NUTRITIONAL ECOLOGY OF THE MUGA SILKWORM, *Antheraea assama* WESTWOOD AND EFFICIENCY OF CONVERSION TO ECONOMIC CHARACTERS ON TWO MAJOR HOST PLANTS IN INDOOR REARING

Thesis Submitted to the University of North Bengal
for the degree of Doctor of Philosophy (Science)

By

Uddalok Bhattacharyya

Department of Zoology

North Bengal University

Raja Rammohanpur, Darjeeling

2008

Dedicated to

my

Beloved Daughter

Dr. Nilay Ray
Reader,
Post Graduate Department of Zoology
&
Principal Investigator
Muga Research Laboratory
Acharya B.N. Seal College,
Cooch Behar 736 101
West Bengal, India

Phone : (03582) 226 112 (O)
(03582) 250 491 (R)
(+91) 9434081128 (M)
Fax : (03582) 226 112
(03582) 250 047
E-Mail : watchnilay@gmail.com

Ref. No . ...

Date ... ...

CERTIFICATE

*This is to certify that the thesis titled '**Nutritional ecology of the muga silkworm, Antheraea assama Westwood and efficiency of conversion to economic characters on two major host plants in indoor rearing**' embodies the records of original investigation carried out by Mr. Uddalok Bhattacharyya, M.Sc. under my supervision. Mr. Bhattacharyya worked on this topic for about six years.*

Mr. Bhattacharyya has fulfilled the requirements of the University of North Bengal for his thesis. I am pleased to forward this thesis for submission to the University of North Bengal for consideration for the award of the degree of Doctor of Philosophy (Ph. D) in Science (Zoology).

4/12/08

(NILAY RAY)
Reader,
Post Graduate Department of Zoology
Acharya B.N. Seal College, Cooch Behar

READER
P.G. DEPARTMENT OF ZOOLOGY
A.B.N. Seal College
Cooch Behar

ACKNOWLEDGEMENT

With a sense of deepest gratitude, I do express my immense indebtedness to Dr. N. Ray, Reader P.G. Department of Zoology, A.B.N. Seal College, Coochbehar, for his able guidance, kind co-operation, constructive criticism and above all, his unfailing and friendly behaviour and unremitting help during carry out of the work and preparation of this manuscript.

With profound glee, I extend my gratefulness to, all teacher of Department of Zoology, NBU. I would like to convey my profound gratitude to Dr. D. C. Deb, Ex-Prof. Department of Zoology, NBU., Dr. D. Sarkar of UBKV, Pundibari, Cooch Behar for providing expert and benevolent co-operations. It is a pleasure on my part to acknowledge the debt I owe to Samiran Ghosh and Atis Sarmadhikari of A.B.N. Seal College, Cooch Behar and Head Master and staff of Baneswar Khabsha High School for their help and enormous encouragement during the course of investigation.

Sincere thanks are extended to S.K. Das, Deputy Director and all other staff of the Department of Sericulture, Govt. of West Bengal for their sincere co-operation during the period of my work. Thanks to the Director, CSR&TI, Central Silk Board, Beharampur for library facility as and when required.

In omega, I cannot but admit that my words fail to express my cordial love and unfathomable gratitude to Indra for his never-ending heartfelt benedictions and unstinting inspirations which always act as my saviour in the face of all sorts of perils. I warmly thanks to Supriya for valuable assistance during preparation of thesis.

I express my lot of thanks to Deep, Ujjal, Rajat and Prasenjit for their sincere co-operation during the course of my work.

Special thanks to my wife for her co-operation and inspiration during my work. My words fail to express the unfathomable gratitude to my parents and brother who extended me a helping hand and affectionate care and constant encouragement with a smile of love and waited patiently for the day I complete my work.

In thanking all these people, I must emphasize that I am fully responsible for any shortcoming that remains.

Uddalok Bhattacharyya.

Dated: 08.12.2008
Cooch Behar

(UDDALOK BHATTACHARYYA)

Content

Chapter - I

INTRODUCTION

From the dawn of empire, cloths or fibre is important among the basic needs of human. Among the fibres silk has been obtained the position of emperor by virtue of its magnificence, shine, endurance and favorable usefulness, although share of silk among world production of textile fibres is just 0.15%. Today, sericulture is practiced in industrially developed as well as developing countries and has been verdict as the queen of textiles for ages. At present 60 countries are involved in sericulture in the globe.

Silk is the protein fibre produced by silkworm larvae during spinning to produce a protective case called cocoon. After processing the cocoons, the silk is get hold of the filaments from the cocoon through reeling process. The silkworms not only produce cocoons from which the valued silk is obtained but it has other areas of uses. Indian tribes use the mature larvae as food. Huge quantity of discarded pupae after reeling operation may be used as food of fish. The product of silk waste is very cheap and available easily from reeling centers. They are use in the handicraft as raw materials and they are transformed to attractive greeting cards, festoon, flowers, wall hangings and carpets, hankeys etc.

Sericulture is not only the production of cocoons and silk for income generation, but has become the weft of the cultural fabric of the Asian countries in general and India in particular. Silk has a long tradition with pivotal role in Indian culture. It is a cottage industry spread over 53,184 villages in India, employing 5.8 million people and it is potential tool for the improvement of economic condition in rural area, involving the marginal and small farmers. Besides, sericulture has been accepted as a strong instrument of poverty alleviation and generation of rural employment for India, as 70% of the gross population of the country are rural and depend on land-based activities for their livelihood. Sericulture has also been considered as a women friendly profitable enterprise ensuring the activity for socially deprived 50% women population of rural India.

India has the unique distinction of producing all five varieties of silk of commerce viz. mulberry, oak tasar, tropical tasar, eri and muga. India is the second largest producer of both the mulberry and tasar varieties of silk in the world with a share of 18% and 10% of the total respectively, while the golden yellow muga silk is produced only in India (Benchamin and

Giridhar, 2005). The Indian sericulture industry has grown many folds since independence, *i.e.* from about measure 900 MT in 1950 to the present production level of about 19000 MT in 2007 (table 1, fig. 1).

Table 1 : Raw silk production - India (Unit: MT)

Variety	2003-2004	2004-2005	2005-2006	2006-2007
Mulberry	13,970	14,620	15,445	16,805
Tasar	315	322	308	325
Eri	1352	1448	1442	1515
Muga	105	110	110	115
Total	15,742	16,500	17,305	18,760

Source : Silk prices, *Indian silk*, vol. 46(2), 2007 and vol. 44(5), 2005.

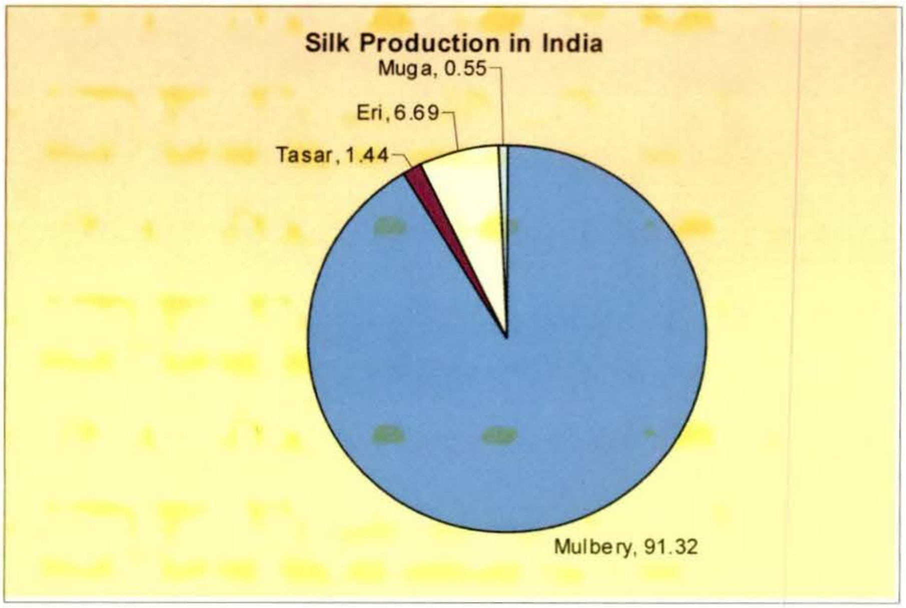


Figure 1 Silk production in India

"Wild silk" or "Non-mulberry silk" includes that fiber spun by various species of silk spinning insect, belonging to the Saturniidae, Lasiocampidae, Thaumetopoeidae, Paychidae families and others. Among these, many species from the Saturniidae produce a large size cocoon which is made by porous cocoon filaments and is different from *Bombyx* silk. The porous raw silks have a more complicated high shining than the *Bombyx* silk. Moreover, the porous cocoon filaments inhibit UV transmissivity by their repeated reflections in the textiles and also the fabrics woven by the porous silks are soft against the skin and are favored by the consumers.

On the other hand, sericine solution and powders from the wild cocoons or silks are used in cosmetics and are highly appreciated by users. For these reasons, wild silks are now recognized as a new material and have a high additional value, which is activating the silk industry.

Raw silk produced by *Bombyx mori* is the most popular textile material for high class fabrics and its uniqueness is highly praised, especially its special sheen. However, the silks of *A. yamama* and *A. assama* are even shinier than that of *B. mori*. The reasons probably because the wild silks have fine porous structure in the filament. In a compact cocoon filament like that of *B mori*, the incident rays pass straight through the filament while in the porous filament, fine porous structures create repeated reflections, hence, a more complex shine. Commercially, porous silk is highly valued because of its sheen, soft feel and the retention of desired warmth and comfort in the fabric (Akai, 2005).

This family makes a large cocoon which sells for a high price characteristics of the cocoon or the cocoon filament mainly its natural cocoon colour and porous filaments or thick and fine size are greatly appreciated by users. The cocoons of *Antheraea yamamai* are beautiful (green in colour) and extremely high priced. The *Antheraea pernyl* cocoon and si lk are produced in great quantities in China and are used widely. The *Samia cynthia ricini* cocoon is produced in India and other Asian countries and the filament is characterized by its porosity and fine size while the *Antheraea mylitta* cocoon is largest in size and filament. *Antheraea assama* produces a golden coloured raw silk, which is well known only, restricted to India, more preciously North-East India and northern West Bengal, and holds a high Price (table 2).

Table 2 : Silk price in India

Variety	Price (Rs/kg)			
	2004	2005	2006	2007
Mulberry silk	1053	1094	1343	1248
Taser silk	1450	1468	1575	1575
Eri silk	1100	1000	1000	1200
Muga silk	3150	2950	2950	3150

Source : Silk price, *Indian silk*, vol **46**(2) : 2007, **45**(2) : 2006, **44**(6) : 2005

Mulberry silk is found in different parts of the country, while the distribution of muga silkworm is mainly confined to the Brahmaputra valley of Assam and foot hills of East Garo hills of Meghalaya. Muga silk is produced by a variety of silkworm, *Antheraea assama*. In muga silkworm rearing, the worms feed on som and soalu leaves that are aromatic and rearing is done on trees. 100% muga silk produced from this region which share 6% of total silk production of the country.

Muga silkworm have about six overlapping generation in a year (Scitz, 1933). Out of six broods of muga silkworm, two are popular for commercial rearing (Thangavelu and Sahu, 1986; Yadav and Goswami, 1999) which are conducted during spring and autumn because the climatic conditions during the period are favourable for growth and development of muga silkworm as well as less environmental hazard. Muga silkworm *Antheraea assama* Westwood, being wild, reared outdoors, and hence prone to natural hazard such as high temperature, heavy winds or rain, hail storms etc. apart from falling prey to pests and predator. Autumn and spring were found as the most ideal seasons in Assam and the commercial rearing on large scales were conducted only during these periods, however, in seed zone rearing was carried out surrounding the year.

To increase the productivity three basic problems should be solved. Firstly, production loss due to field rearing should be minimized. Muga silkworm being reared outdoor on natural host plant suffers heavily due to the vagaries of the weather and pest attack leading to crop loss. Moreover, early larval instars suffer more from environmental hazards. Loss during early instars due to natural biotic and abiotic hazards minimizes the survivability leading to crop loss and ultimately poor silk productions. Therefore, to overcome this problem, scientists of Assam are trying to adopt indoor rearing (Thangavelu and Sahu, 1983, 1986; Azad *et al.*, 2000; Hazarika and Deka, 2002).

In terai region of West Bengal also, the environmental hazards affect muga culture, for this reason preliminary studies had been conducted to investigate whether at least partial indoor rearing can overcome the loss to some extent (Biswas and Ray, 2005; Ray, 2003; Ray *et al.*, 2005). Still, the complete domestication of the worm could not be made successfully. It is obvious that before attempting indoor rearing of muga silkworm, a detailed knowledge about its feeding behaviour, physiology of feeding and digestion are essential. Recent studies by Dey *et al.* (1999, 2002) on feeding behaviour have some important suggestions for indoor rearing which will certainly help in preparing the indoor rearing techniques.

Secondly, as the muga silkworm larvae fed on different host plants primarily on som and soalu, selection of host plant for rearing is the foremost work. 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; Ray *et al.*, 1998; Rahaman *et al.*, 2004 and Balakrishna *et al.*, 2005). The amount, rate and quality of food consumed by a larva influence different parameters like growth, developmental time, final body weight, survival and reproductive potential (Das and Das, 2003). The insect feeds mainly on leaves of som (*Persea bombycina*) and soalu (*Litsea polyantha*). Soalu plant is naturally occuring host plant though systemic plantation of som plant for muga culture has been made. In this present situation a comparative analysis of these two host plants as well as their combinations are required especially on the basis of nutritional efficiency of the larva for selection of the host plant for successful muga culture for both commercial and seed crop.

