Chapter - V

DISCUSSION

5.1. Performance of indoor and outdoor rearing of muga silkworm :

Muga silkworm, *Antheraea assama* Westwood (Saturniidae : Lepidoptera) is predominant in Assam and is mainly distributed in the North Eastern India. Successful extension in non-traditional belt like Terai region of West Bengal is in progress (Ray, 2003; Ray *et al*., 2005). It is the only silkworm which produces naturally colored silk and is golden yellow in luster. Still, muga silkworm is best known among the four different sericigenous species due to its wild nature, geographical isolation, endemicity and other intriguing factors, which are not well known (Thangavelu and Sahu, 1983). In outdoor rearing it is difficult to protect them from the various parasites, predators, environmental hazards like heavy rainfall, strong wind, hailstorm and sunshine. Attempts to domesticate the muga silkworm did not yield fruitful results. However, young worms only upto second or third instar on the branches of som or soalu can be reared but this has no significance to the muga rearers and researchers because it failed to give much needed increase in effective rate of rearing. During 1983, Thangavelu and Sahu developed the technology for indoor rearing and during 1986, they successfully completed the indoor rearing for six generation in a year, still failed to compare the results with outdoor rearing for all the seasons. In the present investigation seven periods in a year has been compared in indoor and outdoor condition on both the principal host plants namely som and soalu.

Results indicate that almost all the rearing parameters namely larval weight, cocoon weight, shell weight, effective rate of rearing and absolute silk content are better in indoor condition while shell ratio and fecundity are higher in outdoor.

The effective rate of rearing, the main objective of indoor rearing is better in indoor rearing (fig. 2) may be due to less pest and predator attack in indoor condition (Thangavelu and Sahu, 1986).

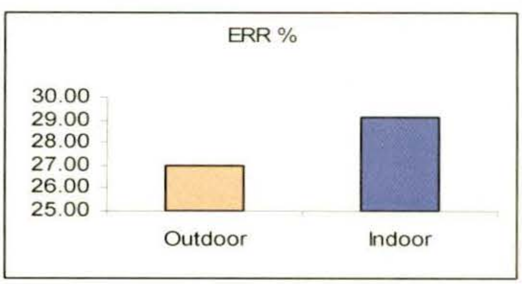
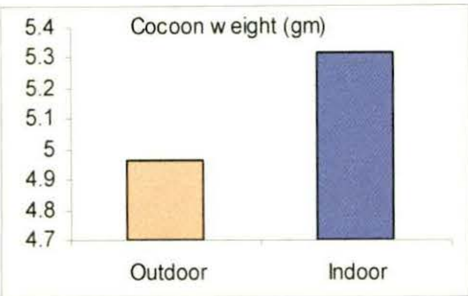


Fig. 2. Effective rate of rearing in outdoor and indoor condition



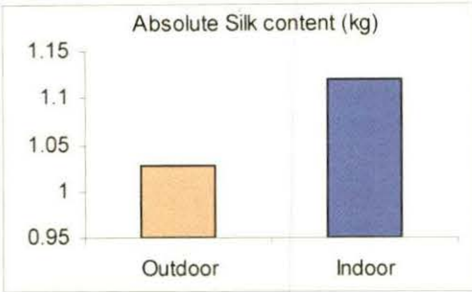
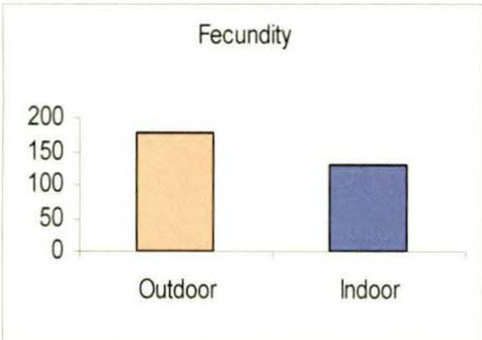


Fig. 3a and 3b : Cocoon weight and absolute silk content in outdoor and indoor condition

Moreover, better cocoon weight and absolute silk content in indoor condition also reflect no deleterious effect on silk due to indoor rearing (fig. 3a and 3b). However, oviposition is not completely inhibited due to indoor rearing (fig 4) but a considerable reduction in fecundity due to domestication may further be studied in future. Thangavelu and Sahu (1983) also recorded low fecundity in indoor condition. It can be noted that the yield of seed in indoor condition improves as high ERR in indoor produces high number of adults which ultimately improves the pairing as well as oviposition.



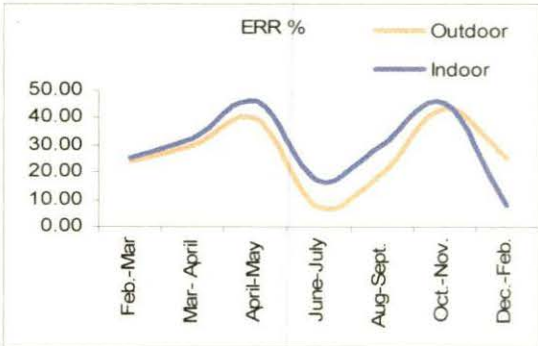


Fig. 4. Fecundity in outdoor and indoor condition

Fig. 5. Effective rate of rearing in outdoor and indoor condition

Effective rate of rearing (ERR%) varies greatly during the different rearing seasons and the same is quite high during April – May and October – November both in indoor and outdoor condition (fig 5). Unlike the reports of Thangavelu and Sahu (1986) the ERR is higher in April – May than in October – November in indoor condition. This two generation represents the spring and autumn commercial crops respectively and the other seasons are unfavorable for mugaculture and muga rearings are conducted only to augment seed multiplication, confirming the conventional rearing seasons *i.e.* April – May and October – November. Effective rate of rearing is comparatively low during winter and summer and hence commercial rearing during there seasons is avoided. Just prior to the two commercial crops there are two main seed broods viz. February – March (early spring) and August – September (early autumn). During these seasons also the muga rearing is not favourable.

Hence, in the present study the rearing rate and cocoon characteristics are better only during April – May and October – November while the poor rearing performance during other periods is attributable to the natural and seasonal factors.

Muga silkworm is polyphagous and therefore the performance among the two important food plants viz. som and soalu were studied in indoor rearing. The study indicates higher effective rate of rearing (fig. 6) and all other rearing parameters with som than with soalu except larval weight. However, observation from efficiency of conversion of food as well as combination of leaves can only give the final recommendation.

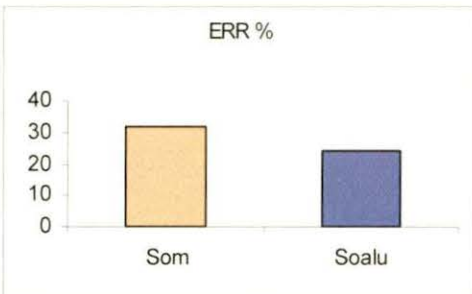


Fig. 6 : Effective rate of rearing in indoor condition on som and soalu

Finally, domestication of muga silkworm is considered as a significant breakthrough in mugaculture even in non-traditional belt also. The indoor rearing technique is very simple and quite inexpensive and hence muga rearers can readily adopt this technique as well as researchers can able to modify the innovation for further improvement of indoor rearing technique. Domestication of muga silkworm will break the geographical barrier and mugaculture will extend far and wide and also will open new areas of research on muga silkworm on host plant preference and nutritional physiology with qualitative and quantitative improvements in the silk produced by *Antherea assama* having similar opinion of Thangavelu and Sahu (1983).

