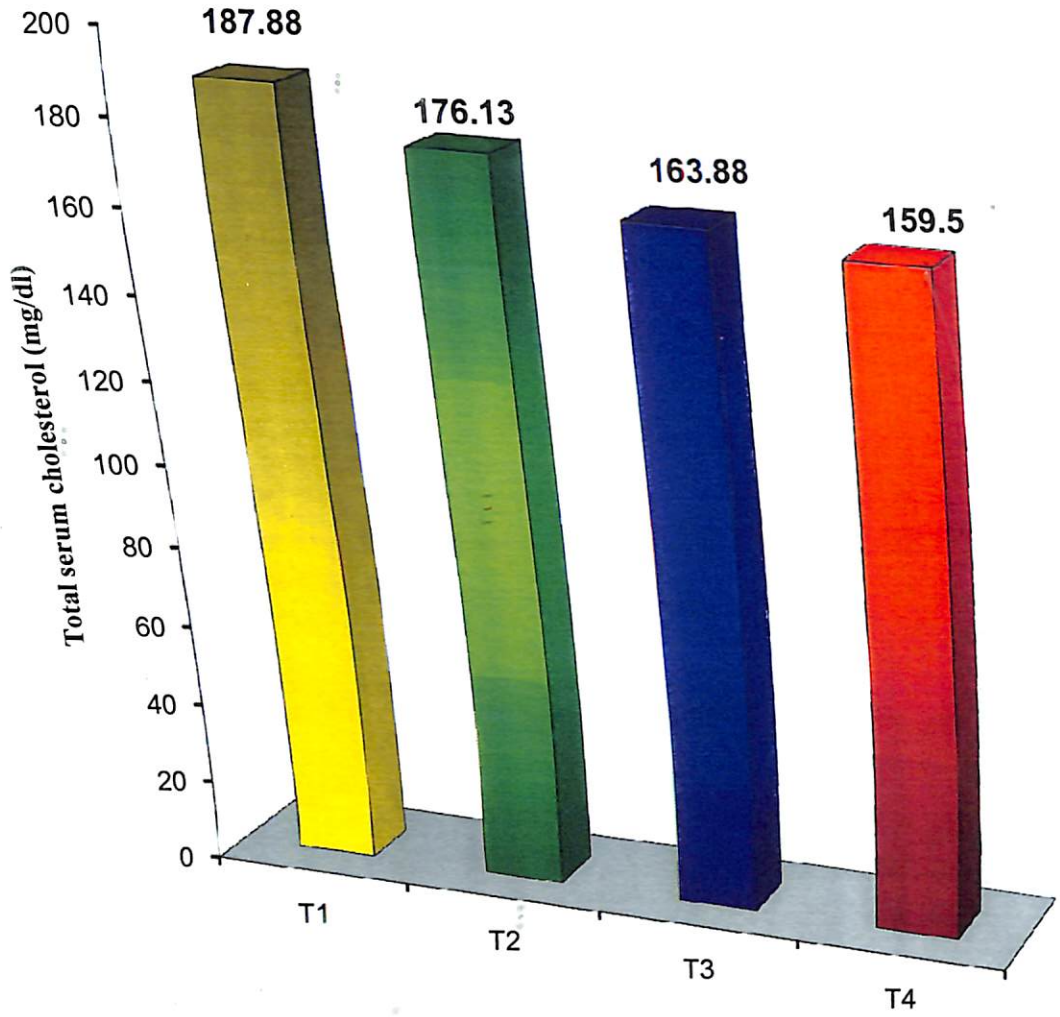

Fig. 10 Mean serum cholesterol (mg/dl) in Japanese quail as influenced by dietary inclusion of dried Azolla

4.8. MEAT CHOLESTEROL

The mean meat total cholesterol estimated at the end of sixth week of age is presented in Table 10.

4.8.1 **Breast Meat Total Cholesterol**

The mean values of total cholesterol in breast meat recorded in dietary groups T1, T2, T3 and T4 were 47.43, 47.79, 46.72 and 47.32 mg per cent respectively with an overall mean of 47.32 mg per cent. Statistical analysis of the data did not reveal any significant difference between the groups.

4.8.2 Thigh Meat Total Cholesterol

The mean thigh meat total cholesterol values for the groups T1, T2, T3 and T4 were 54.23, 55.31, 50.27 and 50.51 mg per cent respectively with an overall mean of 52.58 mg per cent. Statistical analysis of the data did not reveal any significant difference between the groups. The thigh meat cholesterol was numerically lower in 5.0 and 7.5 per cent Azolla fed groups, compared to other groups.

4.10. LIVABILITY

The mean livability percentage and number of quails died from zero to six weeks of age, as influenced by dietary inclusion of Azolla is presented in Table 11. Two quails died during the entire period of experiment. One quail died in the control group at fourth week and one quail died in the group T4 at sixth week of age.

Table 10. Mean breast and thigh meat total cholesterol (mg/dl) kg of Japanese quails at six weeks of age as influenced by dried Azolla in quail rations.

Sl no	Parameters	Azolla levels (%) in Experimental Diets				Overall mean
		T_1 (0 %)	T_2 (2.5 %)	T_3 (5.0 %)	T_4 (7.5 %)	
1.	Thigh cholesterol (mg/dl)	54.23 ± 6.03	55.31 ± 4.85	50.27 ± 4.39	50.51 ± 5.50	52.58 ± 2.52
2.	Breast Cholesterol (mg/dl)	47.43 ± 2.85	47.79 ± 1.76	46.72 ± 4.71	47.32 ± 3.12	47.32 1.57

Table 11. Mean Livability percentage and number of quails died from day old to six weeks of age.

Age in weeks	Azolla levels (%) in Experimental Diets			
	T_1 (0 %)	T_2 (2.5 %)	T_3 (5.0 %)	T_4 (7.5 %)
I	-	-	-	-
II	-	-	-	-
III	-	-	-	-
IV	1	-	-	-
V	-	-	-	-
VI	-	-	-	1
Livability % 0- 6 weeks	97.9	100	100	97.9

4.1.1 ECONOMICS

The cost and returns recorded at different levels of Azolla in quail diets are presented in Table 12. The feed cost per kg diet was Rs.11.11, 11.03, 10.95 and 10.87 for diets T1, T2, T3 and T4 respectively, based on the existing rate of feed ingredients used for the study. The feed cost showed decreasing trend with the increase of Azolla levels in diets.

The mean cumulative feed intake noticed for 0 to 5weeks in dietary groups T1, T2, T3 and T4 was 551.81, 552.44, 559.44 and 560.21 g and the cumulative feed cost per quail for the above period in above dietary groups was Rs.6.13, 6.09, 6.13 and 6.09 respectively, indicating lower feed cost in T2 and T4 than that of control group. The mean body weight of quail at fifth week of age in dietary groups T1, T2, T3 and T4 were 162.63, 159.47, 155.61, 151.73 g and the income by sale of quails were Rs.16.24, 15.95, 15.56 and 15.17 at the rate of Rs.100 per kg live weight. The receipts in the control group were the highest followed by group T2, T3 and T4 in that order .The margin of return over feed cost plus chick cost was worked to Rs.5.11, 4.85, 4.43 and 4.08 in groups T1, T2, T3 and T4 respectively. The statistical analysis of data on margin of return over feed cost revealed that it was significantly lower in group T4 and groups T1, T2 and T3 were comparable each other.