Thirdly, extension of mugaculture outside the north-eastern states should be explored. Terai region of West Bengal particularly Cooch Behar district has choosen as non-traditional belt from last two decades (Singha *et al.*, 1991; Ray *et al.*, 2005). In Cooch Behar district, the district under consideration, there present micro climatic variations with Assam. This variations might effect the Muga culture in West Bengal. So, the climatic variation should be studied and a separate crop schedule should be prepared for successful Muga culture. In this context, in present study environmental factors will be assessed.

Bodenheimer (1928) who was one of the first to propose that the population of insects was primarily controlled by weather, which affects their development and survivability. While formulating his idea on the effect of low temperature on the rate of egg laying and the speed of development he observed the large-scale mortality (85-90%) of the insects caused by weather in their early stages. Uvarov (1931) regarded weather factors to be the major agents responsible for controlling populations and laid stress on correlation between insect population and weather. He emphasized the instability of populations in nature and doubted that all populations are in a stable equilibrium in nature. The most desirable form of insect survival is one, which is stable across locations and seasons. However, climatic and edaphic factors influence the level and nature of insect survivability. Several environmental factors are known to influence the inherited characters, especially those involving physiological characteristics of crop plants (Heinrichs, 1998; Dhaliwal and Dilawari, 1993; Kalode and Sharma, 1993; Panda and Khush, 1995).

Temperature is one of the most imperative physical factors of the atmosphere affecting the behaviour and physiological interactions of insects and host plant. Temperature induced stress can cause changes in plant physiology and affect the morphological defenses and / or changes in the levels of biochemicals or nutritional quality of the host plant. Temperature also has pronounced effect on plant growth, which indirectly influences the extent of feeding. Temperature also affects the biology and behaviour of insects and thus influences insect growth and general population climax. In general, moderate temperature is favourable for insect development.

The intensity of feeding influenced by water stress, high level of water stress reduces the quantity food ingestion by the organism; check the population build-up due to lower rates of reproduction on water stress condition. Atmospheric humidity also influences the insect-plant interaction. High humidity increases the ease of detecting of odors which may influence host preferability. Leaf moisture plays a vital role in improving nutrient level of leaves, which in turn, improves the palatability of leaves to the larva, enhances the feeding efficiency and increases the growth rate (Bose and Bindroo, 2001; Paul *et al.,* 1992).

Photoperiod has effects on the development of both the insects and their host plants. It may also bring about changes in the physico-chemical characteristics of crop plants and thus influences the interaction between insects and plants. Intensity and quality of light have been reported to influence biosynthesis of anthocyanins and phenylpropanoids.

Finally, success of silkworm breed in any eco-climatic condition depends on its acclimatization ability, survival efficiency to produce more dry matter (silk/egg) per unit food intake at the shortest duration without hampering quality parameters (Anantha Raman *et al.*, 1993). Non-traditional area like Cooch Behar district of West Bengal needs a detailed study on nutritional efficiencies of muga silkworm as nutritional quality as well as environmental conditions have greater impact on regulation over the quantum of ingesta, digesta and digestibility of food among silkworm. Waldbauer (1964) studied that nutritional deficiency or imbalanced diet, high content of crude fibre and deficiency of water in the food affecting digestibility. Moreover, the quality of leaf produced by different host plants or in the same plant are different in different seasons. The influence of host plants and seasons on the efficiency of converting ingested and digested food into the body weight, cocoon, cocoonshell and egg should be given emphasis particularly efficiency of conversion of ingested and digested food to cocoon and shell as according to Machii and Katagiri (1991) these are the ultimate indices to evaluate the production efficiency of a breed/hybrid in terms of the production of cocoon shell percentage vis-à-vis the food transformed.

Consequently, under present circumstances of technological development of muga culture, standardization of indoor rearing technique appears to be important item of research to avoid crop loss. Whereas evaluation of nutritional efficiencies of the muga silkworm larvae and selection of suited host plants spp. are the pre-requisite to technical feasibility for successful muga culture in terai region of West Bengal. Keeping this view under consideration the present investigation has been designed with the following objectives.

1) To compare relative economic performances between the field rearing and the indoor rearing of muga silkworm (*Antheraea assama* Ww.) larvae with a view to avoid environmental hazards such as heavy rainfall, storms, high and low temperature and to prevent predator attack in field causing heavy damage of the crop.

2) To evaluate the consumption of leaves of two principal host plant spp. (Som and Soalu) by the larvae of muga silkworm with an objective to select the better host plant for

food supply to the larvae as well as to measure the leaf requirement of the larvae in indoor rearing.

3) To assess the nutritional efficiencies of muga silkworm larvae fed on different combinations of leaves of two host plants with an ultimate objective to supply better nutrition to the larvae for better quality and quantity silk and seed yield.

4) To identify seasonal influence on nutritional efficiencies and its conversion to economic performances *i.e.* silk and seed production with a view to find out season-specific rearing schedule for the zone under consideration.

5) To determine the efficiency of conversion of ingested and digested dry matter (food) into cocoon, cocoon-shell and egg with an ultimate objective to find out the possibility of successful muga-culture in a newly explored area as well as to compare with conventional area of muga culture.

Chapter - II

REVIEW OF LITERATURE

2.1 Muga silkworm rearing in outdoor and indoor condition :

The muga silkworm, *Antheraea assama* is a semi domesticated multivoltine, polyphagous insect having about six broods in a year (Scitz, 1933). It has been reported that the growth and development of muga silkworm, its pupal weight, shell weight, fecundity as well as reelability of silk are greatly influenced by the environmental conditions during different reasons (Thangavelu and Sahu, 1986, Yadav and Goswami, 1999). Out of the six broods of Muga Silkworm, two are popular for commercial rearing (Thangavelu and Sahu, 1986; Yadav and Goswami, 1999) which are conducted during May – June and October – November. The two seasons, spring (May – June) and autumn (October – November) are preferred for commercial rearing because the climatic conditions during these period are favourable for growth and development of muga silkworm.

The commercial rearing however is carried out mostly under outdoor conditions. The outdoor rearing of the worms subjects them to environmental constraints such as rain, hailstorm and a number of natural predators (e.g. bird). Due to compulsion of outdoor rearing, dependence on favourable climatic conditions for the growth and development of the worm has become quite high, and hence only two commercial rearing are possible although the insect has six broods in a year.

Success of large scale indoor rearing is not very encouraging despite some attempts made in the past (Thangavelu and Sahu, 1983, 1986). It is obvious that before attempting indoor rearing of muga silkworm, a detailed knowledge about its feeding behaviour, physiology of feeding and digestion are essential. It is to be noted that reports on the basic studies on Muga Silk worm are extremely low (Dey *et al.*, 1997; Hazarika and Bardoloi, 1998 ; Dey, 1999) and probably this lacuna in our knowledge is one of the reasons for less success in any experimentation with the worm, including indoor rearing.

Various methods for early instar indoor rearing of tasar silk worm were reported by various authors (Alam *et al.*, 1991 and Jayaprakash *et al.*, 1993). Naveen and Savanurmath (1998) have been successfully domesticated tasar silkmoth, *Antheraea mylitta*. In order to achieve higher economy and effective rearing rate the methodology they suggested may attract farmers who like to try the production at higher magnitude.

In Simlipal biosphere reserve, Orissa, *Antheraea paphia* resides in two eco-races namely, Modal and Nalia. Domestication of this species was not successful due to its wild nature previously. However, Nayak and Jagannatha Rao (1998) by use of both natural and artificial diet at ambient temperature and humidity domesticated the species. Cocoon weight, shell weight, pupal weight and fecundity of the silkworm larva feeding on natural diet was very much akin with its parents.

Partial indoor rearing upto third instar of *Antheraea mylitta* showed a significant gain of 34.75% in ERR, uniform and healthy growth of silkworm in the late age and improvement in cocoon, pupal and shell weight of female, dry larval weight, raw silk and filament length with little improvement in denier were observed over the control in the conventional infield rearing (Sudhakar Babu and Rao, 1998).

But reports on other wild silk moth *i.e.* muga silk worm regarding indoor rearing is scanty. Thangavelu and Sahu (1983, 1986) conducted indoor rearing of muga silk worm inside the room by keeping the food plant branches in water contained in earthen pot and these were kept in a wooden stand and the whole set up was covered with polythene cover, except the ground surface and established the suitability of indoor rearing. Thangavelu and Sahu (1983) reported that som and soalu were more suitable food plant for indoor rearing than digloti. Studies indicate that higher effective rate of rearing, cocoon weight during July-August than other seasons may be due to degeneration (Choudhary *et al.*, 1998), season variation (Thangavelu and Sahu, 1983), high humidity (82.05%), and favourable temperature (24.5^{0}C) is suitable for indoor rearing. Moreover, improvement over outdoor rearing in effective rate of rearing and cocoon weight has been reported by Thangavelu and Sahu (1986) from a year round experiment.

According to Raja Ram and Sinha (2004), from the comparative study of indoor and outdoor rearing revealed that the variation was non-significant; however larval period 32 days, effective rate of rearing 24.25%, single cocoon weight 5.3 gm single shell weight 0.49gm and silk ratio 9.24% was higher in outdoor than indoor rearing. According to the result, the indoor rearing was found to be encouraging on economic characters. The establishment of indoor rearing on suitable genotype of primary food plant would increase the economic character of the muga silk worm. Azad *et al,* (2000) also conducted indoor rearing of muga silk worm and observed better results. Annual report (1995-96) of CMRS, CSB (Boko, Assam) (Anonymous, 1996) reflected that during favourable seasons, indoor rearing till the third instar is not effective. However, during unfavorable seasons the technique did show some edge over the control. According to Hazarika *et al*, (2006) larval period of the indoor reared domesticated strain of *Antheraea assama* on detached leaves of *Machilus bombycina* was found longer than that of the outdoor one, while, the latter yielded heavier cocoons (5.95 ± 0.29g). However, the silk ratio was found higher in the indoor reared group (7.54 ± 0.39 g) without showing much difference in pupal weight and effective rate of rearing. Hazarika and Deka (2002) opined that silk ratio of indoor rearing (7.54±0.39%) was significantly higher than that of outdoor rearing (6.81±0.19%). The ERR was almost similar in both the cases. However, the larval period in the indoor condition was prolonged by more than 10 days.

In West Bengal condition, Ray (2003) working on muga silk worm indoor rearing as complete indoor, partial indoor (upto 4th, upto 3rd, upto 2nd and upto 1st) and complete outdoor found that the survivability was highest in complete indoor rearing and lowest in complete outdoor rearing which was almost one fourth of complete indoor and half or partial indoor upto 3rd instar. Moreover, cocoon characters were also better from partial indoor rearing upto 3rd instar.

2.2. Nutritional efficiencies of muga silkworm :

Nutritional efficiency is considered important to assess the cost benefit ratio of sericulture practice upto the level of cocoon production (Rahmathulla *et al.*, 2002). The feed consumption has a direct impact on larval weight, cocoon weight, amount of silk produced and number of eggs laid (Magadum *et al.*, 1996a). At the same time, success of silkworm breed in any eco-climatic condition depends on its acclimatization ability, survival efficiency to produce more dry matter (silk / egg) per unit food intake at the shortest duration without hampering quality parameters (Anantha Raman *et al.*, 1993).

Horie *et al.* (1976) and Jaksheva and Genova (1991) have reported higher ingesta values for fourth and fifth instars of different breeds of mulberry silkworm. Variation in ingesta values among breeds of *B. mori* have also been reported (Yamamoto and Fugimaki, 1982). Low feeding rate, nutritional inadequacy of feed or combination of both lead to poor growth (Waldbauer, 1964). The poor ingestion recorded by Anantha Raman *et al.* (1993) in mulberry hybrids is due to low growth potential. Benchamin and Jolly (1984) have reported 88.67% higher ingesta in NB_{18} over the indigenous breed, PM. More than 85% food consumption in the last instar of *B. mori* has been reported by (Hiratsuka, 1920; Benchamin and Jolly, 1984; Naik and Delvi, 1987; Anantha Raman *et al.*, 1993, 1995, Rahamathulla *et al.*, 2006). This is also true for non-mulberry silkworm especially in *Antheraea mylitta* (Sinha *et al.*, 1998, 2001).

Excreta values progressively increases as growth advances. 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. Higher food intake tends to mobilize the gut contents faster and provides less time for enzyme activity and food absorption making the efficiency poor (Waldbauer, 1964).

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. This is noticed in young instars. The poor RR recorded in fourth and fifth instar is due to poor absorption and digestion and this is true for both mulberry and non-mulberry silkworm. Excreta production and RR values depends 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 larva on the succulent and nutritionally rich leaf lamina without engulfing the venation zones (Anantha Raman *et al.*, 1993). Mathavan and Pandian (1974) recorded 1.5 RR value for the fifth instar larvae of lepidopterans.

Consumption index explains in a nutshell the rate at which nutrients enter into digestive system and is expressed in fresh or dry weight of food per mean larval body weight per day

(Prabhakar *et al.*, 2000). Soo Hoo and Fraenkel (1966) reported that nutritionally inadequate diet may be ingested at a faster rate. Prabhakar *et al.* (2000) further opined that growth rate explains how much of dry matter increased in the larvae per gram of body weight per day. It directly influences the rate of development, which depends on quality of host or physiological stage of the larvae. Pant (1986) reported that consumption index (CI) and growth rate (GR) were declined during 5^{th} instar larval life and CI and GR appeared inversely proportional to the gross efficiency.