5.2 Nutritional efficiency of larva on two principal host plants during favourable seasons :

Nutritional efficiency is considered important to asses the cost benefit ratio of sericulture practice up to the level of cocoon production. The efficiency of converting the ingested and digested food varies among silkworm under the influence of season and host plant (Anantha Raman *et al*., 1995). Nutritional qualities as well as environmental conditions have greater impact on regulation over the quantum of ingestion, digestion and digestibility of food among silkworm (Ito, 1972). Muga silkworm larvae depend mainly on som (*Machilus bombycina*) and soalu (*Litsea polyantha*) for food. Commercial crop rearings are conducted in north-east India and West Bengal during spring (April – May) and autumn (October – November) of which October – November rearing is the main commercial crop rearing. So, firstly it is important to assess the host plant on the basis of nutritional efficiency of the larvae during this two period.

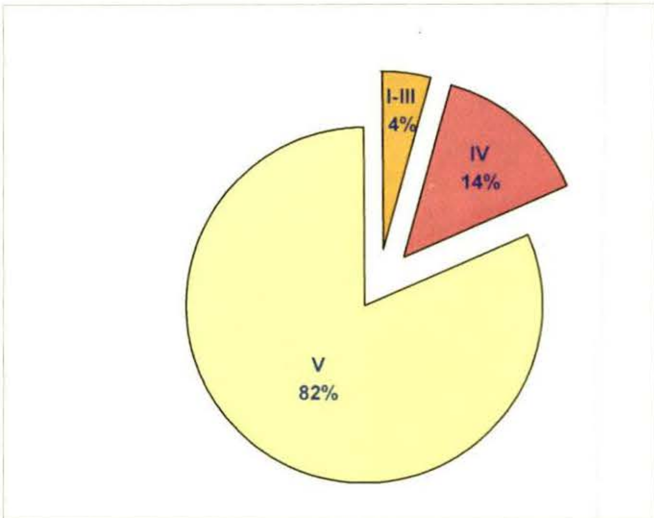


Fig. 7 : Instarwise food ingestion by muga silkworm

Food ingestion during fifth instar is 82% of the total consumption (fig 7) having similarity with the findings of Rana *et al*. (1987) in *Antheraea proylei*, Sinha *et al*. (2001) in *Antheraea mylitta* and Barah *et al*. (1989) in *Antheraea assama*. However, total food ingestion is higher in the larvae fed on som (22.230 gm) than on soalu (20.900 gm). Higher ingesta in fifth instar is necessary as the larva has to maintain metabolic demand during the transformation stages from larva to pupa, pupa to moth and also for the secretion of silk as a protective cover during this period (Anantha Raman *et al*., 1993). Seasonal effect shows higher consumption during October – November on som (25.160 gm) than on soalu (21.642 gm) and higher food consumption during April – May on soalu (20.157gm) than on som (19.299 gm), which is probably due to seasonal nutritional variation in food plant and higher consumption is required to compensate the nutritional inadequacy (Prabhakar *et al.*, 2000).

In the insects, digesta is the total quantity of food available to be incorporated as body substances or to be metabolized for energy (Reddy and Alfred, 1979). Som or soalu leaf feeding shows 75% and 19% of digestion (fig 8) during fifth and fourth instar respectively. The highest digestion recorded in the fifth instar is found to be related with the amount of food consumed. This is in agreement with the findings of Vats and Kaushal (1982) and Sinha *et al.* (1998). Digesta available in body is higher on som (7.338 gm) than on soalu (6.589 gm) though during April – May digesta present in higher amount when fed on soalu leaves than on som leaves which are found to be related with the amount of food consume as the correlation studies reveals strong positive correlation between food ingestion and digestion (0.997). This finding is in agreement with those of Barah *et al.* (1989) and Sinha *et al.* (2001).

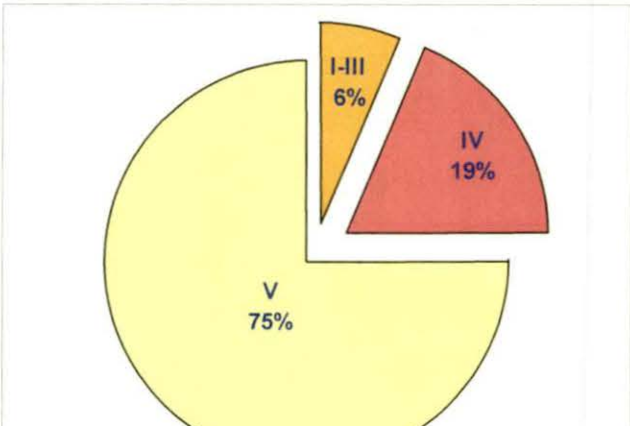


Fig 8. Instarwise food digestion by muga silkworm

Excreta values progressively increased as growth advanced. The production of excreta depends on quality of food, rate of food intake, absorption rate and also the retention time of food in the gut showing higher excreta production by the larvae fed on som leaves. Higher food intake tends to mobilize the gut content faster and provides less time for enzyme activity and food absorption, making the efficiency poor (Waldbauer, 1964). No significant variation in excreta production is there between the seasons fed on soalu leaves while it is higher during October – November fed on som leaves.

Reference ratio (RR) is an indirect expression of absorption and assimilation of food. It also expresses the ingesta requirement per unit excreta production. Higher RR values mean high rate of digestion and absorption of food having strong positive correlation with AD (0.994) and ECD (0.982). This is noticed in young instars. The poor RR recorded in fourth and fifth instars are due to poor absorption and digestion. Excreta production and RR values depend on the quality of food, retention time, rate of enzyme activity and the ingestion rate. Higher RR values in young instars is due to the feeding habits of the larva on the succulent and nutritionally rich leaf lamina without engulfing the venation zones. These findings have clear conformity with the reports of Anantha Raman *et al.* (1993). Among the host plants, som shows higher RR (1.49) than soalu (1.46) which means larvae fed on som leaves have high rate of digestion and absorption of food and the seasonal variation on RR is non significant. Mathavan and Pandian (1974) have reported RR value of 1.5 in lepidopteran larvae and the present RR values are close to this.

69% and 67% weight gains in fifth instar by larvae fed on som and soalu respectively which is maximum and 22-23 % weight gain has been recorded in fourth instar. The current findings are comparable with the results of Horie (1978), Prabhakar *et al.* (2000) and Sinha *et al.* (2001). Weight gain is higher during October – November due to higher larval duration coupled with higher food consumption and digestion.

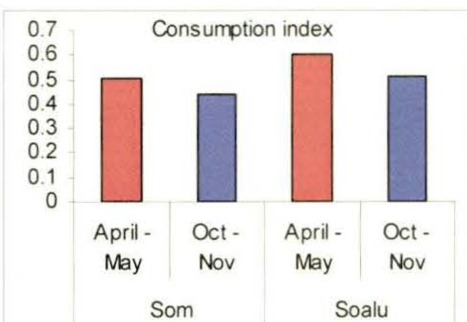


Fig. 9. Consumption index of larvae fed on som and soalu during favourable seasons

Less consumption index is considered to be high efficiency in feed utilization (Trivedy and Nair, 1999). In the present findings, CI is less when fed on som leaves and during October – November (fig. 9) showing higher utilization efficiency in som especially during October – November.