The mean cumulative feed intake noticed for the dietary groups T1, T2, T3 and T4 were 745.33, 742.55, 743.13 and 750.87 g .The cumulative feed cost per quail for the period from 0 to 6 weeks of age, for dietary groups T1, T2, T3 and T4 were Rs. 8.27, 8.19, 8.13 and 8.16 respectively. The feed cost observed was the highest in the control group followed by T2 and T4 and the lowest was recorded with the group T3.The total cost, including feed cost and chick cost at the rate of Rs. 5 per chick is 13.27, 13.19, 13.13 and 13.16 in groups T1, T2, T3 and T4 respectively.

Table 12. Economics as influenced by dried Azolla in quail rations(5th& 6th wk)

Sl. No.	Parameters (%)	Azolla levels (%) in Experimental Diets			
		T_1 (0 %)	T_2 (2.5 %)	T_3 (5.0 %)	T_4 (7.5%)
	Feed cost per kg diet (Rs.)	11.11	11.03	10.95	10.87
At 5th week					
1	Cumulative feed intake per quail (g)	551.81	552.44	559.44	560.21
2	Feed cost per quail (Rs.)	6.13	6.09	6.13	6.09
3	Mean BW at fifth week (g)	162.63	159.47	155.61	151.73
4	Returns by sale of Quails @ Rs.100 per kg BW	16.24	15.95	15.56	15.17
5	Feed cost + chick cost	11.13	11.09	11.13	11.09
6	Margin of return/ feed + chick cost (Rs.)	5.11	4.85	4.43	4.08
At 6th week					
1	Cumulative feed intake (0-6 wk) per quail (g)	745.33	742.55	743.13	750.87
2	Feed cost (0-6 wk) per quail (Rs.)	8.27	8.19	8.13	8.16
3	Mean BW at fifth week (g)	177.16^{a}	175.4^{ab}	169.8^{bc}	164.17^{c}
4	Returns by sale of Quails @ Rs.100 per kg BW	17.72	17.54	16.98	16.41
5	Feed cost + chick cost	13.27	13.19	13.13	13.16
6	Margin of return/ feed + chick cost(Rs.)	4.45	4.35	3.85	3.25

Mean values bearing the different superscript within a row differ significantly ($P \leq 0.05$

The mean body weight of quail at sixth week of age for dietary groups T1, T2, T3 and T4 were 177.16, 175.42, 169.81 and 164.07 g respectively and the income by sale of quails in the corresponding groups were Rs.17.72, 17.54, 16.98 and 16.41 at the rate of Rs.100 per kg live weight. These results indicated that the receipts in the control group were the highest followed by group T2, T3 and T4 in that order and the income was decreased as the level of Azolla was increased in the diets.

The margin of return over feeding cost plus chick cost per quail on live weight basis was Rs.4.45, 4.35, 3.85 and 3.25 in groups T1, T2, T3 and T4 respectively, at sixth week of age. The statistical analysis of data on margin of return over feed cost revealed that it was significantly lower in group T4 and groups T1, T2 and T3 were comparable each other. The margin of return recorded in the control group was higher by Rs.0.10 in comparison with the group (T2) fed 2.5 per cent Azolla.

Discussion

5. DISCUSSION

The results of dietary inclusion of dried Azolla on the performance of Japanese quail are discussed in this chapter.

5.1 NUTRITIVE VALUE OF AZOLLA

Fresh Azolla contained 93.55 per cent moisture and the dry matter content was too low which in turn will increase bulkiness on feeding fresh Azolla and thereby reduces the nutrient density. In the present study, fresh Azolla after sun drying, ground and mixed in the experimental diets at the level of 0, 2.5, 5.0 and 7.5 per cent in diets T1, T2, T3 and T4 respectively.

The proximate composition of dried Azolla (Table 3) revealed that the dry matter content was 88.80 per cent. On dry matter basis, the crude protein content in the dried Azolla was 25.46 per cent. This finding is in close agreement with Basak *et al.* (2002) who reported 25.78 per cent crude protein in *Azolla pinnata*. Subudhi and Singh (1978) reported a range of 24 to 30 per cent crude protein while Parthasarathy *et al*. (2001b) reported a lower range of 23.91 to 24.22 per cent crude protein in Azolla. Lower crude protein values of 16.5, 21.4 and 23.14 per cent reported by Ali and Leeson (1995), Alalade and Iyayi (2006) and Raseena (2006) respectively did not agree with the results obtained in the present study. High crude protein value of 28.54 per cent (Khatun *et al*., 1999) and 26.02 per cent (Parthasarathy *et al*., 2002) are contrary to the current findings.

The crude fiber content in the dried sample of Azolla used in the present study was 14.80 per cent. Ali and Leeson (1995), Khatun *et al*. (1999) and Parthasarathy *et al*. (2002) reported lower values of crude fibre as 12.5, 12.38 and 13.60 per cent respectively. Whereas, Parthasarathy *et al*. (2001a) reported 13.84 to16.40 per cent crude fibre, is in agreement with the present study.

The total ash content of 15.5 per cent in dried Azolla recorded in the present study is in agreement with Parthasarathy *et al*. (2001b) who reported a range of values from 12.8 to 16.26 per cent. Subudhi and Singh (1978) and Parthasarathy *et al*. (2002) also recorded lower value of 10.5 and 12.30 per cent respectively. Very high value of 36.1 per cent total ash reported by Ali and Leeson (1995) is not in agreement with the present findings.

The Azolla used in the present study recorded 2.25 per cent calcium, which was higher than the values reported by various authors. Subudhi and Singh (1978), Ali and Leeson (1995), Parthasarathy *et al*. (2002), and Alalade and Iyayi (2006) reported per cent calcium as 0.4 to1.0, 1.4, 1.24, and 1.16 per cent respectively. Whereas, Raseena (2006) recorded 2.29 per cent calcium in *Azolla pinnata* is in close agreement with the present study.

The Azolla used in the present study showed 0.40 per cent total phosphorus, is in close agreement with Raseena (2006) who reported 0.39 per cent phosphorus in dried Azolla. Wide variations in phosphorus to the tune of 0.31, 0.72, 0.5 to 0.9 and 1.29 per cent total phosphorus was reported by Ali and Leeson (1995), Parthasarathy *et al*. (2002), Subudhi and Singh (1978) and Alalade and Iyayi (2006).

The variations in the proximate composition of dried *Azolla pinnata* reported by the above authors might be due to differences in the time of harvest and method of drying and also due to variation in environmental condition.

The calculated value of metabolisable energy (1807 kcal /kg). The above results revealed that dried Azolla is an ideal combination of protein, energy and minerals for inclusion in quail diets. The apparent ME value of 1529 kcal / kg and true ME value of 1855 kcal of ME/ kg DM were reported in *Azolla pinnata* (Parthasarathy *et al*., 2002).

5.2 BODY WEIGHT

The mean body weight (BW) of day old quail chicks in the groups T1, T2, T3 and T4 were 7.53, 7.59, 7.41 and 7.50 g respectively (Table 4) and the non-significant variation among dietary groups indicated that all the experimental groups were identical in respect of body weight at the beginning of the experiment. Dhariwal *et al.* (2004) observed mean body weight of 7.02 g in day old quail chicks in non selected line which is in partial agreement with the present results.