Three mulberry silkworm race namely pure Mysore, NB_{18} and PM x NB_{10} reared on three varieties of mulberry viz. Mysore local, M_5 and S_{54} grown under rainfed condition was studied by Prabhakar *et al.*, 2000. NB_{18} fed on M_5 recorded lower consumption index and higher growth rate. Furthermore, CI was negatively correlated with the characters like fecundity, larval duration, silk gland weight and length, cocoon weight, shell weight, cocoon shell ratio, cocoon filament length and denier, but positively related with floss content and number of breaks per cocoon while reverse trend was established with GR. Nutritional and feed conversion efficiency parameters of CSR16 x CSR17 were studied by Rahamathulla *et al.* (2006). Nutritional indices like ingesta, digesta, approximate digestability, reference ratio and consumption index were recorded significantly less in CSR16 x CSR17 when compared with control (CSR2 x CSR4).

The approximate digestibility is higher in early instars which gradually reduces, lowest being in fifth instar in both mulberry (Horie *et al.*, 1976; Ito and Kobayashi, 1978; Horie and Watanabe, 1983; Benchamin and Jolly, 1984) and tasar silkworm (Sinha *et al.*, 1998 and 2001). The reduced AD in fifth instar is due to high content of dry matter in the feed. Efficiency of conversion of ingested food is an overall measure of larval ability to utilize the ingested food for growth. 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 with the nutritional value of the food. The ECI values are higher in early instars due to quality of food and small size of larva. The low ECI in late instars is because of aging, duration of instar, 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; Anantha Raman *et al.*, 1993). However, ECI and ECD values increased from first to fourth instar and then declined in the fifth instar in tasar silkworm as reported by Sinha *et al.* (1998). A number of workers supported this trend of rise and fall in ECI and ECD in different insects (Mukherjee and Guppy, 1970; Latheef and Harcourt, 1972 and Bailey, 1976). The mean ingesta and digesta increases as larval growth progresses. The values are low in younger instar and higher in late instar. This tendency is due to lower gut volume, low ingesta and small size of body. Moreover, lesser ingesta and digesta requirement to produce unit larval dry weight is due to higher efficiency in assimilation by the silkworm (Matsumara *et al.*, 1955; Horie *et al.*, 1976; Benchamin and Jolly, 1984; Anantha Raman *et al.*, 1993). Better efficiency of converting the digesta and ingesta into cocoon and cocoon shell as well as less ingesta and digesta requirement to produce unit cocoon and shell production reflect better survival efficiency of any breed in any eco climatic condition. (Anantha Raman *et al.*, 1993).

However, the efficiency of converting ingested and digested food into the body, cocoon and cocoon shell varies among silkworm races under the influence of season and host plant varieties (Anantha Raman *et al.*, 1995). Nutritional quality as well as environmental conditions have greater impact on regulation over the quantum of ingesta, digesta and digestibility of food among silkworm (Ito, 1972).

2.2.1. Nutritional efficiency as influenced by host plant :

The qualitative aspect of nutrition in any insect is the fundamental importance for understanding the insect plant relationship (Waldbauer, 1968; Bhattacharya and Pant, 1976). At the same time, various physiological activities of an organism are expressed in growth which results from the balance between matter assimilation and dissimilation by complicated phenomenon. Food ingestion, consumption and utilization patterns with relation to host plant and sex-specific differences observed in different insects have been studied quite extensively by many workers (Bailey, 1976; Biren *et al.*, 1987; Yamamoto and Fuzimata, 1960; Joshi, 1984; Slansky and Scriber, 1985). Studies on nutritional ecology of an insect become important for its commercial exploitation (Scriber and Slansky, 1981) as there exists a direct correlation between the nutritional status of the leaves and the cocoon quality in case of silkworm food plants (Srivastava *et al.*, 1998). In the insects, assimilation in the total quantity of food available to be incorporated as body substances or to be metabolized for energy (Reddy and Alfred, 1979). Studies on the consumption and utilization of food in insects facilitate the understanding of the adaptability of insects to the environment. Scriber and Slansky (1981) and Muthukrishnan and Pandian (1987) have extensively reviewed the different aspects of insect bio-energetics. Consumption and utilization of food (Yamamoto and Fujimaki, 1982) and adaptability to environmental factors vary not only among species but also among races (Periaswamy *et al.*, 1984). Also, enormous literature exists of food intake and utilization in different instars of both mulberry (Takeuchi and Kosaka, 1961 ; Kurubayashi *et al.*, 1990) and non-mulberry silkworms (Poonia, 1978, 1985; Reddy, 1983; Pant *et al.*, 1986; Barah *et al.*, 1988 and Khalequzaaman, 1990).

The credit of quantitative study on the consumption and utilization of mulberry leaves by the silkworm goes to Hiratsuka (1920). Most of studies on food utilization and nutrition of Bombyx mori were summarized as early as 1970 (Legay, 1958; Yokoyama, 1963; Ito, 1978). Horie and Watanabe (1983) have studied the utilization of food towards body growth on a daily basis. The quantity and quality of mulberry leaves consumed, digested and the digestion ratio are intimately associated with the larval weight / growth (Ito and Arai, 1963; Somioka *et al.*, 1982). If the growth rate is kept below the ideal level, the fitness may be reduced because of the extended period of vulnerability to predators and parasitoids (Price *et al.*, 1980). Sharma *et al.* (1986) and Dar *et al.* (1988) investigated various nutritional parameters in silkworms fed on different varieties of mulberry leaves. Moreover, food assimilation efficiency in *Bombyx mori* differs with the race as well as with the variety of mulberry (Hassanein *et al*, 1972). There are few reports concerning the effect of rearing conditions (Matsumara *et al.*, 1958), leaf ratio (Sunioka *et al.*, 1982 and Radhakrishnan and Delvi, 1987) and insecticides (Delvi and Naik, 1984; Pant and Katiyar, 1983 and Radhakrishnan and Delvi, 1992) on the silkworm nutrition and development.

There appears to be in a good food plant an inverse correlation between food consumption and efficiency of utilization (Soo Hoo and Fraenkel, 1966). Narayana Prakash *et al.* (1985) reported a consumption of 3.873g and 3.153g by a larva of NB_{18} x NB_7 and local x KA respectively. Horie and Watanabe (1983) observed 6.2g of ingestion per larva during fifth instar.

The average daily consumption of energy was 0.18 and 0.17 Kcal/g fresh body weight for the male and female larvae respectively. Kurubayashi (1990) reported that the total amounts of dry matter ingestion and digestion by 5th instars larvae were about 5.8g and 2.1g respectively. The highest assimilation was recorded in the 5th instar and was found to be related with the amount of food consumed (Sinha *et al.*, 1998). This is in agreement with the findings of Vats and Kaushal (1982). The consumption was maximum during the 5th instars being 80.13% of the total consumption. Magadum *et al.* (1996b) from the studies of 5th instar larvae of nine bivoltine breeds of *Bombyx mori* through regression analysis indicated that the total amount of ingesta was related to the total amount of digesta, mature larval weight, larval duration, cocoon weight, shell weight and fecundity. Yamamoto and Gamo (1976) observed a high positive correlation between ingesta and cocoon weight, shell weight and larval weight. Nutritional background of the larval stage significantly influences the status of the resulting pupae, adult and production of silk in the economically important insect like *Bombyx mori* (Fukuda *et al.*, 1963; Takano and Arai, 1978 and Aftab Ahamed *et al.*, 1998). Horie and Watanabe (1983) carried out studies on the digestion and daily utilization of mulberry leaves in *B. mori* larvae. The polyvoltine breeds varied in their growth, development, economic characters, food consumption, utilization and conversion efficiencies (Remadevi *et al.*, 1992).

The percentage digestibility and the efficiency of conversion of ingested (ECI) and digeted food (ECD) to body matter, cocoon, cocoon shell and egg are important in phytophagous insect. Other factors which appear to affect the overall nutritional efficiency with relation to particular plant are water content, protein content and possibly the fibre content.

The approximate digestibility (AD) is higher in early instars which gradually decreases and reaches the lowest in fifth instar larvae (Sinha *et al.*, 1998). The efficiency of conversion of ingested (ECI) and digested (ECD) food to body substances increased from first to fourth instars and declined in the fifth stage. A number of workers supported this trend of rise and fall in ECI and ECD in different insects (Mukherjee and Guppy, 1970; Latheef and Harcourt, 1972 and Bailey, 1976). The lower values of ECI and ECD are perhaps due to the fact that a smaller portion of ingested and digested food is used for tissue growth and major portion for its maintenance (Sinha *et al.*, 1998). In the later stages, metabolic rate is higher than the early stage and hence major portion of ingested or digested food is available for conversion to body tissues. Horie and Watanabe (1983) carried out studies on the digestion and daily utilization of mulberry leaves in *B. mori* larvae. The polyvoltine breeds varied in their growth, development, economic characters, food consumption, utilization and conversion efficiencies (Remadevi *et al.*, 1992). Hiratsuka (1920) reported 23% of ECI during its larval stage of NB_{18}. Shyamala *et al.* (1960) observed 48% ECD in larvae of *B. mori*. Yamamoto and Fuzimaki (1982) have reported that the food utilization efficiency varies markedly among the silkworm strains. The efficiency of food conversion of a silkworm hybrid, PM x NB_4 D_2 showed that AD and ECI reduced in successive instars. The ECI and ECD values for larvae were 24.20 and 56.92% (Anantha Raman *et al.*, 1993). Yokoyama (1962) recorded AD in *B. mori* during its larval stage around 41%. Periaswamy and Radhakrishnan (1985) recorded an ECD of 46 to 49% when NB_{18} larvae fed on $S_{54,}$ 36 to 42% on M_5 and 30-32% on local varieties of mulberry respectively. Yamamoto and Fujimaki (1982) reported a lower correlation of ingesta and AD for Japanese breeds and a high negative correlation was observed between cocoon shell weight and ingested dry matter for the production of unit cocoon shell weight. Remadevi *et al.* (1992) reported that low AD in *B. mori* is associated with high ECI /ECD and vice-versa. Anantha Raman *et al.* (1992) reported that the amount of dry matter ingested and digested in different instars were significantly different. The AD and ECI reduced gradually from first to fifth instars. The ECD values fluctuated from 54.47 to 59.07% in different instar.

In Cooch Behar district of West Bengal an investigation was carried out by Ray *et al.* (2000) to study the interaction of mulberry varieties (S_1, TR_{10} and Kosen) and bivoltine silkworm breeds (P_5, KPGB, P_5 x KPGB and KPGB x P_5). Among the silkworm breeds, hybrids showed better nutritional efficiencies. Kosen Variety has consistently proved its superiority to TR_{10} and S_1 as evident from shorter larval duration, low quantity of food ingestion and food balance and higher gain in weight. Furthermore, the lower consumption index and approximate digestibility are substantiated by higher conversion efficiencies by the larvae specially the hybrids fed with Kosen.

From the standpoint of conversion efficiencies to body matter, cocoon and shell it was observed by Rahamatulla *et al*, (2006) that ingesta and digesta required to produce one gram of larvae, cocoon and shell were significantly higher in control (CSR2 x CSR4) than newly evolved race (CSR16 x CSR17). Horie (1978) opined that *B. mori* larvae requires 4.5g of dry matter ingestion for a gain of one gram body weight on dry weight basis. According to Trivedy and Nair (1999), almost all nutritional efficiency indices were categorical pointers to prove that the new hybrid, BL_{44} x NB_4D_2 which established its clear edge over PM x NB_4D_2. Anantha Raman *et al.* (1993) reported that the ECI and ECD values for larvae, cocoon and cocoon-shell were 24.20, 20.18, 10.39 and 56.92, 53.38 and 27.489% and the ingesta and digesta required to produce one gram larval, cocoon and cocoon shell weight were 4.22, 4.97, 9.66 and 1.80, 1.88 and 3.65 gm respectively. It is evident from this results that among the tropical silkworms, PM x NB_4D_2 is very efficient in utilizing dry matter for body growth, cocoon and cocoon shell production.

Considerable literature are available in the field of eri silkworm, *Philosamia cynthia ricini* (Joshi and Misra, 1979; Devaiah *et al.*, 1988; Hussain and Shahjahan, 1997; Joshi, 1984, 1985; Pant *et al.*, 1986 and Reddy and Alfred, 1979) and eri silkworm is also domesticated.

The literature for tasar silkworm and muga silk worm, both are wild and being reared in field is scanty for nutritional efficiencies.

Tasar Silk worm, *Antheraea mylitta*, polyphagous insect feeds on a number of host plants of which *Terminalia arjuna, Terminalia tomentosa* and *Shorea robusta* are considered as primary food plants for commercial rearing. A feeding trial of *A. mylitta* was conducted on the foliage of *T. arjuna, T. tomentosa* and *S. robusta* to determine its food consumption, utilization and tissue growth during different larval instars. Average total consumption of an individual larvae was highest in *T. arjuna* (123.630g) followed by *T. tomentosa* (105.717g) and lowest in *S.robusta* (94.256g). Quantitalively difference in consumption, assimilation and respiration starts from second instar onwards depending on the types of food plant. From second instar onwards consumption, assimilation and respiration were found to be lowest in the worms fed on *S. robusta*. Similarly, tissue growth and efficiency of conversion of ingested and digested food to body substances recorded to be lowest from third instar onwards in the worm fed on *S.robusta*, *T. arjuna* and *T. tomentosa* behave equally in respect of efficiency of ingested and digested food to body substances. Efficiency of conversion of ingested and digested food to body substances showed increasing trend from first to fourth instars and then decreased in fifth instar in all the three cases. However, the worms fed on *T. arjuna* were found significantly superior in respect of food consumption, assimilation, respiration, tissue growth and digestibility among all the three types of food plants followed by *T. tomentosa* and *S. robusta* (Sinha *et al.*, 1998).