Growth rate explains how much of dry matter increased in the larvae per gram of body weight per day which is lowest in fifth instar as the larval duration of fifth instar is highest. Higher larval duration during October – November is probably the cause behind the lower GR during that period. Slightly high GR on soalu may be due to quality of host or physiological stage of larvae as the influence of GR on rate of development directly depends on these (Prabhakar *et al.*, 2000).

The approximate digestibility (AD) is a precise measure of digestibility to evaluate the best host compared to the amount of food digested (Prabhakar *et al.*, 2000) which is higher in early instars which gradually reduces, lowest being in fifth instar(fig.10). The reduced AD in fifth instar is due to high content of dry matter in the feed (Anantha Raman *et al.*, 1993). The highest AD in early instars may be due to the fact that young larvae are generally selective feeders and feed on the young and succulent leaves which contain low content of crude fibre and is easy to digest (Sinha *et al.*, 1998). The grand mean value of AD for five larval instars fed on som and soalu are 32.835 % and 31.499 % respectively showing better digestibility in larvae fed on som leaves may be due to low content of crude fibre in som leaves. The higher AD and lower CI (fig. 11) of larvae fed on som leaves reflect the fact that the CI varies in a passive manner. When CI increased, the rate of passage of food through the gut increased allowing less time for digestion and assimilation, which results in low AD. On the contrary, when CI decreases, the passage of food through gut becomes slow and facilitates increased digestion and assimilation, which ultimately results in improved AD and other corresponding efficiency parameters. A similar opinion has been made by Trivedi

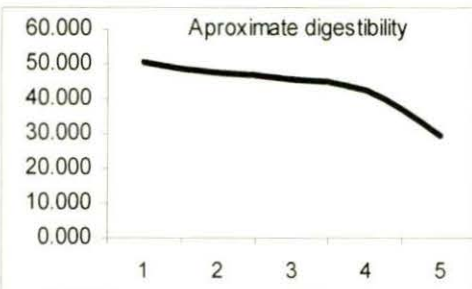


Fig 10 Approximate digestibility of muga silkworm larvae

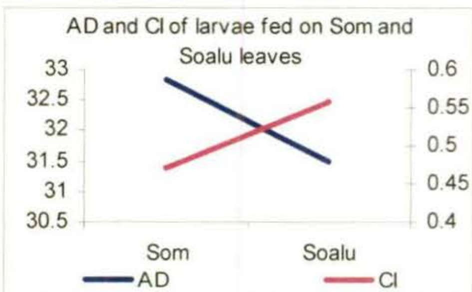


Fig. 11 AD and CI of larvae fed on som and soalu

and Nair (1999) on *Bombyx mori*. No significant difference is there between the seasons on soalu and significantly higher AD is during October – November in som. According to Soo

Hoo and Frankel (1966) the higher AD in winter seasons may be due to high content of nutrients in the leaves.

Efficiency of conversions of ingested food to body substance (ECI) is an overall measure of larval ability to utilize the ingested food for growth. The ECI values are higher in early instars (fig.12) due to the quality of food and small size of the larvae. The low ECI in the late instar is because of aging, duration of instar, poor quality of food and high fibrous content and also low absorption and high utilization of energy for organ development (Matsumara *et al.*, 1955; Horie *et al.*, 1976; Benchamin and Jolly, 1984 and Anantha Raman *et al.*, 1993).

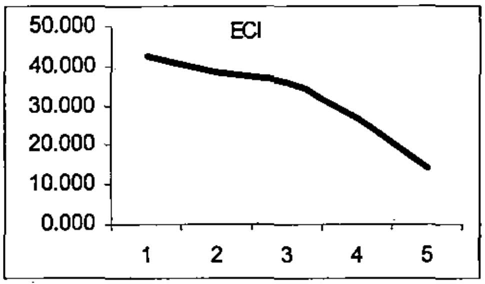


Fig 12 Efficiency of conversion of ingested food of muga silkworm larvae

Non significant variation is there between the two seasons. The grand mean values of ECI over the entire larval period are calculated to be 17.657 % and 16.466 % in som and soalu respectively. According to Hiratsuka (1920), during the larval stage ECI is 23 % and Periaswamy and Radhakrishnan (1985) has the opinion of 13-21 % ECI in *B. mori* larvae fed on different varieties of mulberry leaves. This value has been reported to be 20-30 % in *Menduce sexta* (Waldbauer, 1964) and 20-22 % in *Antheraea mylitta* fed on different types of leaves. The ECI values of the present findings are similar to the other findings on mulberry and other non-mulberry silkworms.

ECD is the proportion of digested food utilized for the body built up. ECD is not directly dependent upon the digestibility but it varies with the level of nutrient intake and the nutritional values of food. Like ECI, ECD values are higher in early instars. It is also evident that ECD sharply declines in the fifth instar where maximum tissue growth takes place having conformity with the opinion of Sinha *et al.* (1998).The grand mean values of ECD is found 53.856% and 52.26% in *Antheraea assama* on som and soalu respectively(fig.13).

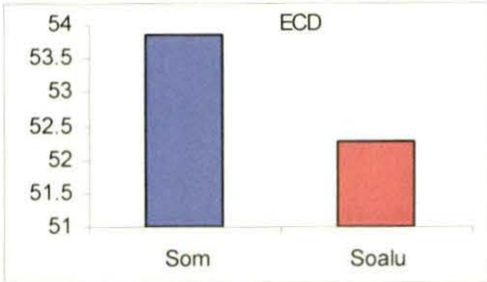


Fig. 13 ECD of larvae fed on som and soalu leaves

The present observations are comparable with the findings of Shyamala *et al.* (1960) who observed 48% ECD in larvae of *B.mori* ; with the findings of Periaswamy and Radhakrishnan (1985) who recorded 36-49% ECD in different mulberry varieties and with the findings of Sinha *et al.* (1998) who recorded 31-32% ECD in *Antheraea mylitta* on different types of leaves. On soalu there observed no significant variation between the seasons while on som the ECD is high in April –May as the AD is lower in that period.

The longer life span and maximum consumption of food during fifth instar are perhaps responsible for the high rate of tissue growth in spite of decline in ECI and ECD. The fall of ECI and ECD in late stages may be due to the fact that the major portion of the ingested and the digested food is metabolized for maintenance of the body and smaller portion of it is used for tissue growth.A strong positive correlation exists between AD and ECI (0.981), AD and ECD (0.971) and ECI and ECD (0.998).

The mean ingesta and digesta in each instar increased as the larval growth progressed. The values were low in young instars and higher in late instars. This tendency is due to lower gut volume , low ingesta and small size of the body (Anantha Raman *et al.*, 1993). MDFI and MDFD are higher when fed on soalu leaves which may be due to shorter larval duration of the larvae fed on soalu leaves (21.845 days) than som (24.191 days). One gram larval dry weight production needs 5.664 gm.ingesta and 1.860 gm. digesta in som and 6.081gm.ingesta and 1.914 gm. digesta in soalu. Lesser ingesta (fig. 14) and digesta requirement to produce unit larval dry weight is due to efficient assimilation by som leaves. Similar findings are reported by Matsumara *et al.* (1955); Horie *et al.* (1976) and Anantha Raman *et al.* (1993).