At the end of first week, the mean body weight (BW) of quails fed control diet was significantly higher than the three groups (T2, T3 and T4) fed 2.5, 5.0 and 7.5 per cent Azolla ($P \leq 0.05$). This finding indicated poor assimilation of Azolla in the initial phase of growth at the first week itself. Within the Azolla fed groups, the reduction in growth was uniform with 2.5 and 5.0 per cent Azolla fed quails, indicated low and medium levels of Azolla also depressed growth during the first week of age.

At the end of second week, the mean body weights were 63.46, 59.49, 58.88 and 56.02 g for groups T1, T2, T3 and T4 respectively. Significantly lower body weights were also noticed in all groups fed Azolla in comparison with the control group. Moreover, the reduction in body weight in the group fed 7.5 per cent Azolla (T4) was also significant in comparison with groups T2 and T3 fed low and medium levels of Azolla ($P \leq 0.05$). This also indicated poor utilization of nutrients in Azolla by quails at second week of age.

At third week of age, the mean body weights revealed significantly lower body weight in all dietary groups fed Azolla in comparison with the control group ($P \leq 0.05$). These results clearly showed lower body weights in all groups fed Azolla

consistently during the initial three weeks. The consistently high body weight in the control group until third week of age revealed that the inclusion of Azolla in quail starter rations lead to adverse effects.

Whereas, at fourth week of age, significantly lower body weight was observed only in quails fed diet T4 containing 7.5 per cent Azolla in comparison with the control group ($P \leq 0.05$). At this age, the mean body weight in groups T1, T2, T3 and T4 were 138.96, 137.09, 135.25 and 133.50 g respectively.

The quails fed 2.5 and 5.0 per cent Azolla showed marked improvement in body weights at fourth week resulting in statistically comparable body weights with the control group. While the 5.0 per cent Azolla fed quails could not maintain this positive trend in subsequent weeks.

At the end of fifth week, mean body weight in quails fed 5.0 and 7.5 per cent Azolla was significantly lower than that of control group ($P \leq 0.05$). The mean body weight recorded was 162.40, 159.47, 155.61 and 151.73 g in groups T1, T2, T3 and T4 respectively. The fifth week BW in all groups were higher than the value of 143.75 g reported by Mishra *et al.* (1993) at fifth week of age in Japanese quail fed 27 per cent crude protein and 2800 kcal of ME / kg. The broiler quail line of Ujjwal developed by central Avian Research Institute recorded a body weight of 170 to 175 g at five weeks of age. It was higher than the value obtained in the present study.

In the present study, at the end of sixth week of age, the mean body weight in groups T1, T2, T3 and T4 were 177.16, 175.42, 169.81 and 164.07 g respectively, showing significantly lower body weight in T4 group than control group. The adverse effects due to 7.5 per cent Azolla feeding were consistent and continued up to the end of sixth week of age.

The sixth week body weight of quails in the present study were higher than that reported by Das *et al.* (1989) and Shrivastav *et al.* (1995) who showed a body weight of 119.45 g and 139.2 g respectively in Japanese quail at six week of age. This difference might be due to the fact that Das *et al.* (1989) fed quails with a finisher ration having 24 per cent protein and 2800 kcal of ME per kg diet, from four to six week of age. But Pakhira and Samanta (2005) observed a higher body weight of 203.83 g in Japanese quail at six week, fed with starter ration (27 per cent CP and 2794 kcal of ME/kg) up to 3 weeks of age and finisher ration (24 per cent CP and 2814 kcal of ME/kg) from 4 to 6 weeks.

In the present study the body weight in control group from 1 to 6 weeks of age were 26.30, 63.46, 98.99, 138.96, 162.40 and 177.16 g respectively. Shrivastav and Johri (1993) observed lower body weight of 23.0, 59.3, 96.4, 123.3 and 144.6 g respectively from 1 to 6 weeks of age in Japanese quail fed with ration containing 27 per cent crude protein, throughout the period up to five weeks of age.

The trend of results during fifth and sixth week of age was exactly the same, in the present study. Even though the mean body weight in groups T2 and T3 was statistically comparable, the body weight in the quails fed 5.0 per cent Azolla (T3) was significantly lower than the control group. The lowest mean body weight observed with the group T4 was comparable with group T3. The highest mean body weight observed with the control group (177.16 g) was statistically comparable with the body weight of quails fed 2.5 percent Azolla and the pattern of growth at 5 and 6 weeks of age support the inclusion of 2.5 per cent Azolla in quail diet.

While considering the BW as a single trait, it can be inferred that, rearing quails upto sixth week of age is not economical. It is evident that the body weight has attained the market weight satisfactorily in all groups at fifth week of age. Therefore, it is suggested that growing quails may be marketed for meat purpose at fifth week

instead of sixth week of age since weight gain has deteriorated markedly during sixth week.

The variations in body weight reported by different authors can be attributed to the system of rearing, strain, stocking density, composition of feed, feeding pattern, nutrient intake, photoperiod and ambient temperature.

5.3 BODY WEIGHT GAIN

The weight gain (WG) during first week (Table 4) in groups T2 and T3 was almost same (17.03 and 16.98 g) but both values were numerically lower than that recorded in the control group. The mean values in T2 and T3 were intermediary and was statistically comparable with that of control group (18.78 g) and the T4 group (15.83 g) as well. At the same time, the weekly body weight was significantly lower in Azolla fed groups than the control group. The mean body weight was arrived based on individual body weight of quails while the weight gain was calculated from the mean value of the replicates in each group. In spite of uniform feed intake, at the end of first week, the weight gain in the group fed 7.5 per cent Azolla was significantly lower than the control group. This indicated that the nutrients present in the Azolla was not be utilized properly during first week.

At second week of age, the body weight gain (32.73 g) in group fed 7.5 per cent Azolla (T4) was significantly lower in comparison with control group (37.18 g) leading to significantly lower body weight also (Table 4) in group T4. The trend of results pertaining to weight gain in second week was exactly same as that observed in the first week leading to consistent effects. The weight gains in T2 and T3 (34.95 and 34.38 g) were intermediary and was comparable with that of control group.

The magnitude of weight gain during third week was lower than the corresponding weight gain recorded in second week in all groups including the

control group, indicated slight decline in rate of growth. Moreover, the gain in weight was significantly lower in groups T2, T3 and T4 (30.43, 29.83 and 30.50 g) than that in control group (35.53 g). This effect was reflected in body weight as well as feed intake recorded at third week of age. However, the weight gains were significantly low with all levels of Azolla only at third week. The higher level of neutral detergent fibre (NDF) in Azolla meal may limit the efficient utilization of Azolla, which can be attributed to the decreased weight gain in Azolla fed groups, especially at early periods of growth.