In *Antheraea proylei* assimilation efficiency was observed 71% (Rana *et al.*, 1987). Sinha *et al.* (1998) reported that mean values of ECI over the entire larval period were calculated to be 21.845%, 21.504% and 20.216% in *T. arjuna, T. tomentosa* and *S. robusta* respectively. The grand mean values of ECD was found 32.388%, 32.154% and 31.083% in *A. mylitta* on *T. arjuna, T. tomentosa* and *S. robusta* respectively while ECD for *A. proylei* fed on *Quercus serrata* was 34% (Rana *et al.*, 1987).

Food consumption, utilization and tissue growth during different larval instars were worked out through a feeding trial on laria eco-race of tropical tasar silkworm, *Antheraea mylitta* Drury on the foliage of *Shorea robusta*. During its larval span of 42 days, the average total consumption of an individual larva was 108.06g of which 61.81g was assimilated by the larva. The assimilation and tissue growth were found positively correlated with the leaf consumption and maturity of the larva. The approximate digestability declined with the advancement of age whereas efficiency of conversion of ingested and digested food rose up in 4th instar and decreased in the fifth instar (Sinha *et al.*, 2000).

Again, food consumption and utilization during different larval instars were quantitatively studied through a feeding trial on laria eco-race of tasar silk worm *Antheraea mylitta* Drury on the foliage of *Terminalia tomentosa*. During its larval span of 42 days, the average total consumption on an individual larva was 136.713g of which 80.518g was assimilated by the insect. The quantity of food consumption increased with the increase in age of larvae and reached its peak in the fifth instar (80.13% of total consumption). The assimilation and tissue growth were found positively correlated with the consumption and maturity of the larva. With the advancement of age, the approximate digestibility declined where as efficiency of conversion of ingested and digested food rose upto 4th instars and thereafter decreased in the fifth instar.

In Muga silkworm, the investigation in the field of nutritional efficiency is very little. Barah *et al.* (1989) tried to investigate the nutritional efficiency of *Antheraea assama* on Som plant (*Persea bombycina*). During 32 days of larval life, the total consumption was 33.925g/insect of which 21.295g were assimilated. About 80.1% of the total consumption took place in fifth instar. Assimilation and tissue growth were positively correlated with consumption and larval age. The approximate digestibility was negatively correlated to the amount of food consumed. Efficiency of conversion of ingested and digested food increased in the first four instars and declined in the fifth instar.

The diet efficiency study involving the biochemical analysis of ingesta, larva, silk gland and excreta during various stages of development of larva provided an evidence of stage specific utilization of the dietary constituents during the larval development and spinning period. The highest value of coefficient of digestibility (CAD %) was observed for total soluble sugar (69.5%) followed by minerals (40.05%) and crude fat (29.13%) by Das *et al.* (2004). Bhattacharyya and Ray (2006) estimated the consumption of food, digestion, utilization and efficiency of conversion of food into larval body, cocoon and cocoon shell of muga silkworm utilizing leaves of som plant as food under indoor condition. Results recorded on dry weight basis and the amount of dry matter ingested and digested in different instars were significantly different. 83.62% leaves consumed in fifth instar larval stage. Highest ECI and ECD being 19.76% and 45.10% were recorded in the third instar while highest digestibility was found in first instars (53.48%). The ECI and ECD value for larva, cocoon and cocoon shell were 11.50, 10.03, 1.88 and 33.50, 29.21, 5.46% respectively. The ingesta and digesta required to produce one gram cocoon and cocoon shell weights were 9.97, 53.32 and 3.42, 18.30gm respectively.

Nutritional value of food plants either alone or in combination play significant role in larval growth and silk productivity.

In mulberry sericulture, different combinations of mulberry varieties for two growth stage (early and late) oriented bi-voltine silkworm rearing through systematic evaluation of nutritional efficiencies has been done by Ray and Deb, (2007) and they suggested Kosen – S_1 combination

(Kosen at early stage and S_1 at late stage) for higher productivity and profitability in sericulture for terai region of West Bengal.

Scanty of reports are in non-mulberry sericulture also (Raja Ram and Samson, 1998, Barah *et al.*, 1988). Biswas *et al.* (2008) studied on effect of different food plants and reared muga worms on secondary food plant after initial rearing on som and soalu and Joshi and Mishra (1979); Devaiah *et al.* (1988) and Hussain and Shahjahan (1997) on eri silkworm.

2.2.2 Nutritional efficiency as influenced by season :

There is seasonal effect of nutritional efficiencies from mulberry leaves by *B. m ori* larvae. Petkov and Mircheva (1979) emphasized that the quantity taken in and utilization of energy from the ingested food depends on age of silkworm, the norm of feeding and the season in which the silk worm reared. Silkworm takes in greatest quantity of energy from mulberry leaves in the spring season. In spring, the coefficient of digestibility was higher in comparison to those in summer and fall season. Rahmattulla *et al.* (200 2), studied nutritional indices and nutritional efficiency parameters of fifth instar larvae of newly evolved bivoltine races under different environmental conditions. In adverse environmental conditions during fifth instars, most of the nutritional efficiency parameters were recorded higher than control. During high temperature and low humidity condition comparatively high consumption, digestion and utilization of food was observed in new race. This is an indication of more efficiency of the race to feed and convert into body matter during unfavorable conditions.

The efficiency of converting the ingested and digested food into the body, cocoon and cocoon shell varies among silkworm races under the influence of season and mulberry varieties (Anantha Raman *et al.*, 1995). Nutritional quality as well as environmental conditions have greater impact on regulation over the quantum of ingesta, digesta and digestibility of food among silkworm (Ito, 1972).

Low temperature (26^0C) throughout the rearing favours higher silk conversion (Muniraju *et al.*, 1999). Dutta *et al.* (1996) opined that better growth rate and efficiency of ingested and digested food into body biomass of multivoltine *B. mori* in spring season even though the rate of food intake was lower in this season. M ultivoltine race pure Mysore showed poor ingesta, digestibility, AD, ECI and ECD values in summer. The C I and GR were high in summer (Gokulamma and Reddy, 2005).

Efficiency of conversion of mulberry leaf into silk is one of the important properties of silkworm *Bombyx mori* L. as this is of commercial value. Conversion efficiency will be influenced by factors ,temperature plays an important role in conversion of leaf into silk. The silkworm, Pure Mysore (PM) a multivoltine and NB_4D_2 a bivoltine (BV) were reared under constant temperature of 26^0, 28^0, 30^0 and 32^0C during young age and different combinations during late age to understand the relevance of temperature on leaf silk conversion and survival. Low temperature (26^0C) throughout the rearing favoured higher silk conversion (0.062mg per mg leaf intake) with better survival (87%)in bivoltine and 32^0C during young age and 26^0C during late age for multivoltine (94.4%survival). Negative correlation for survival and cocoon yield was observed with increasing temperature upto 32^0C and lethal beyond this temperature in case of bivoltine (Muniraju *et al.*, 1999).

The body temperature of silkworm varies with ambient temperature. The physiological activities, food intake and economic parameters are influenced by body temperature of silkworms (Anonymous,1972). The effect of temperature during rearing on survival, growth, cocoon production and silk quality have been studied by many workers (Matsumura and Ishizuka 1929; Kogure, 1933; Matsumara *et al.*, 1958; Ueda 1963; Udea and Harizuka, 1962; Yamamoto and Fujimaki, 1982; Verma and Atwal, 1967; Sigematsu and Takeshita 1967; Rapusas and Gabrial, 1976; Muniraju, 1995) and Muniraju *et al.* (1999) recorded low silk production when reared at high temperature and suggested 24-26^0 C as optimum for good rearing results.

It is evident from the present study that when the temperature is to go beyond 30^0C, during late age, the worms during young age are to be reared at lower temperature of 26^0C for better adaptability and productivity (Muniraju *et al.*, 1999).

The nutritional efficiency of multivoltine mulberry breeds namely, Assamese Sarupat and Nistari reared on Jatinuni and K_2 under the eco-climatic conditions of Assam in different seasons revealed better growth rate and efficiency of conversion of ingested and digested food into body biomass of the breeds in spring season even though the rate of food intake was lower in this season. The breeds were at par and season had no effect so far as food digestibility was concerned. The breeed nistari was the better converter of ingested as well as digested food to body biomass though its food intake was less and growth rate was slightly less compared to Sarupat. Jatinuni was rated as the suitable host plant in respect of food consumption, growth rate and digestibility where as K_2 exhibited better performance in respect to ECI and ECD (Dutta *et al.*, 1996).

Breed and seasonal differences in food consumption and utilization efficiencies in fifth instar of nine bivoltine breeds (36PC, JSV_6, KA, NB_1, NB_{18}, NB_4D_2, NB_7, NN_6D and SH_6) have been studied. The relative consumption was highest in 36PC (1.307) and lowest in NB_1 (1.103). The approximate digestibility varied from 30.34% (KA) to 41.79% (36PC). AD values were high in rainy season except 36PC and NN_6D, which showed high AD in summer. The reference ratio varied from 1.45 (KA) to 1.77 (36PC). The efficiencies of conversion of food ingested (17.82) and food digested (46.26) were very low in 36PC.The ingestion to body ratio and ingestion to shell ratio also varied amongst the breeds (Magadum *et al.*, 1996a).

Studies on consumption and utilization of food in two races (C-nichi and KA) of the silkworm *Bombyx mori* were conducted at three different temperature i.e., 33 ± 1^0C, 25 ± 1^0C and 17 ± 1^0C. The rearing was conducted with the help of an environment chamber fabricated for this purpose .The fourth and fifth instar consume the maximum food (90-95%) of total consumption during larval life .Hence the food consumption studies were confined to this instars. The results showed that the nutritional parameters are higher at 33^0C and lower at 17^0C in both fourth and fifth instars of the multivoltine (C-nichi) race. The bivoltine (KA) race showed higher nutritional indices at 25^0C and lower at 17^0C with a few variations between the instars. The results also revealed that the temperature not only influenced the metabolic activities of the larvae depending on age, but also on different races used in present investigation (Basavaraju *et al.*, 1998).

The multivoltine race pure Mysore and bivoltine races $NB_4D_2$and CSR_5 were reared on three different mulberry varieties viz. M-5, S36 and V-1 under different environmental conditions. The combined effect of leaf quality and rearing temperature and on the nutritional parameters such as approximate digestibility (AD), efficiency of conversion of ingested (ECI) and digested food (ECD) into body matter, Reference ratio (RR), consumption index (CI) and growth rate (GR) were studied. The dry matter ingested and digested were significantly high in silkworm breeds fed with V-1 mulberry variety during winter and three silkworm races showed better efficiency of conversion of ingested and digested food into body substances with V-1. Seasons also had significant effect on ECI and ECD irrespective of the type of leaf offered. V-1 was found to be the suitable host plant for bivoltine silkworm breeds in all the three seasons of the year. However, the multivoltine pure Mysore race reared on V-1 showed poor ingesta, digestibility, AD, ECI and ECD values in summer. The CI and GR were high in summer in both pure Mysore and bivoltine breeds studied (Gokulamma and Reddy, 2005).

Chapter - III

MATERIALS AND METHODS

3.1 Geographical location :

Cooch Behar district of West Bengal is under Terai region and is situated in the north-eastern part of West Bengal, adjacent to Kokrajhar and Dhubri district of Assam. Terai zone is situated between $25^0 57'$ N and 27^0 N latitude and $88^0 25'$ E and $89^0 54'$ E longitude. This northern region of West Bengal is situated along the foot of Karseong and Kalimpong hills and Bhutan hills in the north, Bihar border on the west and Assam border on the east. It includes Siliguri Sub-Division of Darjeeling district and entire district of Jalpaiguri and Cooch Behar and Islampur Sub-Division of North Dinajpur District. The total geographical area of the zone is 12025 sq Km., which is 13.5% of the state area. Rural population comprises about 90% of the population of the zone. Cooch Behar district of West Bengal lies between $26^0 57'40''$ N and $26^0 32'20''$ N latitude and $88^0 47'44''$ E and $89^0 54'35''$ E longitude. The altitude of the district is 43m above MSL.

3.2 Climate :

The climate of the zone is sub tropical and humid in nature. Average annual rainfall about 80% is received from south-western monsoon during the rainy months of June to September. The range of minimum temperature of the area is 11.19 – 30.24^{0}C while the maximum is 20.54 - 34.24^{0}C. The relative humidity of the area at 8.30 am is 58-89% respectively in March – July. The relative humidity in the afternoon at 5.30 pm is 48 – 81% respectively in March – November. The maximum temperature never rises above 35^{0}C and the high temperature is recorded only for a few days. Autumn and spring are very pleasant and the minimum and maximum temperatures ranges from 19 ^{0}C to 27^{0}C and 17^{0}C to 25^{0}C during these two seasons. Winter is moderate and the minimum temperature dose not fall below 10^{0}C.

3.3 Experimental site :

3.3.1 Outdoor rearing :

Experimental rearing of muga silkworm was conducted at the instructional plantation and adopted farmer's field of Acharya B.N. Seal College, Cooch Behar, West Bengal. All rearings were conducted in natural outdoor condition.