Fig 14 : Ingesta required per unit growth

The data presently depict that, for a unit larval growth larva fed on som leaves requires less ingesta and digesta compared to soalu leaves. This indicates that larva fed on som leaves has a better efficiency of converting ingested and digested food into body substances.

5.3 Nutritional efficiency of larva on different combination of leaves during favourable season :

Nutritional efficiencies of the larvae fed on som leaves are better than the larvae fed on soalu leaves, still the lower food ingestion, larval duration and mean daily food ingestion by the larvae fed on soalu leaves has provoked to investigate the possibility of better nutritional efficiencies if soalu leaves can be used in different combinations with som leaves. In mulberry sericulture, this approach is well accepted (Ray and Deb, 2007).

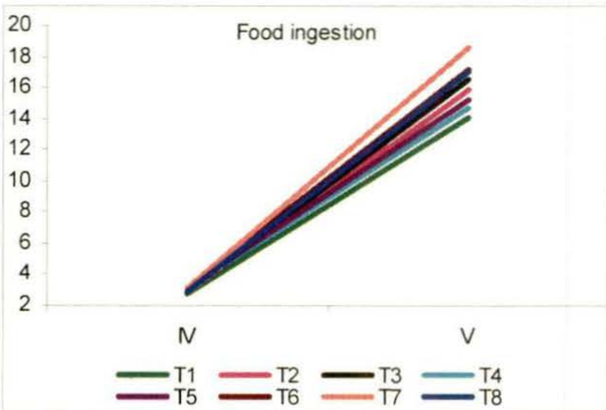


Fig. 15 : Food ingestion in different combination of leaves during IV and V instar

Food ingestion during fifth instar is 80 % of the total consumption of leaves in different combination having similarity with the previous experiment where it is 81 % of the total consumption of leaves of som and soalu. Soalu upto third instar in combination with som for fourth and fifth instar when fed shows highest food ingestion of 22.75 gm, which is higher than som (22.23 gm) or soalu (20.90 gm) alone. Soalu upto second instar and then som fed larvae shows food ingestion slightly lower than som fed larvae alone (21.284 gm). Soalu upto fourth instar and only fifth instar on som shows food ingestion same (20.962 gm) as the consumption by larvae fed on soalu alone (fig. 15). Food ingestion by the larvae fed on som initially and combining soalu instar wise shows lower food consumption than other combinations where soalu from initial stage utilized and combining som instar wise or som / soalu alone (fig.16).

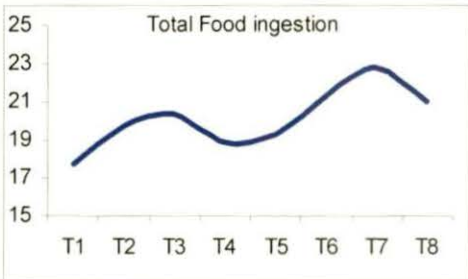


Fig. 16 : Food ingestion in different combination of leaves during total larval period

Digesta, the total quantity of food available to be incorporated as body substances or to be metabolized for energy, is found to be related with the amount of food consumed showing highest in fifth instar and by the larvae fed on soalu upto third instar and som in fourth and fifth instar. Digesta values of combinations soalu upto third and then som (7.982 gm) and soalu upto second and then som (7.417 gm) are better than som or soalu alone (7.338 gm and 6.589 gm) respectively. Soalu upto fourth and then som shows good digesta value even better than soalu alone and nearly same as som alone. In rest of the combinations, the digesta values are lower than som / soalu fed larvae.

Excreta values progressively increase as growth advances. Combinations of leaves show lower excreta than single type food and only in soalu upto third instar and then som combination excreta production is little high than soalu alone. The production of excreta depends on quality of food, rate of food intake, absorption rate and also the retention time of food in the gut. Hence, combination of leaf feeding improves the quality of nutrition.

Reference ratio (RR) in combination as an average is higher than soalu and lower than som. However, combination of leaves in late stages from third instar onwards *i.e.* from third instar, from fourth instar and in fifth instar when som leaves are utilized the RR are higher than som alone and highest in combination where som is used in fourth and fifth instar and during October – November it reaches upto 1.635 while it is 1.518 when fed on som and 1.476 when fed on soalu leaves alone. Higher RR values mean high rate of digestion and absorption of food (Anantha Raman *et al.*, 1993) which means that combination of leaf, soalu upto third instar and som in fourth and fifth instar when utilized as food the larvae shows higher digestion and absorption rate than any type of food consumption. RR value of 1.5 in lepidopteran larvae as reported by Mathavan and Pandian (1974) is at par in that combination (1.536).

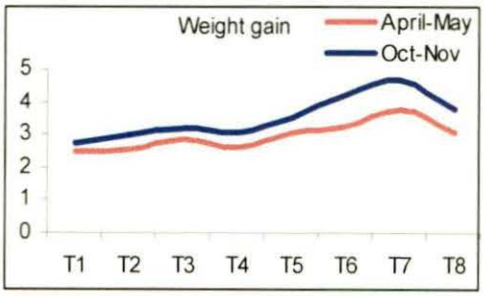


Fig. 17 : Weight gain by larvae fed on different combination of leaves

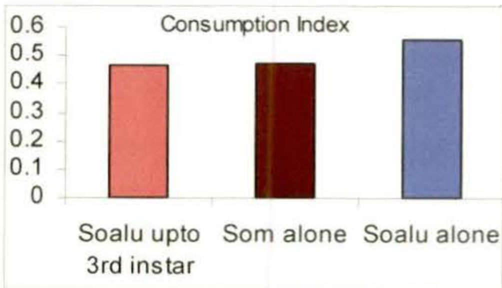


Figure 18 : Consumption index fed on som, soalu and different combination of leaves

Weight gain by the larvae fed on som leaves is 3.926 gm and on soalu leaves is 3.446 gm. Higher weight gain of 4.208 gm is achieved by the larvae fed on soalu upto third instar and then som and no other combination can able to achieve the weight gain by the larvae fed on som and only the combination upto second instar soalu and then som can able to achieve the weight gain better than soalu. Higher weight gain during October – November (fig. 17) is due to longer larval duration coupled with higher food consumption and digestion.

Consumption index as a whole in combination is 0.543 which is higher than single leaf utilization. But when soalu used upto third instar followed by som the CI is lower than som leaf fed larvae also (fig.18). Moreover, when soalu used in early stages namely upto second instar and upto fourth instar CI are lower than soalu alone and higher than som alone. As less consumption index is considered to be high efficiency in feed utilization (Trivedy and

Nair, 1999), best efficiency in feed utilization on soalu upto third instar and som in fourth and fifth instar.

Growth rate explains how much of dry matter increased in the larvae per gram of body weight per day which is lowest in fifth instar as the larval duration of fifth instar is highest. Early stages soalu and late stages som combination shows GR higher than som alone and lower than soalu alone which is due to the difference in larval durations.