At fourth week of age, it is imperative that the weight gains, in the Azolla fed groups T2, T3 and T4 were almost similar (47.15, 46.58 and 46.98 g) and the mean values were significantly higher than that recorded in the control group (39.90 g) exhibiting an opposite trend observed at third week. This peculiarity is clearly depicted in Fig.2. The weekly weight gains recorded at this age were the highest mean values observed in respective experimental groups, in the present study. The rate of growth was maximum at this age. The mean values of weight gain were 39.9, 47.15, 46.58 and 46.98 g in groups T1, T2, T3 and T4 respectively. Shanaway (1994) reported weekly weight gain of 13, 25, 27 and 21 g per week at 1 to 4 weeks of age respectively, showing rapid growth from hatching upto the end of three weeks of age and rate of growth is declined thereafter gradually, is contrary to the present findings.

The magnitude of weekly weight gain showed drastic reduction in all groups at five weeks of age and the mean values for dietary groups T1, T2, T3 and T4 were 23.50, 22.40, 20.40 and 18.25 g respectively. In the corresponding groups, the mean weight gain was further declined to the level of 14.75, 15.88, 14.23 and 12.28 g at sixth week of age. The mean values were statistically comparable among dietary groups both at 5 and 6 weeks of age. This trend of reduction in weight gain is in agreement with Shanaway (1994), who reported mean weight gain of 17 and 8 g at fifth and sixth weeks of age respectively, showing drastic decline in growth.

The rate of growth exhibited was high up to four weeks of age and slow down at fifth week, but declined drastically during sixth week of age, support marketing of quails for meat purpose at fifth week of age.

The cumulative weight gain in group T4 is significantly lower than that of the control fed group and T1, T2 and T3 (169.63, 167.84 and 162.40 g) formed a homogenous group. Even though the cumulative weight gain in group T3 was comparable with that of control group, the weekly body weight recorded at sixth week of age in the group T3 and T4 were significantly lower than control group. Therefore, the inclusion of 5.0 and 7.5 per cent levels of Azolla are not suitable for optimum growth in quails based on the mean values of weekly weight gains and body weights.

The weekly body weight gains obtained in the present study in quails fed the control diet was 37.18, 35.53, 39.90, 23.50 and 14.75 g at 2 to 6 weeks of age respectively. These results did not agree with the findings of Narayanankutty (1987) who reported mean weekly body weight gain of 15.41, 21.27, 27.29, 20.48 and 26.29 at the above ages in Japanese quail fed diets containing 26 per cent protein and 2700 kcal of ME / kg. Parthasarathy *et al*. (2001a) and Basak *et al.* (2002) observed better weight gain with diet containing 5 per cent Azolla in broilers and it was reduced at higher levels of Azolla in diet. But in the present study the inclusion of 2.5 and 5.0 per cent Azolla in quail ration is found to be comparable to the control group with regard to cumulative weight gain.

Raseena (2006) reported the mean body weight gain of 37.74, 37.27, 35.51 and 36.76 g in layer quails fed dried Azolla at 0, 1.5, 3.0 and 4.5 per cent level during the experimental period of 6 to 26 weeks, indicating no significant difference in body weight gain up to 4.5 per cent level. Querubin *et al.* (1986) observed that body weight gain of the birds was not significantly affected with Azolla meal in broiler diet.

Parthasarathy *et al*. (2002) reported that broiler chicken feed supplemented with 5 per cent Azolla replacing 2.6 per cent wheat bran and 2.4 per cent fish meal gained more or less similar body weight with that of control group at 8 weeks of age. These findings are not in line with the results of the present study.

5.4 FEED INTAKE

The variations in mean daily feed intake showed that it was statistically comparable between dietary groups during the initial two weeks (Table 6).

At first week of age, the mean daily feed intake was ranged between 5.30 and 5.70 g and during second week of age, the mean feed intake values were ranged between 11.73 and 12.37 g in various dietary groups. The statistically comparable feed intake in all dietary groups, at first week (5.70, 5.51, 5.65 and 5.30 g) and second week of age (12.37, 12.11, 11.86 and 11.73 g), indicated that inclusion of different levels of Azolla did not affect feed intake adversely in quail chicks. The body weight gain was reduced substantially in group T4 at both these ages and was significantly lower than that of control group. Whereas, the corresponding weekly body weights in all groups fed Azolla was significantly lower than that of control group.

The increase in feed intake recorded during second week was 6.67, 6.60, 6.21 and 6.43 g over that in the first week. The feed intake registered during second week in all groups was double than the actual feed intake recorded at first week. In initial two weeks, even though the feed intake was comparable among different dietary groups, the body weights were decreased in Azolla fed groups. This might be due to less utilization of nutrients in Azolla in initial two weeks. The numerical differences in feed intake and poor digestibility of Azolla elicited marked effects on weekly BW

and WG with 2.5 and 5.0 per cent levels of Azolla during the first and second weeks of age.

A comparison of weekly feed intake data for second and third weeks revealed that an increase of 1.27, 0.18, 0.41 and 0.21 g over the previous week was registered in third week, in groups T1, T2, T3 and T4 respectively. These results indicated that the difference in feed intake between second and third weeks was negligible in T2, T3 and T4 groups. At the same time, the increase of 1.27 g in the control group became significant in comparison with the Azolla fed groups at third week of age.

The significant effects observed with feed intake during third and fourth weeks of age were exhibited in the same manner with the respective weekly weight gains. Significantly lower feed intake resulted in significantly lower weight gain in Azolla fed groups at third week of age. The mean daily feed intake recorded during third week was 13.64, 12.29, 12.27 and 11.94 g and that during fourth week was 21.01, 24.60, 24.16 and 24.78 g in groups T1, T2, T3 and T4 respectively. The differences in feed intake between the control group and the Azolla fed groups were significant both at third and fourth weeks of age.

The variations in feed intake depicted in Fig. 4 clearly showed an opposite trend at fourth week compared to that at third week of age. The feed intake at third week of age was significantly lower in all groups fed Azolla. Consequently, the weight gains as well as weekly body weights at this age were lowered significantly in comparison with the control group showing a direct impact on weight gain. This clearly indicates that incorporation of Azolla did not promote feed intake, instead it depressed the appetite significantly at third week of age.

In Azolla fed quails, the body weight, weight gain and feed intake were significantly lower at third week of age. While the fourth week feed intake was

doubled compared to that in the third week in Azolla fed groups. This doubling was not observed in the control group. Contrary to the findings in third week, the feed intake was significantly higher in Azolla fed groups during fourth week. The higher feed intake directly resulted in significantly higher weight gains in all groups of quails fed Azolla. Whereas, the consequential weekly body weights in groups fed 2.5 and 5.0 per cent Azolla (T2 and T3) only were comparable with that of control group at fourth week of age. This was contributed by carried over effect of numerical differences in initial weight gains at first and second weeks in groups T2 and T3 and severe growth depression in group T4 initially, for two weeks.

At fifth week of age, the feed intake in quails fed 2.5 per cent Azolla (T2) was significantly lower than other groups. The effect due to lower feed intake was not reflected as such in weight gain at this age and the mean body weight in this group was comparable with T1 and T3. Moreover, the difference in feed intake in Azolla fed groups at 4 and 5 weeks age was not wide. In Azolla fed groups, the feed intake during sixth week (27.16, 26.25 and 27.25 g) was slightly higher than that recorded during fifth week (24.41, 25.98 and 26.28 g). The weight gain also did not differ at sixth week of age.