3.3.2 Indoor rearing :

Indoor rearing and other studies were conducted at Muga Research Laboratory, P.G. Department of Zoology, Acharya B.N. Seal college, Cooch Behar, West Bengal.

3.4 Insect :

Among most successful animal groups in terms of species, insects are predominant one an estimate of total number of leaving species ranges from 10 – 30 million. Muga silkworm *Antheraea assama* Westwood is a highly heterogeneous unique and semi domesticated multi voltine strain of Saturniidae family of Lepidopteran insect endemic to Assam, adjacent foot hill of Meghalaya, Nagaland, Arunachal Pradesh and Mizoram. However, it grows under semi-domesticated conditions in North Eastern States of India but it has immense possibility of expansion in area and increasing productivity under befitting agro-ecological situation of Terai zone of West Bengal.

As it is wild in nature, so rearing was done in the field. At the time of rearing 4-6 big trees together, cover with a mosquito net (rearing net) to kept them away from the natural enemies like birds, snakes, wasps, britle, lizard etc.

3.5 Food plants or host plants :

Muga silkworm is polyphagous in nature. It feeds on various plants, viz. *Persea bombycina* Kosterm (*Machilus bombycina* King), *Litsea monopetala* Pers, *Litsea polyantha* Juss, *L. citrata*, *L. Salicifolia*, *Magnolia sphenocarpa* and *Zizyphus jujuba*. In present investigation, larvae were reared on the two principal host plants namely *Persea bombycina* King (som) and *Litsea polyantha* Juss. (soalu).

3.6 Rearing of silkworm :

3.6.1 Outdoor :

During different seasons in a year, rearing was done at different field alternately. Immediate after completion of rearing the pruning of tree, liming of soil, organic manuring, bleaching powder spray etc. were done for the purpose of increasing new leaves, changing of soil pH, growth and free from larvae eating hunter ants, beetles etc. respectively. During dry season March – April proper irrigation was maintained to avoid the water scarcity. Rearing were carried out during different seasons namely summer, rainy, winter, autumn and spring utilizing seven period viz. February – March, March – April, April – May, June – July, August – September, October – November and December – February.

3.6.2 Indoor rearing :

The indoor rearing was carried out following the methodology of Thangavelu and Sahu (1983) within the rearing cell. The branches of the food plant, som and soalu were kept immerged in water contained in earthen pots and these were kept in a stand in three tiers and the whole setup was covered with polythene cover except the ground surface (Plate 1 and 2). The rearing was conducted inside the room. The polythene cover was knitted on all sides except on the front and the front sheet was used like door curtain enabling rearing operation and these also facilitated maintaining the desired level of crop loss in outdoor rearing,. Indoor rearing was done in seven different season namely February – March, March – April, April – May, June – July, August – September, October – November and December – February. In each seasons, eggs after hatching were reared following the recommended schedule until the attainment of cocoon, adult moth and egg.

3.7 Diet :

For outdoor and indoor rearing, the larvae were fed with the leaves of som (*Machilus bombycina*) and soalu (*Litsea polyantha*). Trees were used after two months of pruning. For consumption besides pure som and pure soalu, different combinations were used. Combination be depict in table 3.

Table 3 : Combination of feed of muga silkworm

T_1	1st instar on som and rest on soalu
T_2	1st and 2nd instar on som and rest on soalu
T_3	1st to 3rd instar on som and rest on soalu
T_4	1st to 4th instar on som and rest on soalu
T_5	1st instar on soalu and rest on som
T_6	1st and 2nd instar on soalu and rest on som
T_7	1st to 3rd instar on soalu and rest on som
T_8	1st to 4th instar on soalu and rest on som

Plate 1 : Rearing cell for muga silkworm, the rearing stand completely closed on all sides with polythene cover.

Plate 2 : Polythene cover of the front portion partly removed for feeding and other operations.

3.8 Rearing performances :

Twenty-five disease free laying (eggs laid by a single disease free female) were reared in mass from hatching still spinning. The cocoons were harvested on sixth day from the onset of spinning, as this time gap is more than sufficient for the transformation of larvae into pupae. After the emergence of moth and coupling them, after laying eggs were collected upto 6th days for counting fecundity.

From the view point of economic importance, the following parameters and their method of evaluation were considered :

1. Larval duration calculated from the date of hatching to the date of spinning (in days)
2. Weight of single larva (gm)
3. Effective rate of rearing by percentage which was calculated as :

$$\text{ERR \%} = \frac{\text{Number of cocoons harvested}}{\text{Number of larvae reared}} \times 100$$

$$\text{ERR Number} = \frac{\text{Number of cocoons harvested}}{\text{Number of larvae reared}} \times 10000$$

4. Single cocoon weight (gm)
5. Single shell weight (gm)
6. Shell ratio (SR%) which was determined as :

$$\text{SR\%} = \frac{\text{Single shell weight (gm)}}{\text{Single cocoon weight (gm)}} \times 100$$

7. Absolute silk content (Kg) which was determined by :

   ERR number x Single shell weight (gm)
8. Fecundity = Number of egg lay by single gravid female moth

All the parameters were recorded on fresh weight basis. Twenty larvae as well as cocoons (10 males and 10 females) were taken for each of the three replications for assessment of quality of cocoon. For fecundity twenty gravid females were taken for each of the three replications. All values of rearing results comprising rearing performance as well as quality of cocoons were subjected to suitable statistical analysis.

3.9. Consumption and utilization of food by muga silkworm larvae :

In order to determine the consumption and utilization of som and soalu leaves a colony of muga silkworm was raised in the laboratory and was maintained from brushing till spinning in indoor. Three replication with fifty larvae per replication were maintained for the study of nutritional efficiencies. Aliquot was kept for dry weight determination.

An.additional larval batch was also maintained as above for determining dry weight values. The healthy larvae were counted daily in each replication and unequal, weak, unhealthy if any, were replaced by healthy ones of the same age from the reserve stock. The left over leaf (LOL) and excreta were collected carefully and separated daily at 9 AM. The excreta and leaf were dried at 60^0C to a constant weight. The experiment was conducted five consecutive years (2003-2008) considering five seasons per year February – March, April – May, June – July, August – September and October – November.

For pure som, pure soalu and different combinations the experiments were conducted during two main commercial crop rearing season (April – May and October – November). Later on the experiment with pure som and better combinations were conducted during five different seasons namely February – March, April – May, June – July, August – September and October – November. The amount of dry matter ingested, digested and converted were determined by standard gravimetric methods (Waldbauer, 1968). The indices used in the study were followed after (Waldbauer, 1968) and are given below :

3.9.1 Consumption and growth :

3.9.1.1 Reference ratio (RR) = Food Ingestion / Excretion

3.9.1.2. Consumption index (CI) :

$$(CI) = \frac{F}{TA}$$

Where,

F = Dry weight of food ingested

T = Duration of feeding period (day)

A = Mean dry weight of larvae during feeding period.

3.9.1.3. Growth rate

$$(GR) = \frac{G}{TA}$$

Where,

G = Dry weight gain of larvae during feeding period

T = Duration of feeding period (day)

A = Mean dry weight of larvae during feeding period.

3.9.2 Digestibility and Efficiency of Conversion

3.9.2.1 Digestibility

The approximate digestibility (AD) was calculated as :

$$AD\,\% = \frac{\text{Weight of food ingested - weight of faeces}}{\text{Weight of food ingested}} \times 100$$

3.9.2.2 Conversion of ingested food to larval biomass, cocoon, cocoon shell and egg

The efficiency of conversion of ingested food to the larval biomass (ECI %) which calculated as :

$$ECI\,\% = \frac{\text{Final weight of larva - initial weight of larva}}{\text{Weight of food ingested}} \times 100$$

$$ECI\,\%\text{ to cocoon} = \frac{\text{Weight of cocoon}}{\text{Weight of food ingested}} \times 100$$

$$\text{ECI\% to shell} = \frac{\text{Weight of shell}}{\text{Weight of food ingested}} \times 100$$

$$\text{ECI\% to egg} = \frac{\text{Weight of total egg laid}}{\text{Weight of food ingested}} \times 100$$

3.9.2.3 Conversion of digested food to larval biomass, cocoon, cocoon shell and egg

The efficiency of conversion of digested food to the larval biomass (ECD %) which calculated as :

$$\text{ECD \%} = \frac{\text{Final weight of larva - initial weight of larva}}{\text{Weight of food digested}} \times 100$$

$$\text{ECD\% to cocoon} = \frac{\text{Weight of cocoon}}{\text{Weight of food digested}} \times 100$$

$$\text{ECD\% to shell} = \frac{\text{Weight of shell}}{\text{Weight of food digested}} \times 100$$

$$\text{ECD\% to egg} = \frac{\text{Weight of total egg laid}}{\text{Weight of food digested}} \times 100$$

3.9.3 Ingesta required to produce

$$\text{One gram cocoon} = \frac{\text{Weight of food ingested}}{\text{Cocoon weight}}$$

$$\text{One gram shell} = \frac{\text{Weight of food ingested}}{\text{Shell weight}}$$

$$\text{One gram egg} = \frac{\text{Weight of food ingested}}{\text{Weight of total egg laid}}$$

3.9.4 Digesta required to produce

$$\text{One gram cocoon} = \frac{\text{Weight of food digested}}{\text{Cocoon weight}}$$

$$\text{One gram shell} = \frac{\text{Weight of food digested}}{\text{Shell weight}}$$

$$\text{One gram egg} = \frac{\text{Weight of food digested}}{\text{Weight of total egg laid}}$$

3.10.1 Cocoon yield (gm) = Single Cocoon Weight x ERR%

3.10.2 Egg yield = Total number of egg laid by a single gravid female x ERR%

3.11 Statistical analysis :

For better interpretation of results experiments were laid out on various design of experiment as and when required. All the experiment were replicated thrice. Indoor and outdoor performances were plotted on Three-Factor Factorial Randomized Block Design (RBD). The data of consumption on som and soalu leaves, eight treatments (T_1 to T_8) on different combinations of leaves during two commercial crop rearing season, were plotted on Two Factor Factorial Randomized Block Design (RBD). Data of consumption on som and better combination during five different seasons were plotted on Three Factor Factorial Randomized Block Design (RBD) and their conversion efficiencies to cocoon, cocoon shell and eggs were plotted on Two Factor Factorial Randomized Block Design (RBD).

The relationship between the environmental factors, economic performance of larvae fed on both som and soalu were correlated. The significant levels were taking under consideration from 0.5 % to 0.01 % level of confidence.

Chapter - IV

RESULTS

4.1 Indoor and outdoor rearing in different seasons :

Different rearing parameters were studied during different seasons namely summer, rainy, winter, autumn and spring utilizing seven periods viz. February – March, March – April, April – May, June – July, August – September, October – November and December – February on two principal host plant – Som (*Machilus bombycina*) and Soalu (*Litsea polyantha*) in field (outdoor) and indoor condition. Data thus obtained, were analyzed statistically and depicted in table 6 to 13.

4.1.1 Environmental factors during different seasons :

4.1.1.1 Temperature :

Highest average temperature was observed during June – July which was 32.24^{0}C with maximum temperature of 34.24^{0}C and minimum 30.24^{0}C followed by August – September where it was 29.32^{0}C. During December – February the average temperature was 15.86^{0}C having a minimum of 11.19^{0}C and temperature never rises beyond 20.54^{0}C. During February – March and March – April average temperature was 19-21^{0}C and the maximum temperature was below 25^{0}C. During October – November and April – May the commercial crop rearing season, the average temperature was 23.07^{0}C and 24.63^{0}C respectively and in both the seasons the maximum temperature was below 28^{0}C (table 4).

Table 4: Mean meteorological data of 2003-2007 (out door)

	Temperature (^{0}C)			Relative Humidity (%)			Photoperiod (hrs)		Rain fall (mm)
	Maximum	Minimum	average	Maximum	Minimum	average	Light	Dark	
February-March	23.96	15.17	19.56	72.40	57.38	64.89	12.15	11.45	57.53
March-April	24.80	17.18	20.99	74.20	58.25	66.23	12.30	11.30	80.25
April-May	27.75	21.52	24.63	76.75	71.07	73.91	12.46	11.14	164.14
June-July	34.24	30.24	32.24	85.15	78.93	82.04	13.07	10.53	725.44
August-September	30.90	27.74	29.32	79.62	74.30	76.96	12.31	11.29	381.15
October-November	26.91	19.24	23.07	75.41	70.63	73.02	11.14	12.46	42.32
December-February	20.54	11.19	15.86	77.32	62.80	70.06	10.50	13.10	12.42

In indoor condition the temperature was observed 1-2^{0}C higher than in outdoor, highest during December – February (15.86^{0}C in field and 18.34^{0}C in indoor) and the maximum temperature in indoor condition was during June – July (36.24^{0}C) showing an average of 34.24^{0}C. During August – September also the maximum temperature was above 32^{0}C while during other seasons the temperature never rises beyond 28^{0}C and the average temperature was below 26^{0}C (table 5).