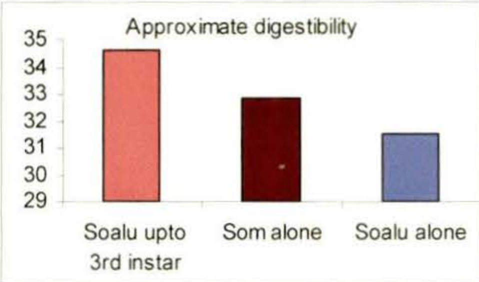


Figure 19 : Approximate digestibility of the larvae fed on Som, Soalu and better combination of leaves

Approximate digestibility (AD) has been recorded higher in som than soalu fed larvae. Combination of leaves on an average shows lower AD in larvae than som fed larvae. Still, combination of leaves as soalu upto second instar, upto third instar and upto fourth instar (fig.19) gives higher AD than the larvae fed on som alone showing better digestibility in larvae fed on these combinations especially from soalu upto third instar and som in fourth and fifth instar which may be due to low content of crude fibres in som leaves as late stages consume nearly 85 % of leaves. The higher AD and lower CI of larvae (fig. 20) fed on the above mentioned combination reflect the fact that the CI varies in a passive manner. When CI decreases, the passage of food through the gut becomes slow and facilitates increased digestion and assimilation as opined by Trivedi and Nair (1999), which ultimately results in improved AD in the combination, soalu upto third instar and som in fourth and fifth instar.

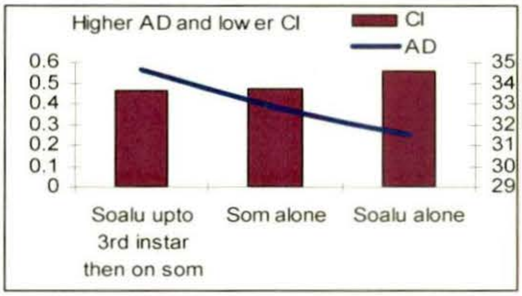


Figure 20 : AD and CI of larvae fed on som, soalu and better combination of leaves

Efficiency of conversion of ingested food to body substance (ECI) which is an over all measure of larval ability to utilize the ingested food for growth is higher than the som leaf feeding alone (better among som and soalu) only from the combination soalu upto third instar and som for rest two instars (fig. 21). As the single leaf feeding, combination of leaves show higher ECI values in early instars which is due to the quantity of food and small size of the larvae and lower ECI values in late instar is due to ageing, duration of instar, poor quality of food, high fibrous content and also low absorption and high utilization of energy for organ development (Matsumara *et al*., 1955; Horie *et al*., 1976; Benchamin and Jolly, 1984 and Anantha Raman *et al*., 1993).

Efficiency of conversion of digested food (ECD) is the proportion of digested food utilized for the body built up. Som leaf feeding shows ECD 53.856 % and soalu leaf feeding shows ECD 52.260 % (fig. 22). Except the combinations soalu upto third instar and som for the rest (54.204 %) and soalu in first instar and som for the rest all other combinations show lower ECD than single leaf feeding. ECD is not directly dependent upon the digestibility but is varies with the level of nutrient intake and with the nutritional value of the food which means that the abovementioned combination of leaf improves the nutritional value of food as well as the increased nutrient intake which ultimately improves the nutritional efficiency of the larvae.

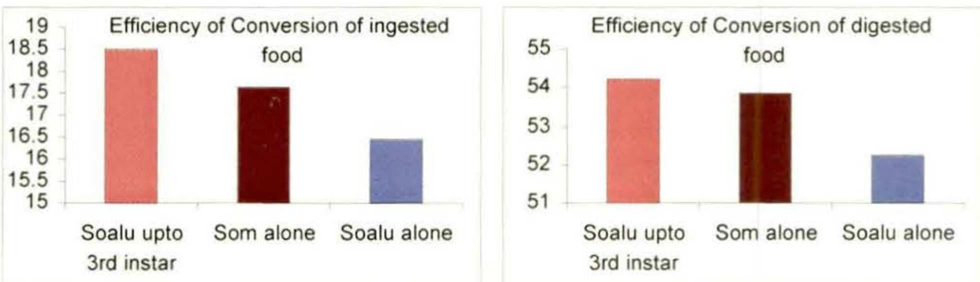


Fig 21 and Fig 22 : ECI and ECD of larvae fed on som, soalu and better combination of leaves

The mean ingesta and digesta in each instar increases as the larval growth progresses. MDFI and MDFD of the combination of leaf by the larvae are on an average 0.865 gm and 0.278 gm respectively which are lower than the single leaf feeding which may be due to shorter larval duration. However, the combination of soalu upto third instar followed by fourth and instar shows slightly higher MDFI and MDFD due to longer larval duration than single leaf feeding.

Lowest ingesta requirement to produce one gram larval body weight is 5.407 gm in the combination soalu upto third instar followed by som which is even lower than the som alone (lower than soalu) where the value is 5.664 gm (fig. 23). Digesta requirement to produce one gram larval body weight is also lowest in combination soalu upto third instar followed by som (1.873 gm), which is close to the som alone (lower than soalu) where the value is 1.860 gm (fig. 24). Lesser ingesta and digesta requirement to produce unit larval dry weight is due to efficient assimilation by the aforementioned combination of leaves (Matsumara *et al.*, 1955; Horie *et al.*, 1976 and Anantha Raman *et al.*, 1993).

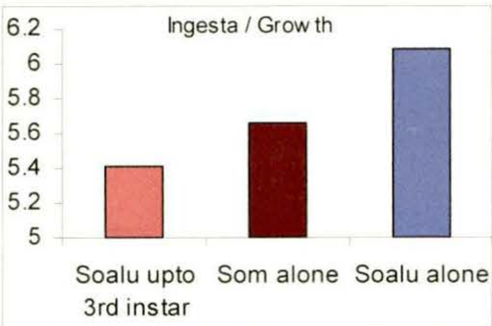


Fig 23 and Fig 24 : Ingesta and Digesta required for one unit growth of larvae fed on som, soalu and better combination of leaves

From the above discussion it can be said that higher reference ratio, AD, ECI, and ECD as well as lower CI, ingesta/growth, digesta/growth in the larvae fed on soalu upto third instar and then on som (fourth and fifth instar) leaf compare to any other combination or som or soalu leaf feeding alone made this combination better efficient in conversion of ingested and digested food into body substances. Still, this combination and slightly lower performing combination *i.e.* soalu upto second instar followed by som (third, fourth and fifth instar) as well as som alone (better than soalu alone) should be assed in detail taking all the seed crop as well as commercial crop rearing seasons under consideration and their conversion efficiencies in cocoon, cocoon shell and egg before going to any strong recommendation towards the food selection.

5.4 Nutritional efficiencies of larval instars fed on better-selected host plant as well as better combination of leaves during different seasons.

Nutrition efficiencies of larvae are considered important to assess the cost benefit ratio of sericulture practice up to the level of cocoon production. The efficiency of converting the ingested and digested food into the body varies among silkworm races under the influence of season and host plant verities (Anantha Raman *et al.*, 1995). The host plant has profound effect on relative survival behaviour, rate of food intake, digestion and assimilation, which directly influence growth, and development of silkworm (Krishnaswami *et al.*, 1970; Sinha *et al.*, 1993; Rahaman *et al.,* 2004; Balakrishna *et al.*, 2005 and Ray *et al.*, 1998). Nutritional status of host plant varies season wise, which has a direct effect on food consumption and utilization. An extensive study on nutritional efficiency of larvae has been made during the commercial crop growing seasons (October – November and April - May) as well as during the seed crop growing seasons (August - September and February – March) and during most adverse season in June-July to assess the impact of feed : better screened host plant, som as well as the combinations better observed in previous study (Soalu upto III instar and som in IV and V instar and soalu upto II instar and som in III, IV and V instar) for selection of food source to the larvae for better silk and seed output.