The feed intake at sixth week of age did not differ among dietary groups and the mean values were 27.63, 27.16, 26.25 and 27.25 g respectively. This was in agreement with Basak *et a*l. (2002) and Ali and Leeson (1995) who observed statistically comparable feed consumption in broilers with different dietary levels of Azolla, at sixth week of age.

The cumulative feed intake were 551.81, 552.44, 559.44 and 560.21 g during 0 to 5 weeks and 745.33, 742.55, 743.13 and 750.87g during 0-6 weeks of age in groups T1, T2, T3 and T4 respectively and the mean values were comparable among dietary groups. This observation was contrary to the finding of Parthasarathy *et al*.

(2001a) who observed a significant reduction in cumulative feed intake in broilers fed with 5, 10 and 15 per cent levels of Azolla. Similarly, Alalade and Iyayi (2006) observed that 10 and 15 per cent of Azolla meal in the diet of chicks significantly reduced the average weekly feed intake.

The cumulative feed intake is considerably low at fifth week compared to that at sixth week. Thus the cumulative FCR is further improved at fifth week. Therefore it is suggested that the quails for meat purpose can be marketed at fifth week itself instead of sixth week considering all the traits particularly cumulative weight gain, feed intake and FCR.

In the present study there was significant reduction in cumulative weight gain and the body weight at six weeks of age in quails fed 7.5 per cent Azolla (T4) which confirm poor utilization of nutrients in this group. The cumulative feed intake in quails fed 2.5 and 5.0 per cent Azolla was similar (742.55 and 743.13 g) and the cumulative weight gains and the sixth week body weights in the two groups were also comparable. But the weight gains and body weight in group fed 2.5 per cent Azolla was only comparable with the control group, indicated suboptimal utlisation of nutrients in the diet containing 5.0 per cent Azolla.

The mean daily feed intake values in the present study did not agree with findings of Narayanankutty (1987) who observed a mean daily feed consumption of 8.34, 9.01, 14.09, 16.22 and 19.59 g at 2, 3, 4, 5 and 6 weeks respectively in Japanese quail.

5.5 FEED CONVERSION RATIO

The data presented in Table 7 reveals that the feed conversion ratios (FCR) between dietary groups were statistically significant only at fifth week of age

($P \leq 0.05$). The mean values of FCR recorded for dietary groups T1, T2, T3 and T4 for first week of age were 2.15, 2.27, 2.34 and 2.37 respectively and in the corresponding groups the FCR during second week was 2.33, 2.43, 2.43 and 2.51, indicated poor FCR in quails fed 7.5 per cent Azolla.

The mean feed conversion ratio in quail chicks at the end of third week of age were 2.70, 2.83, 2.89 and 2.75 with daily mean feed intake of 13.64, 12.29, 12.27 and 11.94 g in groups T1, T2, T3 and T4 respectively. These results showed that, the significantly lower feed intake in Azolla fed groups in turn resulted in lowered weight gains and therefore the FCR values did not show adverse effects at this age. At fourth weeks of age also the FCR values (3.69, 3.67, 3.64 and 3.70) did not show significant differences in spite of significantly higher feed intake in all groups fed Azolla because of the proportionate increase in weight gains at this age. These results recorded at third and fourth weeks of age showed that the marked difference in feed intake upward or downward direction was in line with the weight gain, but not reflected as such in the FCR values. However at fifth week of age, there was direct reflection of feed intake on FCR.

At fifth week of age, the feed conversion efficiency was altered greatly and the FCR in all groups were poor compared to the values recorded in earlier weeks because of the very low weight gains registered during the week. The mean values of weekly FCR at this age were 8.24, 7.69, 8.94 and 10.12 in groups T1, T2, T3 and T4 respectively. The relatively better feed efficiency recorded in the group fed 2.5 per cent Azolla (7.69) was significant ($P \leq 0.05$) compared to that of group T4, in spite of the significantly lower feed intake in this group in comparison with other diets. The weight gain in group T2 was not reduced in tune with the low feed intake at this age. Significantly higher feed intake in T1, T3 and T4 groups resulted in lower weight gains at this age indicating decline in rate of growth from fifth week onwards.

The mean feed conversion ratios in quails during the sixth week of age were 13.67, 13.78, 13.96 and 15.70 in groups T1, T2, T3 and T4 respectively indicated very poor rate of growth in all groups. In agreement with the present study Parthasarathy *et al*. (2001a) and Basak *et al*. (2002) reported a better feed conversion ratio at 0 and 5 per cent level of Azolla, in broilers and it become poorer towards higher levels of Azolla.

The cumulative feed efficiency of 4.40, 4.43, 4.58 and 4.80 respectively at the end of sixth week in groups T1, T2, T3 and T4 indicated poorest feed conversion efficiency with diet T4 containing 7.5 per cent Azolla and this effect was significant in comparison with other diets. Therefore the inclusion of 7.5 per cent Azolla in diets of quail was proved detrimental.

The cumulative feed conversion ratio (FCR) at fifth week of age was 3.56, 3.63, 3.77 and 3.88 in groups T1, T2, T3 and T4 respectively and the corresponding values at sixth week of age were 4.40, 4.43, 4.58 and 4.80. These results indicated that the cumulative FCR was better at fifth week than those at sixth week in all groups. Therefore marketing meat quails at fifth week of age is suggested instead of sixth week since the weight gain and FCR were found to be deteriorating markedly during sixth week of age.

The overall feed efficiency without considering the dietary effects at first, second and third weeks of age were 2.28, 2.43 and 2.79 respectively. The cumulative feed efficiency at the end of sixth week in the control group and that fed 2.5 per cent Azolla (4.40 and 4.43) agree closely with the value of 4.37 reported by Das *et al.* (1989) at sixth week of age. The cumulative FCR at fifth week of age (4.41) reported by Shrivastav and Panda (1982) and at sixth week (4.19) of age stated by Narayanankutty (1987) were more or less similar to the present findings.

5.6 PROCESSING YIELDS AND LOSSES

The results pertaining to the processing yields of quails at six weeks of age (Table 8) indicated that the gizzard, giblets and R to C yield were statistically significant among dietary groups. The dressed yield was comparable between control group and Azolla fed groups.

The dressed yield in various dietary groups were 92.86, 91.73, 92.55 and 92.16 per cent respectively were higher than that reported by Shrivastav and Panda (1982), Choudhari and Mahadevan (1983a), Narayanankutty (1987) and Sengar *et al*. (2003) who reported dressed yields in the range of 88.3 to 89.7 per cent in Japanese quail fed varying levels crude protein and energy in diets. The eviscerated yield recorded in the dietary groups T1, T2, T3 and T4 were 67.2, 70.5, 72.3 and 70.2 per cent respectively. The values reported by Choudhari and Mahadevan (1983a) and Shrivastav and Panda (1987) Mandal *et al*. (1996) were lower (61.48, 65.95 and 68.75 per cent).

The R-to-C yield in dietary groups T1, T2, T3 and T4 were 71.14, 75.45, 76.78 and 74.53 per cent respectively and that recorded with diet containing 5.0 percent Azolla was significantly higher than that of control diet ($P \leq 0.05$) to the tune of 5.64 per cent more yield with diet T3 than control group. It is imperative that body weight in this group at sixth week of age was significantly lower than that of control group by 4.15 per cent. Kumararaj *et al*. (1997) reported a ready to cook yield of 73.20 per cent at six week of age in Japanese quail fed with ration having 26 per cent crude protein and 2700 kcal of ME /kg which is in agreement with the present results.