Table 5: Mean meteorological data of 2003-2007 (indoor)

	Temperature (ºC)			Relative Humidity (%)			Photoperiod (hrs.)	
	Maximum	Minimum	average	Maximum	Minimum	average	Light	Dark
February-March	23.00	17.15	20.08	73.20	60.50	66.85	11.45	12.15
March-April	24.30	18.20	21.25	77.20	61.10	69.15	11.50	12.10
April-May	28.00	22.52	25.26	79.75	72.70	76.23	11.55	12.05
June-July	36.24	32.24	34.24	91.25	86.92	89.09	12.35	11.25
August-September	32.14	28.70	30.42	90.50	84.10	87.30	12.15	11.45
October-November	27.90	21.24	24.57	78.42	72.60	75.51	10.45	13.15
December-February	22.55	14.12	18.34	77.80	62.90	70.35	10.20	13.40

4.1.1.2 Relative humidity :

In field condition during June – July the average RH was highest (82.04%) having a range between 78.93% to 85.15%. During August – September also, the maximum RH almost reached 80%. During December – February, the RH was 70.06% while during February – March and March – April the average RH showing 64.89% and 66.23% respectively was lowest and minimum RH during those two seasons were below 60%. During April – May and October – November the RH ranged between 70.63% - 76.75% (table 4).

In indoor condition, RH was recorded higher than outdoor condition. During June – July, the maximum RH was 91.25% and minimum RH was 86.92% giving an average of 89.09% showing highest relative humidity followed by August – September where the average RH was 87.30%. During April – May and October – November, the RH was nearly 76% while during rest of the seasons, it was below 70% (table 5).

4.1.1.3 Photoperiod :

13 hours of light (highest light period) and 13 hours of dark (highest dark period) were observed during June – July and December – February respectively. All the periods except June – July and August – September the dark period was longer. In indoor condition also the trend of light period was similar, the dark period was comparatively longer in indoor condition (table 4 and 5).

4.1.1.4 Rainfall :

The rainfall was maximum during June – Ju ly (725.44 mm) followed by August – September (381.15 mm) and there observed high rainfall (164.14 mm) during April – May also. Moreover, in spring and winter seasons there observed 12 mm – 80 mm rainfall (table 4).

So, high temperature along with high RH and maximum rainfall coupled with longer light period was observed during June – September. Low temperature along with low humidity with longer dark period and negligible rainfall was observed during winter months. Pleasant temperature and humidity was observed during March – April and October – November.

4.1.2 Rearing performance :

4.1.2.1 Larval duration :

Larval duration was observed higher in outdoor condition (28.151 days) than in indoor (24.195 days) and during December – February the larval duration was maximum (53.5 days in outdoor and 37 days in indoor). Significantly higher larval duration was observed when the larvae fed on som leaves (26.893 days) than on soalu (25.454 days). However, during June – July (21.50 days) and August – September (23.140 days) the larval duration was higher when fed on soalu leaves and as a whole the larval duration was lower during June – July (21 days) and August – September (22.493 days) than others (table 6).

Table 6 : Larval duration of muga silkworm during different seasons in indoor and out door condition.

	Out Door (days)			In Door (days)			Som (days)	Soalu (days)	Average (days)
	Som	Soalu	Average	Som	Soalu	Average			
Feb. - March	25.400	24.100	24.750	22.910	21.100	22.005	24.155	22.600	23.378
March- April	24.520	22.400	23.460	22.900	21.080	21.990	23.710	21.740	22.725
April-May	24.500	23.500	24.000	22.680	20.830	21.755	23.590	22.165	22.878
June-July	21.000	22.000	21.500	20.000	21.000	20.500	20.500	21.500	21.000
August-Sept.	22.100	24.200	23.150	21.590	22.080	21.835	21.845	23.140	22.493
Oct.-Nov.	26.200	27.200	26.700	25.700	22.860	24.280	25.950	25.030	25.490
Dec.-Feb.	58.000	49.000	53.500	39.000	35.000	37.000	48.500	42.000	45.250
Mean	**28.817**	**27.486**	**28.151**	**24.969**	**23.421**	**24.195**	**26.893**	**25.454**	**26.173**
	Site		Host plant	Site		Host Plant	Season		
S Em (±)	0.017		0.017	0.017		0.017	0.032		
CD (P = 0.05)	0.049		0.049	0.049		0.049	0.091		
Site x Host Plant									
S Em (±)	0.024								
CD (P = 0.05)	0.069								
Site x Season									
S Em (±)	0.045								
CD (P = 0.05)	0.129								
Host Plant x Season									
S Em (±)	0.045								
CD (P = 0.05)	0.129								
Site x Host Plant x Season									
S Em (±)	0.064								
CD (P = 0.05)	Non Significant								

4.1.2.2 Matured larval weight :

Significantly higher larval weight were recorded in indoor condition (8.626 gm) than in outdoor (8.286 gm). Among the periods, larval weight was highest during October – November (9.125 gm) followed significantly by April – May (8.76 gm) (table 7).

Table 7 : Matured larval weight of muga silkworm during different seasons in indoor and out door condition.

	Out Door (gm)			In Door (gm)			Som (gm)	Soalu (gm)	Average (gm)
	Som	Soalu	Average	Som	Soalu	Average			
Feb.-March	8.020	8.340	8.180	8.420	8.720	8.570	8.220	8.530	8.375
March- April	8.120	8.800	8.460	8.630	8.780	8.705	8.375	8.790	8.583
April-May	8.300	9.030	8.665	8.840	8.870	8.855	8.570	8.950	8.760
June-July	7.720	7.920	7.820	7.900	8.885	8.393	7.810	8.402	8.106
August-Sept.	8.150	8.200	8.175	8.830	8.950	8.890	8.490	8.575	8.533
Oct.-Nov.	8.780	9.200	8.990	9.020	9.500	9.260	8.900	9.350	9.125
Dec.-Feb.	7.600	7.820	7.710	7.510	7.920	7.715	7.555	7.870	7.713
Mean	**8.099**	**8.473**	**8.286**	**8.450**	**8.803**	**8.626**	**8.274**	**8.638**	**8.456**
	Site		Host plant	Site		Host Plant	Season		
S Em (±)	0.003		0.003	0.003		0.003	0.006		
CD (P = 0.05)	0.010		0.010	0.010		0.010	0.018		
Site x Host Plant									
S Em (±)	0.005								
CD (P = 0.05)	0.014								
Site x Season									
S Em (±)	0.009								
CD (P = 0.05)	0.025								
Host Plant x Season									
S Em (±)	0.009								
CD (P = 0.05)	0.025								
Site x Host Plant x Season									
S Em (±)	0.012								
CD (P = 0.05)	Non Significant								

4.1.2.3 Single cocoon weight :

Single cocoon weight was also observed significantly better in indoor condition (5.319 gm) than in outdoor (4.964 gm) but unlike larval weight cocoon weight was significantly higher when larvae fed on som leaves (5.298 gm) than on soalu (4.985 gm). From the seasonal standpoint, October – November showed highest cocoon weight of 5.545 gm which was 5.46 gm in outdoor condition and 5.63 gm in indoor condition and always better when fed on som leaves (5.52 gm in indoor and 5.75 gm in outdoor). Cocoon weight during this season was significantly followed by the cocoon weight of April – May (5.233 gm). Cocoon weight observed lower during December – March and June – September (table 8).

Table 8 : Single cocoon weight of muga silkworm during different seasons in indoor and out door condition.

	Out Door (gm)			In Door (gm)			Som (gm)	Soalu (gm)	Average (gm)
	Som	Soalu	Average	Som	Soalu	Average			
Feb.-March	5.000	4.700	4.850	5.420	5.000	5.210	5.210	4.850	5.030
March- April	5.080	4.790	4.935	5.520	5.080	5.300	5.300	4.935	5.118
April-May	5.130	5.090	5.110	5.620	5.100	5.360	5.375	5.090	5.233
June-July	5.000	4.510	4.755	5.310	5.300	5.305	5.155	4.905	5.030
August-Sept.	5.300	4.410	4.855	5.620	5.410	5.515	5.460	4.910	5.185
Oct.-Nov.	5.520	5.400	5.460	5.750	5.510	5.630	5.635	5.455	5.545
Dec.-Feb.	4.880	4.690	4.785	5.020	4.810	4.915	4.950	4.750	4.850
Mean	**5.130**	**4.799**	**4.964**	**5.466**	**5.173**	**5.319**	**5.298**	**4.985**	**5.142**
	Site		Host plant	Site		Host Plant	Season		
S Em (±)	0.004		0.004	0.004		0.004	0.007		
CD (P = 0.05)	0.010		0.010	0.010		0.010	0.019		
Site x Host Plant									
S Em (±)	0.005								
CD (P = 0.05)	0.015								
Site x Season									
S Em (±)	0.009								
CD (P = 0.05)	0.027								
Host Plant x Season									
S Em (±)	0.009								
CD (P = 0.05)	0.027								
Site x Host Plant x Season									
S Em (±)	0.014								
CD (P = 0.05)	Non Significant								

4.1.2.4 Single shell weight :

No significant variation was observed between indoor and outdoor condition. However, significant variation was observed among the season as well as among the host plants. Som fed larvae showed higher shell weight (0.384 gm) than soalu (0.353 gm) and during October – November the shell weight was highest (0.455 gm). Unlike cocoon weight, shell weight was observed better during August – September (0.39 gm) followed significantly by April – May (0.380 gm) and others. Though, there observed no significant variation between August – September and April – May, significantly higher shell weight was observed during August – September (0.405 gm) than during April – May (0.390 gm) on som leaves. However, lowest shell weight was observed during December – February in both the conditions and in both the leaves (table 9).

Table 9 : Single shell weight of muga silkworm during different seasons in indoor and out door condition.

	Out Door (gm)			In Door (gm)			Som	Soalu	Average
	Som	Soalu	Average	Som	Soalu	Average	(gm)	(gm)	(gm)
Feb.-March	0.340	0.320	0.330	0.350	0.340	0.345	0.345	0.330	0.338
March- April	0.350	0.320	0.335	0.360	0.340	0.350	0.355	0.330	0.343
April-May	0.400	0.380	0.390	0.380	0.360	0.370	0.390	0.370	0.380
June-July	0.360	0.310	0.335	0.370	0.350	0.360	0.365	0.330	0.348
August-Sept.	0.400	0.370	0.385	0.410	0.380	0.395	0.405	0.375	0.390
Oct.-Nov.	0.490	0.440	0.465	0.480	0.410	0.445	0.485	0.425	0.455
Dec.-Feb.	0.340	0.300	0.320	0.350	0.320	0.335	0.345	0.310	0.328
Mean	**0.383**	**0.349**	**0.366**	**0.386**	**0.357**	**0.371**	**0.384**	**0.353**	**0.369**
	Site		Host plant	Site		Host Plant	Season		
S Em (±)	0.002		0.002	0.002		0.002	0.003		
CD (P = 0.05)	0.005		0.005	0.005		0.005	0.010		
Site x Host Plant									
S Em (±)	0.003								
CD (P = 0.05)	0.007								
Site x Season									
S Em (±)	0.005								
CD (P = 0.05)	0.014								
Host Plant x Season									
S Em (±)	0.005								
CD (P = 0.05)	0.014								
Site x Host Plant x Season									
S Em (±)	0.007								
CD (P = 0.05)	Non Significant								

4.1.2.5 Shell ratio :

Shell ratio was observed significantly higher in outdoor condition (7.346 %) than indoor (6.971 %) on som leaves. During October – November both in outdoor (8.513%) and indoor condition (7.895%) the shell ratio was best followed significantly by August – September in both out door (7.969%) and in indoor condition (7.160%). During December – March the SR% was lowest (table 10).

Table 10 : Shell ratio of muga silkworm during different seasons in indoor and out door condition

	Out Door (%)			In Door (%)			Som (%)	Soalu (%)	Average (%)
	Som	Soalu	Average	Som	Soalu	Average			
Feb.-March	6.800	6.809	6.805	6.458	6.800	6.629	6.629	6.805	6.717
March- April	6.890	6.681	6.786	6.522	6.693	6.608	6.706	6.687	6.697
April-May	7.797	7.466	7.632	6.762	7.059	6.911	7.280	7.262	7.271
June-July	7.200	6.874	7.037	6.968	6.604	6.786	7.084	6.739	6.912
August-Sept.	7.547	8.390	7.969	7.295	7.024	7.160	7.421	7.707	7.564
Oct.-Nov.	8.877	8.148	8.513	8.348	7.441	7.895	8.613	7.795	8.204
Dec.-Feb.	6.967	6.397	6.682	6.972	6.653	6.813	6.970	6.525	6.747
Mean	**7.440**	**7.252**	**7.346**	**7.046**	**6.896**	**6.971**	**7.243**	**7.074**	**7.159**
	Site		Host plant	Site		Host Plant	Season		
S Em (±)	0.035		0.035	0.035		0.035	0.066		
CD (P = 0.05)	0.100		0.100	0.100		0.100	0.187		
Site x Host Plant									
S Em (±)	0.05								
CD (P = 0.05)	0.14								
Site x Season									
S Em (±)	0.093								
CD (P = 0.05)	0.264								
Host Plant x Season									
S Em (±)	0.093								
CD (P = 0.05)	0.264								
Site x Host Plant x Season									
S Em (±)	0.132								
CD (P = 0.05)	Non Significant								

4.1.2.6 Effective rate of rearing (ERR) :

ERR, the survivability rate of the larvae, was significantly higher in indoor condition (29.127%) than in outdoor condition (26.967%). Though during December – February the ERR% was very low in indoor condition (7.5%), in outdoor condition it was 25.387%. ERR% was better when the larvae fed on som leaves 31.746% than soalu and this trend was followed during every season and in both the conditions significantly. As a whole highest ERR% was observed during October – November (44.53%) which was 43.55% in outdoor and 45.51% in indoor condition followed significantly by April – May (42.778%), where it was 39.445% in outdoor and 46.11% in indoor. Significantly lowest ERR was observed during June – July (12%) followed by December – February (16.443%), where ERR was 7% in outdoor in June – July and 7.5 % in indoor during December – February (table 11).