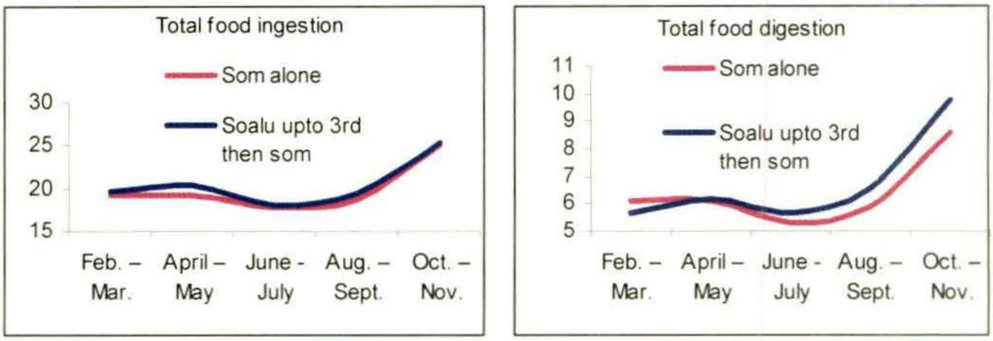
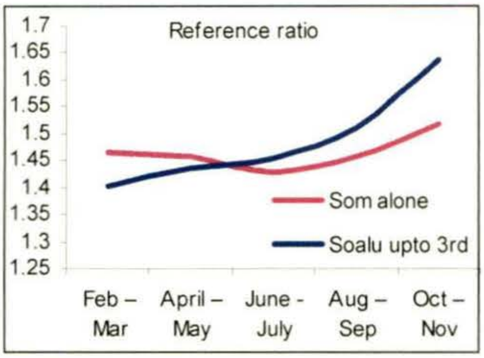


Fig. 25 and 26 : Total food ingestion and digestion by larvae fed on som, and better combination of leaves

Food ingestion is highest in combination where soalu and som are in combination of up to III instar and IV and V instar respectively followed by som alone. Seasonal variation shows higher food ingestion by the larvae fed on that combination in every season followed by som alone in every season except August – September where food ingestion is lowest from som. Moreover, food ingestions are higher during commercial crop remaining seasons followed by seed crop rearing season (fig. 25). As a whole digesta values are higher in upto III instar and then som; only during February-March, digesta values are higher in som alone (fig. 26). Like ingesta, digesta values are higher during commercial crop rearing seasons. Reference ratio, the expression of absorption and assimilation of food is highest in the combination soalu upto III instar then in som (fig. 27). Non-significant variation among the treatments in all the seasons except during October – November and August – September where combination of leaves show higher than som alone reflects similar rate of absorption and assimilation of food through out the seasons and seasonal average in RR varies from 1.466 to 1.489 among the treatments having conformity with Mathavan and Pandian (1974). Weight gain by the larvae is best in combination soalu up to III instar then som in all the seasons and highest during October - Novemb er (fig. 28) due to higher larval duration coupled with higher food consumption and digestion. Som alone when fed to the larvae shows better weight gain.



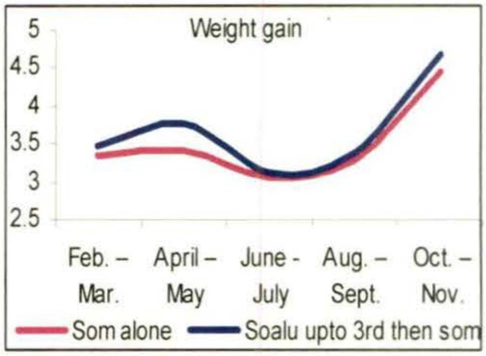
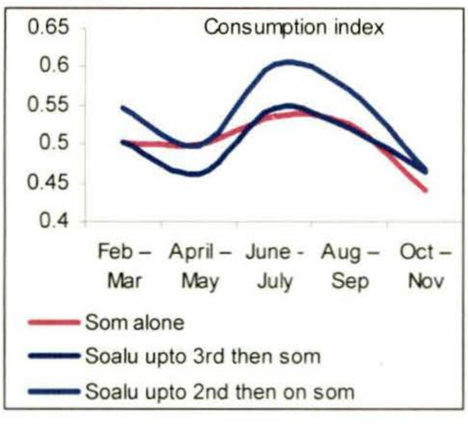


Fig. 27 and 28 : Reference ratio and weight gain by larvae fed on som, and better combination of leaves

Less consumption index is considered to be high efficiency in feed utilization (Trivedy and Nair, 1999). Lowest consumption index in the larvae fed on soalu up to III instar and then som (fig. 29) in the present investigation means higher efficiency in feed utilization than from any other food source .Feed utilization efficiency by som alone is also better due to lower consumption index and during October - November the lowest consumption index reflects highest feed utilization efficiency during that time.



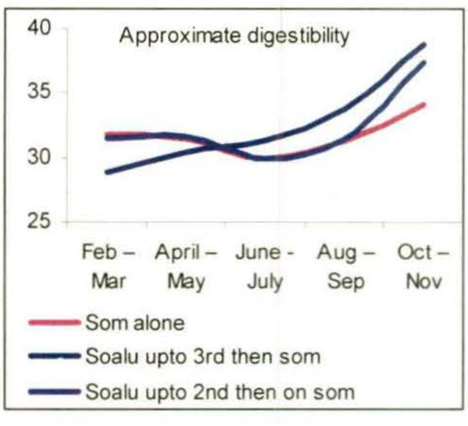
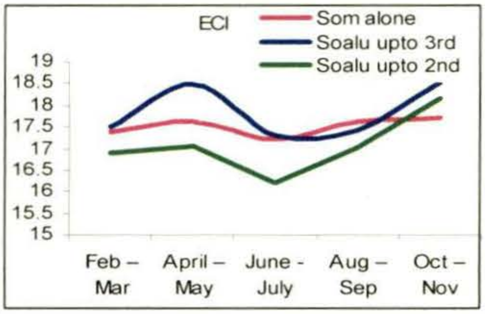


Fig. 29 and 30 : Consumption index and approximate digestibility by larvae fed on som, and better combinations of leaves

So far as five seasons considered, approximate digestibility is highest in combination of leaves than single leaf feeding. Lower CI in combination of leaves makes the passage of food through gut slower facilitating increased digestion and assimilation by the larvae fed on combination of leaves, which ultimately results in improved AD and other corresponding efficiency parameters. AD found higher during October – November (fig. 30) may be due to high nutrient content of leaves in winter seasons as reported by Soo Hoo and Fraenkel (1966).

Efficiency of conversion of ingested food (ECI) is highest in combination of leaf in the form of soalu up to III instar and then som (fig. 31) means larvae have the highest ability to utilized the ingested food, growth best when fed on that combination of leaves and it has been also noticed that higher ability to utilized that ingested food is from som fed larvae. Efficiency of conversion of digested food (ECD) shows significant variation among som leaf feeding and combination as soalu up to III instar then som. However, during October – November ECD is higher in single leaf fed larvae than the larvae fed on combination of leaves (fig. 32).