The giblet yield recorded for the dietary groups T1, T2, T3 and T4 were 4.08, 4.81, 4.40 and 4.23 g respectively and the statistical analysis showed that the giblet yield in quails fed 2.5 percent Azolla (4.81 per cent) was significantly higher than that of control diet (4.08 per cent). This values obtained were in close agreement

with Samanta and Day (1991) who observed giblet yield of 4.19 per cent in quails. Contrary to the present findings, the giblet yields in the range of 7.40 to 8.37 per cent were also reported by Choudhari and Mahadevan (1983b), Narayanankutty (1987), Mandal *et al. (*1993) Kumararaj *et al*. (1997), Dhariwal *et al.* (2004) and Pakhira and Samanta (2005). The Gizzard was found to be significantly higher in quails fed diet (T3) than that of control diet.

The blood loss was comparable among the different dietary groups T1, T2, T3 and T4 and the mean values were 3.49, 3.56, 3.50 and 3.95 per cent respectively. Mandal *et al. (*1993) observed a blood loss of only 2.53 per cent and Kumararaj *et al*. (1997) reported blood loss of 1.60 per cent. The values were much less than that obtained in the present study, whereas Choudhari and Mahadevan (1983a) and Narayanankutty (1987) observed higher values of 4.93 and 4.95 per cent respectively at 6 week of age in quails.

The feather loss different dietary groups T1, T2, T3 and T4 were 3.9, 4.7, 4.1 and 4.0 per cent respectively.The data did not reveal any significant difference. The feather loss of 7.0 per cent reported by Narayanankutty (1987) was not agreement with the present study.

5.7 SERUM PARAMETERS

5.7.1 Serum Total Cholesterol

The mean serum total cholesterol (mg per dl) estimated of quails at the end of sixth week of age is set out in Table 9 and the mean values in dietary groups T1, T2, T3 and T4 were 187.78, 176.12, 163.88 and 159.50 mg per dl respectively. The statistical analysis revealed significant ($P \leq 0.05$) differences among the different dietary groups. The values obtained with the control group and that fed with 2.5 per cent Azolla was comparable each other, but both these values were significantly

higher than that in the group fed 7.5 per cent Azolla. The serum cholesterol values of 173.91 mg per dl (Nirupama *et al*.,1995) and 181.14 mg per cent (Kumar, 1997) are comparable with the present results recorded in groups T1 and T2.

The total cholesterol in serum showed a decreasing trend in groupT1, T2, T3 and T4 in that order but significant decrease was observed only with diet containing 7.5 percent Azolla. This trend in serum cholesterol in agreement with, Raseena (2006), who observed decreasing trend of serum cholesterol with increase in the level of Azolla 0, 1.5, 3.0 and 4.5 per cent in quail ration (167.92, 147.79, 140.35 and 113.99 mg/dl). The serum cholesterol value of 242 mg / dl reported by Joshi and Bhuvanesh (1987) at fifth week of age, and that reported values ranging from 320.57 to 369.44 /dl by Manjumdar *et al.* (1996) in meat line female quail are not in line with the present results.

Simi (2007) and Lonkar (2006) observed a total serum cholesterol of 175.89 and 181.73 mg / dl in broiler chicken at six weeks of age, which is slightly lower than the value recorded with the control group.

5.7.1 Serum Total Protein, Creatinine and Uric Acid

The mean serum total protein levels at sixth week of age were 3.01, 3.15, 3.06 and 3.00 g per dl respectively (Table 9).These observations were in accordance with the findings of Raseena (2006), who observed serum total protein of 3.29, 2.97, 3.37 and 3.02 g / dl in Japanese quail layer fed with diet containing Azolla at 0, 1.5, 3 and 4.5 per cent level, at 26 weeks of age.

Joshi and Bhuvanesh (1987), Narayanankutty (1987) Mandal *et al.* (1996), Sheena (2005), Asrani *et al* (2006) and Preethymol (2006) observed that serum protein values in the range from 4 to 6.83 g per dl in Japanese quail fed varying levels crude protein and energy in diets. The serum total protein value obtained for

control group, in the present study is lesser than the values obtained in all the above studies.

The more or less similar concentration of creatinine in the serum was indicator of renal function and muscular activity in various dietary groups. The results on serum creatinine in the present study revealed that no significant difference among dietary groups. This observation agree with the findings of Raseena (2006), who observed that dietary inclusion of dried Azolla did not affect the serum creatinine concentration.

Mandal et al. (1996) observed that serum uric acid was 6.74 g / dl in Japanese quail fed with ration having 26 per cent crude protein and 2600 kcal / kg ME. The values were higher than obtained in the present study. Raseena (2006) observed the serum uric acid of 3.10, 3.27, 3.31 and 3.27 respectively with 0, 1.5, 3.0 and 4.5 per cent Azolla meal in diet of layer quail at 26 week of age. The values were statistically comparable among different treatments. In the present study also the serum uric acid level is not affected by dietary inclusion of Azolla.

5.8 BREAST MEAT AND THIGH MEAT TOTAL CHOLESTEROL

The mean breast meat total cholesterol estimated at the end of sixth week of age (Table 10) in dietary groups T1, T2, T3 and T4 were 47.43, 47.79, 46.72 and 47.32 mg per cent respectively. Lonkar (2006) reported total cholesterol value of 54.07 mg per cent in broilers at six weeks of age.

The mean thigh meat total cholesterol values of 54.23, 55.31, 50.27 and 50.51 mg per cent respectively in dietary groups T1, T2, T3 and T4 did not differ significantly between dietary groups. Lonkar (2006) and Simi (2007) reported 111.09 and 113.08 mg per cent of total cholesterol respectively in thigh meat of broilers at

six weeks of age, which was double than that of quails fed control diet in the present study.

5.9 LIVABILITY

The mean livability percentage of Japanese quails from zero to six weeks of age was excellent in groups T2 and T3 (Table 11). One quail died in group T1 at 4 weeks of age and another quail in group T4 at 6 weeks of age. Azolla feeding did not show deleterious effects on livability of quail.

5.10 ECONOMICS

The cost and returns presented in Table 12 indicated that the inclusion of dried Azolla at 2.5 per cent level in quail diet did not affect the BW adversely at 6 weeks of age. The inclusion of Azolla in quail diet replaced costlier ingredients in small quantities but reduced the feed cost per kg diet appreciably. The feed cost per kg diet was Rs.11.11, 11.03, 10.95 and 10.87 with diets T1, T2, T3 and T4 respectively, showed decreasing trend with increasing levels of Azolla. In the present study, the inclusion of 2.5 per cent Azolla replaced soya bean meal, unsalted dry fish, yellow maize, wheat bran, de-oiled rice bran and calcite at a level of 0.48, 0.23, 0.19, 1.24, 0.25 and 0.11 per cent respectively and the feed cost per kg diet was reduced from Rs.11.11 to Rs.11.03. Parthasarathy *et al.* (2001a) also reported feed cost reduction in broiler diets from Rs.5.07 to 4.47 as level of Azolla increased from 0 to 20 per cent.