Table 11: Effective rate of rearing of muga silkworm during different seasons in indoor and out door condition.

	Out Door (%)			In Door (%)			Som (%)	Soalu (%)	Average (%)
	Som	Soalu	Average	Som	Soalu	Average			
Feb.-March	25.000	23.000	24.000	30.010	20.000	25.005	27.505	21.500	24.503
March- April	31.330	28.430	29.880	35.200	30.280	32.740	33.265	29.355	31.310
April-May	43.430	35.460	39.445	51.960	40.260	46.110	47.695	37.860	42.778
June-July	10.000	4.000	7.000	23.000	11.000	17.000	16.500	7.500	12.000
August-Sept.	27.810	11.203	19.507	30.050	30.000	30.025	28.930	20.602	24.766
Oct.-Nov.	49.430	37.670	43.550	53.020	38.000	45.510	51.225	37.835	44.530
Dec.-Feb.	24.200	26.573	25.387	10.000	5.000	7.500	17.100	15.787	16.443
Mean	**30.171**	**23.762**	**26.967**	**33.320**	**24.934**	**29.127**	**31.746**	**24.348**	**28.047**
	Site		Host plant	Site		Host Plant	Season		
S Em (±)	0.031		0.031	0.031		0.031	0.059		
CD (P = 0.05)	0.089		0.089	0.089		0.089	0.166		
Site x Host Plant									
S Em (±)	0.044								
CD (P = 0.05)	0.125								
Site x Season									
S Em (±)	0.083								
CD (P = 0.05)	0.234								
Host Plant x Season									
S Em (±)	0.083								
CD (P = 0.05)	0.234								
Site x Host Plant x Season									
S Em (±)	0.117								
CD (P = 0.05)	Non Significant								

4.1.2.7 Absolute Silk Content (kg) :

Absolute Silk Content (ASC) was observed significantly higher in indoor condition (1.119 kg) than in outdoor condition (1.028 kg). Significantly higher ASC was recorded in the cocoon where larvae fed on som leaves (1.262 kg) than on soalu leaves (0.885 kg). Among the seasons October – November showed highest ASC (2.046 kg) (2.422 kg in out door fed on som and 2.545 kg in indoor fed on som), significantly followed by April – May (1.627 kg) and others.

Lowest average ASC was observed during June – July (0.430 kg) though in indoor condition, December – February showed lowest ASC (0.255 kg) (Table 12).

Table 12 : Absolute silk content of muga silkworm during different seasons in indoor and out door condition.

	Out Door (Kg)			In Door (Kg)			Som (Kg)	Soalu (Kg)	Average (Kg)
	Som	Soalu	Average	Som	Soalu	Average			
Feb.-March	0.850	0.736	0.793	1.05	0.680	0.865	0.950	0.708	0.829
March- April	1.097	0.910	1.004	1.267	1.030	1.149	1.182	0.970	1.076
April-May	1.737	1.347	1.542	1.974	1.449	1.712	1.856	1.398	1.627
June-July	0.360	0.124	0.242	0.851	0.385	0.618	0.606	0.255	0.430
August-Sept.	1.112	0.415	0.764	1.232	1.140	1.186	1.172	0.778	0.975
Oct.-Nov.	2.422	1.657	2.040	2.545	1.558	2.052	2.484	1.608	2.046
Dec.-Feb.	0.823	0.797	0.810	0.350	0.160	0.255	0.587	0.479	0.533
Mean	**1.200**	**0.855**	**1.028**	**1.324**	**0.915**	**1.119**	**1.262**	**0.885**	**1.074**
	Site		Host plant	Site		Host Plant	Season		
S Em (±)	0.005		0.005	0.005		0.005	0.009		
CD (P = 0.05)	0.014		0.014	0.014		0.014	0.026		
Site x Host Plant									
S Em (±)	0.007								
CD (P = 0.05)	0.019								
Site x Season									
S Em (±)	0.013								
CD (P = 0.05)	0.037								
Host Plant x Season									
S Em (±)	0.013								
CD (P = 0.05)	0.037								
Site x Host Plant x Season									
S Em (±)	0.018								
CD (P = 0.05)	Non Significant								

4.1.2.8 Fecundity :

Fecundity was observed significantly higher in outdoor condition (177.979) than in indoor condition (130.486). Som leaf feeding showed higher fecundity (166.429) than soalu (142.007). Among the seasons highest fecundity was observed during October – November (188.93) followed by April – May (177.55) and others and lowest from December – February (120.00). Moreover, the highest fecundity was observed in outdoor condition on som leaf during October – November, which was 235.20 in number (Table 13).

Table 13 : Realize fecundity of muga silkworm during different seasons in indoor and out door condition.

	Out Door (nos.)			In Door (nos.)			Som (nos.)	Soalu (nos.)	Average (nos.)
	Som	Soalu	Average	Som	Soalu	Average			
Feb.-March	180.200	160.000	170.100	125.200	105.000	115.100	152.700	132.500	142.600
March- April	201.000	185.200	193.100	130.000	115.200	122.600	165.500	150.200	157.850
April-May	220.200	200.000	210.100	160.000	130.000	145.000	190.100	165.000	177.550
June-July	158.000	116.500	137.250	135.200	120.500	127.850	146.600	118.500	132.550
August-Sept.	195.200	170.000	182.600	150.000	125.000	137.500	172.600	147.500	160.050
Oct.-Nov.	235.200	210.200	222.700	170.200	140.500	155.350	202.500	175.350	188.930
Dec.-Feb.	150.000	110.000	130.000	120.000	100.000	110.000	135.000	105.000	120.000
Mean	**191.400**	**164.557**	**177.979**	**141.514**	**119.457**	**130.486**	**166.429**	**142.007**	**154.219**
	Site		Host plant	Site		Host Plant	Season		
S Em (±)	**0.333**		**0.333**	**0.333**		**0.333**	0.623		
CD (P = 0.05)	0.943		0.943	0.943		0.943	1.764		
Site x Host Plant									
S Em (±)	0.470								
CD (P = 0.05)	1.333								
Site x Season									
S Em (±)	0.880								
CD (P = 0.05)	2.494								
Host Plant x Season									
S Em (±)	0.880								
CD (P = 0.05)	2.494								
Site x Host Plant x Season									
S Em (±)	1.245								
CD (P = 0.05)	Non Significant								

4.1.2.9 Correlation study :

Highly significant positive correlation exists between temperature and RH (0.936) and temperature with light period (0.756) while temperature was negatively correlated with dark period (table 14 a). Moreover, there observed positively significant correlation between larval weight and cocoon weight, cocoon weight and shell weight, larval weight and cocoon weight with ERR, larval weight, cocoon weight and shell weight with ASC and ERR with ASC. Moreover, photoperiod was observed inversely proportional with the larval duration (table 14 b).

Table 14 a . Correlation between the environmental factors

		Temp^{0}C			RH (%)			Photoperiod (PP)	
		Max	Min	Avg	Max	Min	Avg	Light	Dark
Temp^0 C	Max	1 .000	0 .993****	0 .998****	0 .892**	0 .942***	0 .941***	0 .729	-0 .729
	Min	-	1 .000	0 .999****	0 .888**	0 .926***	0 .929***	0 .773*	-0 .773*
	Avg	-	-	1 .000	0 .891**	0 .934***	0 .936***	0 .756*	-0 .756*
RH (%)	Max	-	-	-	1 .000	0 .919***	0 .967****	0 .552	-0 .552
	Min	-	-	-	-	1 .000	0 .989****	0 .502	-0 .502
	Avg	-	-	-	-	-	1 .000	0 .530	-0 .530
PP	Light	-	-	-	-	-	-	1 .000	-1 .000
	Dark	-	-	-	-	-	-	-	1 .000

* Significant at 5 % level of confidence
* Significant at 1 % level of confidence
* Significant at 0.5 % level of confidence
* Significant at 0.1 % level of confidence

Table 14b : Correlation study between the environmental factors and economic parameters of muga silkworm.

Correlation study		Weight of single			Larval duration	SR %	ERR %	ASC	Fecundity
		Larva	Cocoon	Shell					
Temperature	Maximum	0.159	0.253	0.288	-0.609	0.326	-0.162	-0.059	0.370
	Minimum	0.163	0.233	0.263	-0.641	0.305	-0.168	-0.078	0.376
	Average	0.162	0.242	0.274	-0.629	0.314	-0.166	-0.070	0.374
Relative humidity	Maximum	-0.217	-0.068	0.058	-0.233	0.151	-0.459	-0.352	0.016
	Minimum	0.106	0.271	0.393	-0.368	0.469	-0.135	-0.002	0.321
	Average	-0.012	0.150	0.276	-0.325	0.360	-0.258	-0.132	0.214
Photoperiod	Light	0.087	-0.046	-0.172	-0.813*	-0.189	-0.203	-0.246	0.292
	Dark	-0.087	0.046	0.172	0.813*	0.189	0.203	0.246	-0.292

* Significant at 5 % level of confidence

From the overall observation, it can be said that almost all the rearing parameters except fecundity and shell ratio observed better in indoor condition. In all the seasons and except the larval weight all other parameter were found better on som leaf and from the seasonal standpoint October – November observed the best season followed by April – May while June – July and December – February were the worst performing seasons.

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

Nutritional efficiencies in the form of food ingestion, digestion, excretion, reference ratio, weight gain, approximate digestibility, efficiency of conversion of ingested food, efficiency of conversion of digested food, consumption index, growth rate, mean daily food ingestion and digestion, ingesta per growth, digesta per growth were assessed instarwise on som and soalu leaves during October – November (main commercial crop rearing season) and April – May (Second commercial crop rearing season) observed favourable for muga culture.

4.2.1 Nutritional efficiencies of larva fed on som leaves :

4.2.1.1 Food ingestion :

Significant variation was observed in different instars as well as during different seasons except in first instar where the variation between the seasons were non-significant. 81% food was ingested in fifth instar and 95% food were ingested in late instar (fourth and fifth instar). Food ingestion was higher during October – November (25.160 gm) than during April – May (19.299 gm). The ingesta increased gradually as the instars progressed. Significantly highest food ingestion was observed in fifth instar during October – November (20.600 gm) followed by April – May (15.560 gm) and others (table 15 a, b).

4.2.1.2 Food digestion :

Significant variation was observed in different instars as well as during different seasons except in first instar where the variation between the seasons were non-significant. 75% and 19% food were digested during fifth and fourth instar respectively. Food digestion was higher during October – November (8.591 gm) than during April – May (6.084 gm) which was increased gradually with the progress of growth significantly. Highest digestion was recorded during October – November by the fifth instar larvae (6.600 gm) (table 15 a, b).

4.2.1.3 Excreta :

Significant variation was observed in different instars as well as during different seasons except during first instar where the variation between the seasons were non-significant. Highest excreta was observed during fifth instar and during October – November (14.000 gm) followed by during fifth instar in April – May (11.090 gm) (table 15 a, b).

4.2.1.4 Reference ratio :

Reference ratio of the muga silkworm fed on som was 1.489. RR decreased with the progression of growth, highest being from first instar (1.918) having non-significant variation with second and third instar and significant variation with fourth and fifth instar, lowest being from fifth instar (1.437). Seasonal differences between the instars were non-significant upto fourth instar while in fifth instar it was 1.471 in October – November and 1.403 in April-May and as a consequence, in whole instar RR varied non-significantly among the seasons, 1.518 during October – November and 1.460 during April – May (table 15 a, b).

4.2.1.5 Larval duration :

Larval duration was observed 25.700 days during October – November and 22.681 days during April – May having significant difference. Irrespective of seasons, duration of first, second, third, fourth and fifth instar were 3.908 days, 3.675 days, 3.790 days, 4.130 days and 8.688 days, varied significantly (table 15 a, b).

4.2.1.6 Weight gain :

Weight gained by the larvae increased with the age, highest being from fifth instar (3.13 gm) in October - November. 69% weight gain was achieved by the fifth instar alone and 22% weight was gained by fourth instar. Weight gain during October – November was 4.451 gm and during April – May it was 3.401 gm which were significantly varied (table 15 a, b).