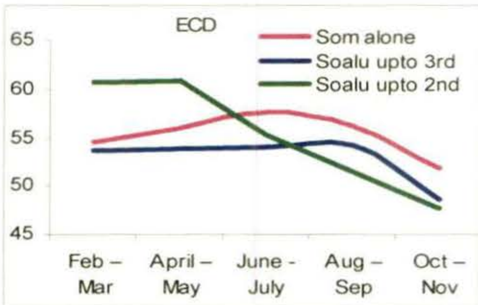


Fig. 31 and 32 : ECI and ECD by larvae fed on som, and better combinations of leaves

Mean daily food ingesta and digesta are higher in the combination soalu up to III instar followed by som. Ingesta requirement to produce one-gram larval weight is lowest by the combination soalu up to III instar and then som for IV and V instars, which is due to higher efficiency of assimilation by that combination of leaves. Digesta requirement to produce one gram larval weight is also lower in combination of leaves soalu up to III instar and then som and in som leaf alone (fig. 33).

The utilization of the feed of insect is determined by the capacity to ingest, assimilate and efficiency to convert it into the body tissues (Scriber and Slansky, 1981) which is further determined by the leaf quality, which varies seasonally (Ueda *et. al,* 1969; Junliang and Xiaofeng, 1992). The present experiment on the three types of feed utilization primarily screened from other types shows that there are variation in utilization efficiency within a period and also in different seasons.

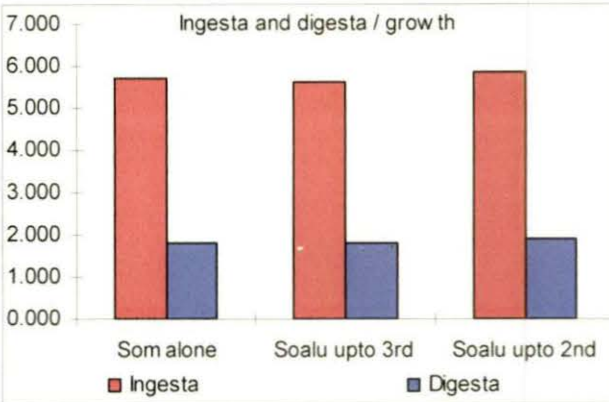


Fig. 33 : Ingesta and digesta required per unit growth of larvae fed on som, and better combinations of leaves

The present study reveals that nutritional efficiencies in the form of approximate digestibility, efficiency of conversion of ingested and digested food are better when fed on leaves in combination in the form of soalu up to III instar and som in IV and V instar than any other combination of leaves or som alone. Lower consumption index associated with lower ingesta requirement to produce one-gram body weight, the most important part of nutritional efficiency, are also in the combination in a year round observation. According to Dutta *et al.* (1996) suitable host plant should be selected on basis of its consumption, digestibility and the growth of larvae and according to Remadevi *et al.* (1992) ECI/ECD can be considered as indices for the physiological efficiency of any breed. The present finding regarding the suitable host plant selection is also on the basis of those opinion.

As the larval stage is completely exposed to environment, the fluctuation in the environment has a drastic effect on the larvae. The major ecological factors namely, temperature and relative humidity besides physiological conditions of the insect greatly influence the nutritional ability and feeding activity of silkworm. Observation also reveal that food consumption is better in October-November having conformity with Dutta *et al.* (1996) who opined that autumn is better than spring and summer. Seasons also showed significant influences on the conversion abilities of silkworm breed. In most of the cases, the higher ECI and ECD values are noticed during winter followed by monsoon and summer. Seasonal influences on the nutritive parameters clearly suggest the importance of leaf moisture in the palatability and assimilation of nutritive components of the leaf (Gokulamma and Reddy, 2005). In the present study, higher ECI and ECD were observed during October- November very close to winter months. An increased digestibility and assimilation ability at lower temperature is an artifact of lower activity. Food passing more slowly through the gut allows more time for digestion and absorption to occur. At higher temperatures, food passes through the gut more rapidly and are exposed to enzymatic action and uptake for a shorter period of time, which result in the lower digestion and assimilative abilities during summer months. Moreover, according to Remadevi *et al.*, (1992) better efficiency of conversion of ingested and digested food in any season makes the season most suitable for successful exploitation which may be due to suitable temperature, humidity and nutritionally superior leaves during that season. As a consequence, for mugaculture from present observation it is noticed that October – November and April – May are suitable due to better conversion ability of food during that period. Furthermore, lowest ECI/ECD during June – July and August – September reveals that high temperature alongwith high humidity during the larval life have the adverse effect on nutritional efficiency showing adverse season for mugaculture. Basavarajau *et al.* (1998) according to whom bivoltine silkworm are very sensitive to higher temperature and shows a decreasing trend in ECI and ECD, has made similar observation on BV-silkworm.

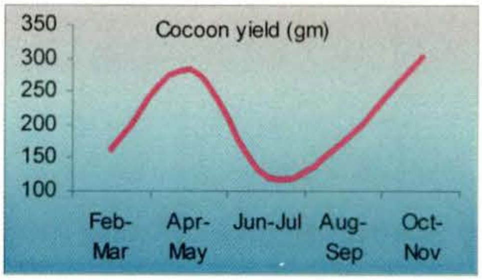


Fig. 34 a : Cocoon yield during different season from 100 brushed larvae

Economic parameters namely single cocoon weight, effective rate of rearing for silk output and fecundity as well as effective rate of rearing for seed output are better in the combination soalu up to third instar followed by som for rest instars .Comparative seasonal performance indicates that October-November and April-May are the better seasons for cocoon weight and ERR showing the suitable commercial crop rearing seasons (fig. 34 a) and February –March and August – September should be the better option for seed production as the fecundity and ERR reflecting the total seed output are satisfactory. Though during June – July the fecundity is better the seed production is less due to very low ERR (fig. 34 b). So, it can be said that for commercial crop rearing as well as for seed crop rearing soalu upto III instar and than som leaf utilization may be the most suitable food source for better muga silk worm rearing. However, the conversion efficiency into cocoon, shell and egg should be assessed for final recommendation.

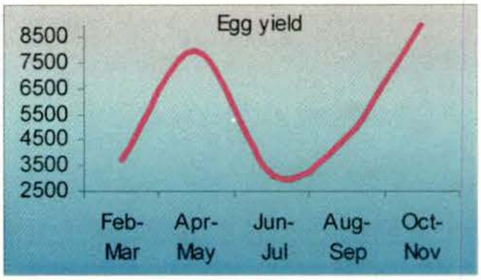


Fig. 34 b : Egg yield during different season from 100 brushed larvae

5.5. Conversion efficiency to cocoon, cocoon-shell and egg of best performed host plant during different season :

ECI and ECD to cocoon and shell are the two efficiency parameters, which are of paramount importance in practical sericulture (Trivedi and Nair, 1998). These two parameters are the ultimate indices to evaluate the production efficiency of a breed in terms of the production of cocoon shell percentage vis-à-vis the food consumed (Machii and Katagiri, 1991).