The results obtained in the present study proved that the inclusion of unconventional feed ingredient Azolla in ‘quail starter cum grower’ ration at 2.5 per cent level is satisfactory with respect to growth, feed intake, FCR and R to C yield of quails. On economical considerations, marketing of quails on live weight basis is less

economical. Therefore, it is suggested that marketing of ready to cook meat will be more beneficial in quails fed 2.5 and 5.0 per cent level Azolla in diets.

The mean cumulative feed intake noticed for the dietary groups T1, T2, T3, T4 was 745.33, 742.55, 743.13 and 750.87 g and the cumulative feed cost per quail for the period from 0 to 6 weeks of age in dietary groups T1, T2, T3 and T4 were Rs. 8.27, 8.19, 8.13 and 8.16 respectively. The mean cumulative feed intake and feed cost were highest in the control group followed by the group fed 2.5 per cent Azolla. The numerically higher cumulative feed intake was resulted in group T4 compared to group T3, in spite of the lowest feed cost /kg diet in group T4.

The mean body weight of quail at sixth week of age in dietary groups T1, T2, T3 and T4 were 177.16, 175.42, 169.81 and 164.70 g and the income by sale of quails were Rs.17.72, 17.54, 16.98 and 16.41 at the rate of Rs.100 per kg live weight, which indicated that the income by sale of quails were the highest in the control group followed by groups T2, T3 and T4 in that order.

The margin of return over feed cost plus chick cost was Rs.4.45, 4.35, 3.85 and 3.25 in groups T1, T2, T3 and T4 respectively. Even though the feed cost per kg diet and the cumulative feed cost were lower in Azolla fed groups, the margin of return over feed cost was lower in all groups fed Azolla diet due to lower body weights at sixth week of age particularly in groups fed 5.0 and 7.5 per cent Azolla (T3 and T4) wherein the body weight reduction was statistically significant. The results of the present study was in accordance with Basak *et al.* (2002), who reported that the cost per quail was higher in control group and the profit per broiler was higher in 5.0 per cent Azolla fed group but it was comparable with the control group. Contrary to the present finding Parthasarathy *et al.* (2001) observed better return over feed cost in broilers fed 5.0 per cent Azolla.

The return per quail recorded at sixth week in the control group was higher by Rs.0.10 than the group fed 2.5 per cent Azolla. The returns per quail were lowered further to the tune of Rs.0.60 in group T3 and Rs.1.20 in group T4, compared with the control group. Hence feeding of 5.0 and 7.5 per cent dried Azolla can not be recommended in quail diets.

The mean cumulative feed intake noticed for 0 to 5 weeks in dietary groups T1, T2, T3 and T4 was 551.81, 552.44, 559.44 and 560.21 g and the cumulative feed cost per quail for the above period in above dietary groups was Rs.6.13, 6.09, 6.13 and 6.09 respectively. The mean body weight of quail at fifth week of age in dietary groups T1, T2, T3 and T4 were 162.63, 159.47, 155.61, 151.73 g and the income by sale of quails were Rs.16.24, 15.95, 15.56 and 15.17 at the rate of Rs.100 per kg live weight. The margin of return over feed cost plus chick cost was worked to Rs.5.11, 4.85, 4.43 and 4.08 in groups T1, T2, T3 and T4 respectively. The marketing at fifth week is advantageous since, margin of return over feed cost plus chick cost is appreciably high in respective group at fifth week of age in comparison with sixth week.

The higher R to C yield was registered in groups fed Azolla at 2.5, 5.0 and 7.5 per cent levels (75.45, 76.78 and 74.53 per cent) and it was significantly higher for the 5.0 per cent Azolla fed group in comparison with that the control group (71.14 per cent). Further investigation is required to confirm this result.

Summary

6. SUMMARY

An experiment was carried out at the Department of Poultry Science, College of Veterinary and Animal Sciences, Kerala Agricultural University, Mannuthy, to study the effect of dietary inclusion of dried Azolla on growth of Japanese quails. The economics of feeding Azolla up to six weeks of age was also evaluated.

One hundred and ninety two (192), day old Japanese quail chicks belonging to single hatch were weighed individually and distributed randomly to four treatment groups with four replicates of twelve quails each. A control ration with 26 per cent crude protein and 2700 kcal ME per kg was formulated. Dried Azolla was included in the basal diet at levels of 0, 2.5, 5.0 and 7.5 per cent after replacing corn and soya bean to form the treatments T1, T2, T3 and T4, respectively. All the rations were made isocaloric and isonitrogenous.

The quails were housed replicate wise in separate cages with dimension of 76 x 63 x 26 cm. Standard management conditions were maintained uniformly through out the experiment from 0 to 6 weeks of age. Body weight of all quails was recorded weekly and weekly weight gains were worked out. The quantity of feed issued was recorded replicate wise in every week and the balance feed available in the feeders at the end of every week was measured. From this data, mean daily feed consumption and cumulative feed intake was calculated. Feed Conversion Ratios (FCR) were calculated replicate wise based on body weight gain in every week. The mortality was recorded at occurrence and per cent livability was recorded weekly for each treatment group.

At the end of sixth week two quails from each replicate were sacrificed to study the mean per cent dressed yield, eviscerated yield, per cent weight of giblet and ready to cook yield. The meat from breast and thigh were collected from each carcass and the total cholesterol was estimated. Blood samples were collected at the time of slaughter and total cholesterol, creatinine, total protein and uric acid in serum were estimated. Economics over feed cost was calculated based on the prevailing cost of feed ingredients. The sale price of quails based on live weight and R to C yield were used for evaluating the

economics of incorporation of Azolla in quail diets. The summary of results obtained in the present study is represented in Table 13.

The results obtained in the present study are summarized below:-

1. The mean weekly body weight (BW) of quails fed 7.5 per cent Azolla was significantly lower consistently up to fourth week of age and that at fifth and sixth week of age were significantly lower with 5.0 and 7.5 per cent of Azolla in comparison with that of control group ($P \leq 0.05$).
2. The cumulative body weight gain recorded in groups T1, T2, and T3 and T4 at the end of fifth week was 154.87, 151.47, 155.61, 151.73 g and that at sixth week was 169.63, 167.84, 162.40 156.57 g respectively. At both these ages, it was significantly lower with quails fed 7.5 per cent Azolla than that of control group ($P \leq 0.05$).
3. The mean daily feed consumption in the Azolla fed groups showed significantly lower feed intake during third week of age and significantly higher feed intake at fourth week of age in comparison with control group. At fifth week of age, the feed intake recorded with diet containing 2.5 per cent Azolla was significantly lower than that of control group ($P \leq 0.05$).
4. The cumulative feed intake per quail in groups T1, T2, T3 and T4 from 0 to 5 weeks (551.81, 552.44, 559.44 and 560.21 g) and 0 to 6 weeks (745.33, 742.55, 743.13 and 750.87 g) was comparable among each other.
5. The cumulative FCR was 3.56, 3.63, 3.77 and 3.88 for 0-5 weeks but a higher values of 4.40, 4.43, 4.58, 4.80 were recorded for 0-6 sixth weeks of age in groups T1, T2, T3 and T4 respectively. The mean value observed with quails fed 7.5 per cent Azolla was significantly higher than that in other groups ($P \leq 0.05$).
6. The R-to-C yield in dietary groups T1, T2, T3 and T4 were 71.14, 75.45, 76.78 and 74.53 per cent respectively. The highest R to C was observed with 5.0 per cent Azolla and lowest in control group. The giblet yield was higher in 2.5 per cent Azolla group. The lowest giblet yield was observed with the control group.
7. The total serum cholesterol was significantly lower with 5.0 and 7.5 per cent levels of Azolla than control group. On the other hand, total protein, creatinine

and uric acid in serum were not influenced by inclusion of Azolla in quail diet. The breast and thigh meat cholesterol also comparable between control group and Azolla fed groups.