The percentage of ECI and ECD to cocoon is highest when larvae fed on soalu upto III then som was utilized in last two instars. Lowest values of ECI and ECD are observed in the combination where som leaves are utilized in last three instars (fig. 35). Ingesta and digesta requirement to produce one gram cocoon is less in the combination where som are

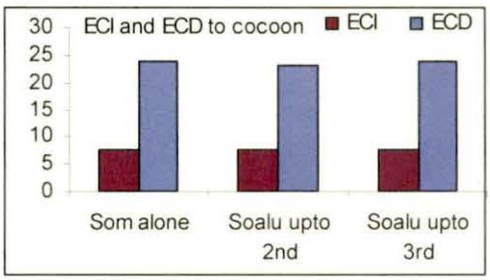


Fig. 35 : ECI and ECD to cocoon by larvae fed on som, and better combination of leaves

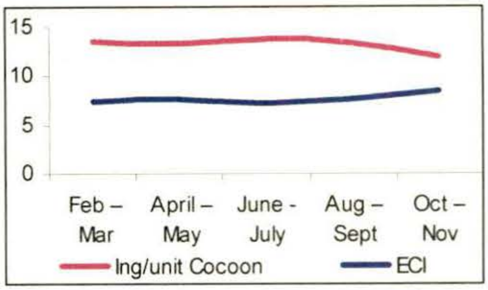


Fig. 36 : Seasonal variation of ECI and ingesta required per unit cocoon production

utilized in last two instars. Singh and Ninagi (1995) also reported that less food ingested and digested batches have high ECI and ECD to cocoon. This may be due to the fact that less choice of feed leads to some physiological adoptions to overcome nutritional stress condition (Nath *et al.*, 1990a and 1990b; Tzenov, 1993). Moreover, efficiency of conversion of ingested food to cocoon is higher during October – November and April – May and at the same time during these periods ingesta requirement to produce one gram cocoon is lower (fig. 36). This observation justifies the commercial crop rearing during these periods.

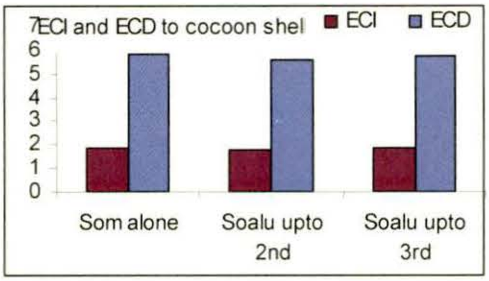


Fig. 37 : ECI and ECD to cocoon shell by larvae fed on som and better combination of leaves

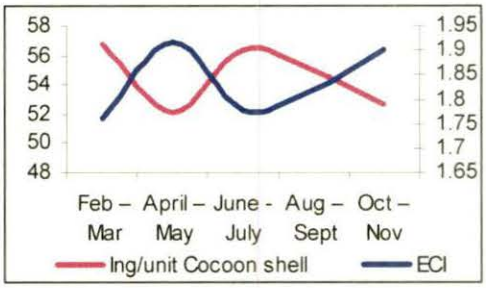


Fig. 38. Seasonal variation of ECI and ingesta required per unit cocoon shell production

ECI to shell is highest when combination of leaves as soalu upto III instar and then som is utilized and ECD to shell is non- significantly highest in som alone, the ECI and ECD to shell are lowest in combination soalu upto II and then on som. Ingesta requirement to produce one-gram shell is less in the combination soalu during I, II, and III instar and som during IV and V instar (fig. 37). However, digesta requirement is lower in som alone followed by the aforementioned combination. The report made by Singh and Ninagi (1995) is also found similar in the present study where soalu upto III instar then som combination has lower ingesta requirement to produce one-gram shell, having higher ECI and ECD values. During October – November and April – May ingesta requirement to produce one-gram shell is less with high efficiency of conversion of ingested food (fig. 38).

So, it can be concluded that for silk production commercial crop rearing seasons are October – November and April – May and where both the host plant are present, soalu upto third instar followed by som leaves in forth and fifth instar would be the best food supply otherwise only som leaves feeding would be quite satisfactory. Moreover, as only 5% of total leaf consumption is the requirement for early instars (I to III), plantation of soalu may be done is a small portion for better food supply (fig. 39).

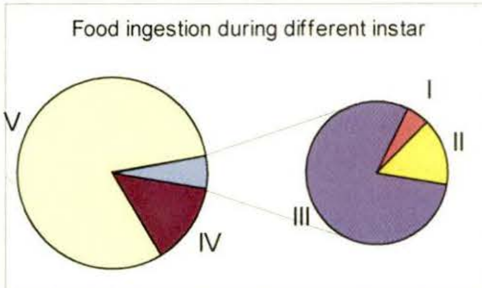


Fig. 39. Larval feeding in different instars

For seed production, ECI and ECD to egg are the two efficiency parameters which are to be considered. ECI to egg was also the highest when soalu upto III instar and rest on som is utilized as food. However, som alone when supplied although the instars shows better ECI to egg (fig. 40). Moreover, though during October – November the conversion efficiency of

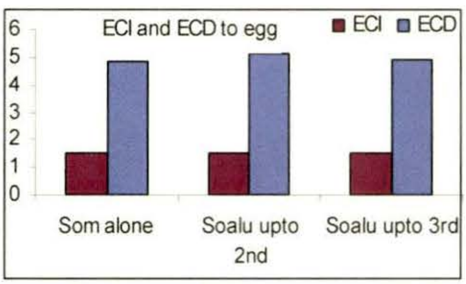


Fig. 40 : ECI and ECD to egg by larvae fed on som and better combinations of leaves

ingested food to egg is higher than February – March and August – September efficiency of conversion of digested food to egg is better during the later two seasons. Ingesta requirement to produce one-gram egg is less in the combination where soalu upto third instar and rest on som is used and som alone. However, digesta requirement to produce one gram egg is less in soalu upto II instar and then som combination having non significant variation with som alone while som alone has non significant variation with the combination soalu upto III instar followed by som. Ingesta requirement is lower during October – November and April – May while digesta requirement to produce one-gram egg is less during August – September and February – March (fig. 41 a, b).

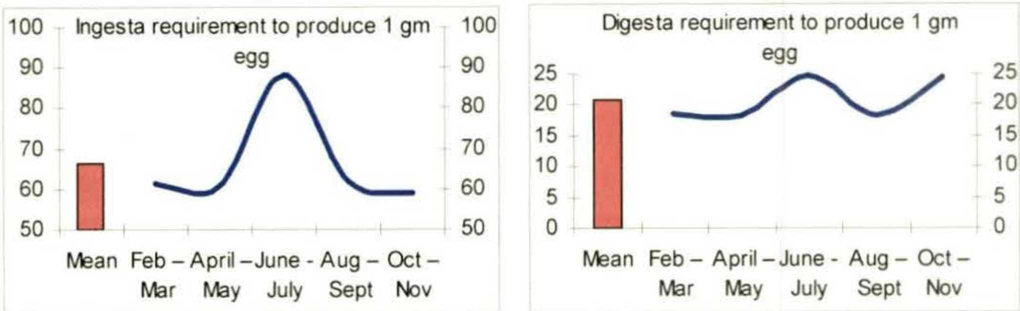


Fig. 41a and 41b. Ingesta and digesta required to produce 1 gm egg during different season

So, for seed production August – September and February – March can be utilized successfully to supply the egg for commercial rearing during October – November and April – May and soalu upto III instar followed by som during IV and V instar should be utilized for better silk and seed yield as the nutritional efficiencies of muga silk worm larvae are better on the particular feed as well as during those particular season.