8. The feed cost per kg showed decreasing trend with the increase of Azolla levels in feed. The return per quail was also decreased in the order of T1, T2, T3 and T4 due to low body weight in Azolla fed groups. The margin of return over feed cost plus chick cost per quail was Rs.5.11, 4.85, 4.44 and 4.08 at five week followed by 4.45, 4.35, 3.85, and 3.25 at six week in groups T1, T2, T3 and T4 respectively.

The results of the present study revealed that the body weight, the cumulative feed intake, FCR, margin of returns and R to C yield at six weeks of age in quails fed 2.5 per cent Azolla was comparable statistically with that of control group. These results clearly indicated that the incorporation of the dried Azolla at 2.5 per cent level can be recommended for feeding Japanese quails. The weight gain and FCR were found to be deteriorating markedly at sixth week and thereby the margin of return was very low during sixth week of age and these traits were better at fifth week of age. Therefore, marketing of quails for meat purpose is suggested at fifth week itself instead of sixth week of age.

Table 13. **Summary of performance of Japanese quail at 5 and 6 weeks of age as influenced by dietary inclusion of dried Azolla in experimental diets.**

Sl. No	Characteristics		Dietary inclusion of dried Azolla in experimental diets (%)			
			T_1 0	T_2 2.5	T_3 5.0	T_4 7.5
1	Mean Bw (g)	5th wk	162.40 a	159.47ab	155.61ab	151.73 c
		6th wk	177.16 a	175.42ab	169.81bc	164.07 c
2	Cumulative body WG (g)	5th wk	154.87 a	151.88 a	148.2ab	144.23 b
		6th wk	169.63a	167.84 a	162.40ab	156.57b
3	Cumulative mean feed intake (g)	0-5 wk	551.81	552.44	559.44	560.21
		0-6 wk	745.33	742.55	743.13	750.87
4	Cumulative mean FCR	0-5 wk	3.56 b	3.63 b	3.77 b	3.88 a
		0-6 wk	4.40 b	4.43 b	4.58 b	4.80a
5	Total cholesterol (mg/dl) at 6th wk					
i)	Serum		187.78 a	176.12ab	163.88bc	159.50 c
ii)	Breast meat		47.43	47.79	46.72	47.32
iii)	Thigh meat		54.23	55.31	50.27	50.51
6	R-to- C yield (%) at 6th week		71.14b	75.45ab	76.78a	74.53ab
7	Margin of return over feed +chick cost (Rs.)	5th wk	5.11 a	4.85 a	4.43ab	4.08 b
		6th wk	4.45 a	4.35 a	3.85ab	3.25 b

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Abstract

EVALUATION OF DIETARY INCLUSION OF AZOLLA FOR GROWTH IN QUAIL (*Coturnix coturnix*)

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6. ABSTRACT

An experiment was carried out at the Department of Poultry Science, College of Veterinary and Animal Sciences, Kerala Agricultural University, Mannuthy, to study the effect of dietary inclusion of dried Azolla on growth of Japanese quails. The economics of feeding Azolla to quails up to six weeks of age was evaluated.

One hundred and ninety two (192), day old Japanese quail chicks weighed individually, distributed randomly to four dietary groups each with four replicates of twelve quails. A control ration with 26 per cent crude protein and 2700 kcal ME per kg was formulated. Dried Azolla was included in the basal diet at levels of 0, 2.5, 5.0 and 7.5 per cent to form the dietary groupsT1, T2, T3 and T4, respectively and all the rations were made isocaloric and isonitrogenous.

The quails were housed replicate wise in separate cages with dimension of 76 x 63 x 26 cm. Standard management conditions were maintained uniformly through out the experiment from 0 to 6 weeks of age. The body weight weight gains, feed consumption and FCR were recorded weekly and cumulative basis. The mortality was recorded at occurrence and per cent livability was worked out in each group.

At the end of sixth week of age, two quails from each replicate were sacrificed to study the carcass yields and losses. The meat from breast and thigh were collected from each carcass and the total cholesterol was estimated. Blood samples were collected at the time of slaughter and total cholesterol, creatinine, total protein and uric acid in serum were estimated. Economics over feed cost was calculated based on the prevailing cost of feed ingredients. The sale price of quails based on live weight and R to C yield were used to evaluate the economics of incorporation of Azolla in quail diets. The salient results obtained in the study are presented below.

The mean BW of quails was162.40, 159.47, 155.61 and 151.73 g at fifth week and that at sixth week of age was177.16, 175.42, 169.81 and 164.07 g in groups T1, T2, T3 and T4 respectively. The BW of quails fed 5.0 and 7.5 per cent of Azolla was

significantly lower than that of control group (P≤0.05) at both these ages. The cumulative feed intake per quail in groups T1, T2, T3 and T4 from 0 to 5 weeks (551.81, 552.44, 559.44 and 560.21 g) and 0 to 6 weeks (745.33, 742.55, 743.13 and 750.87 g) was comparable among each other. The cumulative body weight gain at both 5^{th} and 6^{th} week was significantly lower with quails fed 7.5 per cent Azolla than that of control group (P≤0.05). At these ages the cumulative FCR observed in this group was significantly higher compared with all other groups. The giblet yield of 4.81 per cent in quails fed 2.5 per cent Azolla was significantly higher than that of control group (4.08 per cent). The R-to-C yield (76.78 per cent) and the gizzard per cent (1.90) recorded in quails fed 5.0 per cent Azolla was significantly higher than that of control group. The R-to-C yield of 75.45, in quails fed 2.5 Azolla was numerically higher than the control fed group(71.14per cent).

The serum cholesterol was significantly lower with 5.0 and 7.5 per cent levels of Azolla than that of control group. The total protein, creatinine and uric acid in serum and cholesterol content both in breast and thigh meat were not affected by inclusion of Azolla in quail diet. The margin of return over feed cost plus chick cost per quail was Rs.5.11, 4.85, 4.44 and 4.08 at five week followed by 4.45, 4.35, 3.85 and 3.25 at six week in groups T1, T2, T3 and T4 respectively with low economic return.

Based on the above findings, it was concluded that the sixth week body weight, the cumulative feed intake, FCR and R-to-C yield in quails fed 2.5 per cent Azolla was comparable with that of control group. These results clearly indicated that the incorporation of the dried Azolla at 2.5 per cent level can be recommended for feeding Japanese quails. It is also recommended to market quails for meat purpose at fifth week itself instead of sixth week of age, since the weight gain and FCR were found to be deteriorating markedly at sixth week compared to fifth week.