Table 15 (a) Food ingestion, digestion, excretion, RR, weight gain, and larval duration of the muga silkworm larvae fed on som leaves during two commercial rearing seasons

	Seasons	Larval Instar					Total
		I	II	III	IV	V	
Ingesta	April-May	0.057	0.165	0.685	2.832	15.560	19.299
	Oct.-Nov.	0.060	0.180	0.720	3.600	20.600	25.160
	Mean	**0.059**	**0.173**	**0.703**	**3.216**	**18.080**	**22.230**
Digesta	April-May	0.027	0.077	0.307	1.203	4.470	6.084
	Oct.-Nov.	0.029	0.085	0.327	1.550	6.600	8.591
	Mean	**0.028**	**0.081**	**0.317**	**1.377**	**5.535**	**7.338**
Excreta	April-May	0.030	0.088	0.378	1.629	11.090	13.215
	Oct.-Nov.	0.031	0.095	0.393	2.050	14.000	16.569
	Mean	**0.031**	**0.092**	**0.386**	**1.840**	**12.545**	**14.892**
RR	April-May	1.900	1.875	1.812	1.738	1.403	1.460
	Oct.-Nov.	1.935	1.895	1.832	1.756	1.471	1.518
	Mean	**1.918**	**1.885**	**1.822**	**1.747**	**1.437**	**1.489**
Duration	April-May	3.616	3.050	3.380	4.260	8.375	22.681
	Oct.-Nov.	4.200	4.300	4.200	4.000	9.000	25.700
	Mean	**3.908**	**3.675**	**3.790**	**4.130**	**8.688**	**24.191**
Weight gain	April-May	0.025	0.064	0.247	0.758	2.307	3.401
	Oct.-Nov.	0.026	0.070	0.260	0.965	3.130	4.451
	Mean	**0.026**	**0.067**	**0.254**	**0.862**	**2.719**	**3.926**

Table 15 (b) : Statistical Analysis of table 15 (a)

	Ingesta	Digesta	Excreta	RR	Wt. gain	Duration
Season						
S Em (±)	0.001	0.001	0.002	0.014	0.001	0.003
CD P=0.05	0.004	0.003	0.005	0.042	0.002	0.008
Instar						
S Em (±)	0.002	0.002	0.003	0.023	0.001	0.004
CD P=0.05	0.006	0.005	0.008	0.066	0.003	0.013
Season x Instar						
S Em (±)	0.003	0.003	0.004	0.032	0.001	0.006
CD P=0.05	0.009	0.008	0.011	0.094	0.004	0.018

4.2.1.7 Approximate digestibility (AD) :

Approximate digestibility values varied significantly from third to fifth instar. Except fifth instar, there was no significant variation among the seasons. The AD value was higher during first instar (47.851) and reduced with the advancement of instars, lowest in fifth instar

(30.384). Among the seasons, AD value was highest during October – November (34.145). It was observed that AD decreased drastically in fifth instar during both the seasons (table 16 a, b).

4.2.1.8 Efficiency of conversion of ingested food (ECI) :

The ECI recorded highest in first instar (43.597%) and lowest in fifth instar (15.010%) and the difference was significant from instar to instar. While calculating the ECI values for total larval period, non-significant variation was observed during two different seasons. A drastic reduction of ECI values were observed from early instars (first, second and third) to late instars (fourth and fifth) (table 16 a, b).

4.2.1.9 Efficiency of conversion of digested food (ECD) :

ECD value in first instar was 91.124% which decreased gradually to 49.518% in fifth instar setting ECD of total larval period in 53.856% which differed significantly among the seasons, 51.810% during October – November and 55.901% during April – May. Higher ECD was observed throughout the instars during April – May than during October – November (table 16 a, b).

4.2.1.10 Consumption index (CI) :

Consumption index decreased from first instar (1.020) to fifth instar (0.814) gradually and CI was recorded higher during April – May throughout the instars. Totally it was observed that during April – May it was 0.501 and during October – November it was 0.442 (table 16 a, b).

4.2.1.11 Growth rate (GR) :

Higher growth rate was observed during first instar (0.445), which gradually decreased and lowest during fifth instar (0.122) and except second and third instar, variation between different instars was significant. Growth rate was higher during April - May, however significant variation between April-May and October-November was observed in first, second, third and fourth instar (table 16 a, b).

Table 16 (a) AD, ECI, ECD, CI and GR of the muga silkworm larvae fed on som leaves during two commercial rearing seasons

Som	Seasons	Larval Instar					Total
		I	II	III	IV	V	
AD	April-May	47.368	46.667	44.818	42.479	28.728	31.525
	Oct.-Nov.	48.333	47.222	45.417	43.056	32.039	34.145
	Mean	**47.851**	**46.945**	**45.118**	**42.768**	**30.384**	**32.835**
ECI	April-May	43.860	38.788	36.058	26.766	14.826	17.623
	Oct.-Nov.	43.333	38.889	36.111	26.806	15.194	17.691
	Mean	**43.597**	**38.839**	**36.085**	**26.786**	**15.010**	**17.657**
ECD	April-May	92.593	83.117	80.456	63.009	51.611	55.901
	Oct.-Nov.	89.655	82.353	79.511	62.258	47.424	51.810
	Mean	**91.124**	**82.735**	**79.984**	**62.634**	**49.518**	**53.856**
CI	April-May	1.087	0.917	0.947	0.931	0.828	0.501
	Oct.-Nov.	0.952	0.664	0.755	1.074	0.799	0.442
	Mean	**1.020**	**0.791**	**0.851**	**1.003**	**0.814**	**0.472**
GR	April-May	0.477	0.356	0.341	0.249	0.123	0.088
	Oct.-Nov.	0.413	0.258	0.273	0.288	0.121	0.078
	Mean	**0.445**	**0.307**	**0.307**	**0.269**	**0.122**	**0.083**

Table 16 (b) Statistical analysis of table 16 (a)

	AD	ECI	ECD	CI	GR
Season					
S Em (±)	0.395	0.271	1.044	0.004	0.003
CD P=0.05	1.165	0.799	3.079	0.013	0.007
Instar					
S Em (±)	0.625	0.428	1.650	0.007	0.004
CD P=0.05	1.842	1.264	4.868	0.020	0.012
Season x Instar					
S Em (±)	0.883	0.606	2.334	0.010	0.006
CD P=0.05	2.605	1.787	6.884	0.028	0.016

4.2.1.12 Mean daily food ingestion (MDFI) :

MDFI in total larval period was 0.915 gm which increased from 0.015 gm in first instar to 2.074 gm in fifth instar. MDFI was higher in October – November (0.979 gm) than in April – May (0.851 gm) (table 17 a, b).

4.2.1.13 Mean daily food digestion (MDFD) :

MDFD in total larval period was 0.301 gm which increased from 0.007 gm in first instar to 0.634 gm in fifth instar. Higher MDFD was observed during October – November (0.334 gm) than during April – May (0.268 gm) (table 17 a, b).

4.2.1.14 Ingestion / Growth :

The ingesta required to produce one gram of larval growth was observed lower in early instars and maximum in fifth instar (6.663). However, during total growth period 5.664 gm ingesta require to produce one gram of larval growth. Non-significant variation was observed among the two seasons under consideration (table 17 a, b).

4.2.1.15 Digestion / Growth :

The digesta required to produce one gram of larval growth was 1.860 gm, of which during fifth instar it was 2.024 gm, showing maximum requirement and during first instar it was 1.098 gm showing minimum requirement. Digesta/growth varied significantly between the two seasons, highest being from October - November (1.930 gm) (table 17 a, b).

Table 17 (a) MDFI, MDFD, Ing/Gr and Dig/Gr of the muga silkworm larvae fed on som leaves during two commercial rearing seasons

Som	Seasons	Larval Instar					Total
		I	II	III	IV	V	
MDFI	April-May	0.016	0.054	0.203	0.665	1.858	0.851
	Oct.-Nov.	0.014	0.042	0.171	0.900	2.289	0.979
	Mean	**0.015**	**0.048**	**0.187**	**0.783**	**2.074**	**0.915**
MDFD	April-May	0.007	0.025	0.091	0.282	0.534	0.268
	Oct.-Nov.	0.007	0.020	0.078	0.388	0.733	0.334
	Mean	**0.007**	**0.023**	**0.085**	**0.335**	**0.634**	**0.301**
Ing/Gr	April-May	2.280	2.578	2.773	3.736	6.745	5.675
	Oct.-Nov.	2.308	2.571	2.769	3.731	6.581	5.653
	Mean	**2.294**	**2.575**	**2.771**	**3.734**	**6.663**	**5.664**
Dig/Gr	April-May	1.080	1.203	1.243	1.587	1.938	1.789
	Oct.-Nov.	1.115	1.214	1.258	1.606	2.109	1.930
	Mean	**1.098**	**1.209**	**1.251**	**1.597**	**2.024**	**1.860**

Table 17 (b) Statistical analysis of table 17 (a)

	MDFI	MDFD	Ing/Gr	Dig/Gr
Season				
S Em (±)	0.001	0.001	0.017	0.014
CD P=0.05	0.001	0.001	0.049	0.042
Instar				
S Em (±)	0.001	0.001	0.026	0.022
CD P=0.05	0.002	0.002	0.077	0.066
Season x Instar				
S Em (±)	0.001	0.001	0.037	0.032
CD P=0.05	0.003	0.003	0.109	0.094

From overall results, it could be said that as a whole 81% food were ingested in fifth instar and 95% food were ingested in late instars (fourth and fifth). Food ingestion was higher during October – November (25.160 gm) than during April – May (19.299 gm). 75% and 19% food were digested during fifth and fourth instar respectively which was higher in October – November (8.591 gm) than April – May (6.084 gm). Reference ratio was observed 1.489, during October – November it was 1.518 and during April – May it was 1.460 having non-significant variation between them. 69% weight gain was recorded during fifth instar and 22% in fourth instar and significantly higher duration was recorded during October – November. AD, ECI and

ECD were 32.835%, 17.657% and 53.856% and significantly better during October – November for AD and ECI. Consumption index was 0.472, during October – November it was 0.442 and during April – May it was 0.501 and growth rate was higher during April – May (0.088).

Ingesta requirement to produce one-gram body weight was 5.664 gm and seasonal variation was non-significant. Digesta requirement to produce one gram body weight was 1.860 gm and higher in October – November (1.930 gm).

4.2.2 Nutritional efficiencies of larvae fed on soalu leaves :

4.2.2.1 Food Ingestion :

Significant variation was observed in different instars as well as different seasons except in first and second instar where the variation between the seasons were non-significant. 95% soalu leaves were ingested in late instars *i.e.* fourth and fifth instar, of this 81% food were ingested in fifth instar. Food ingestion was significantly higher during October - November (21.642 gm) than during April - May (20.157 gm). The ingesta increased gradually as the instar progressed, highest from fifth instar during October - November (17.604 gm) followed by fifth instar during April – May (16.402 gm) (table 18 a, b).

4.2.2.2 Food digestion :

Significant variation was observed in different instars as well as different seasons except in first and second instar where the variation between the seasons were non-significant. Like digestion of som leaves, 75% and 19% food were digested during fifth and fourth instar respectively. Food digestion was higher during October - November (6.977 gm) than during April - May (6.200 gm) which increased gradually with the progress of growth significantly, highest being from fifth instar during October – November (5.219 gm) (table 18 a, b).

4.2.2.3 Excreta :

Significant variation was observed in different instars as well as during different seasons except during first, second and third instar where the variation between the seasons were non-significant. Highest excreta were recorded during fifth instar and during October – November (12.385 gm) followed by during fifth instar in April – May (11.810 gm) (table 18 a, b).

4.2.2.4 Reference ratio :

Reference ratio (RR) of the muga silkworm fed on soalu leaves was 1.46, during October – November it was 1.476 and during April – May it was 1.444 having non-significant variation. RR decreased with the progression of growth highest being from first instar (2.118) and lowest being from fifth instar (1.405) (table 18 a, b).

4.2.2.5 Weight gain :

Weight gained by the larvae increased with age, highest being from fifth instar (2.313 gm). 67% and 23% weight gain were achieved during fifth and fourth instar respectively. From seasonal stand point, weight gain was better during October – November (3.689 gm) (table 18 a, b).

4.2.2.6 Larval duration :

Larval duration was observed 22.860 days during October – November and 20.830 days during April – May having non-significant variation. Irrespective of seasons larval duration of first, second, third, fourth and fifth instars were 2.9 days, 3.055 days, 3.55 days, 4.33 days and 8.01 days having significant variation between them (table 18 a, b).

Table 18 (a) Food ingestion, digestion, excretion, RR, weight gain, and larval duration of the muga silkworm larvae fed on soalu leaves during two commercial rearing seasons

Soalu	Seasons	Larval Instar					Total
		I	II	III	IV	V	
Ingesta	April-May	0.061	0.181	0.713	2.800	16.402	20.157
	Oct.-Nov.	0.064	0.189	0.735	3.050	17.604	21.642
	Mean	**0.063**	**0.185**	**0.724**	**2.925**	**17.003**	**20.900**
Digesta	April-May	0.032	0.086	0.331	1.159	4.592	6.200
	Oct.-Nov.	0.034	0.091	0.345	1.288	5.219	6.977
	Mean	**0.033**	**0.089**	**0.338**	**1.224**	**4.906**	**6.589**
Excreta	April-May	0.029	0.095	0.382	1.641	11.810	13.957
	Oct.-Nov.	0.030	0.098	0.390	1.762	12.385	14.665
	Mean	**0.030**	**0.097**	**0.386**	**1.702**	**12.098**	**14.311**
RR	April-May	2.103	1.905	1.866	1.706	1.389	1.444
	Oct.-Nov.	2.133	1.929	1.885	1.731	1.421	1.476
	Mean	**2.118**	**1.917**	**1.876**	**1.719**	**1.405**	**1.460**
Wt. gain	April-May	0.025	0.069	0.250	0.748	2.110	3.202
	Oct.-Nov.	0.027	0.072	0.260	0.815	2.515	3.689
	Mean	**0.026**	**0.071**	**0.255**	**0.782**	**2.313**	**3.446**
Duration	April-May	2.800	2.700	3.350	4.160	7.820	20.830
	Oct.-Nov.	3.000	3.410	3.750	4.500	8.200	22.860
	Mean	**2.900**	**3.055**	**3.550**	**4.330**	**8.010**	**21.845**

Table 18 (b) : Statistical Analysis of table 18 (a)

	Ingesta	Digesta	Excreta	RR	Wt. gain	Duration
Season						
S Em (±)	0.005	0.004	0.004	0.012	0.008	0.004
CD P=0.05	0.015	0.012	0.011	0.035	0.023	0.011
Instar						
S Em (±)	0.008	0.006	0.006	0.019	0.012	0.006
CD P=0.05	0.024	0.019	0.018	0.055	0.036	0.018
Season x Instar						
S Em (±)	0.011	0.009	0.008	0.026	0.017	0.009
CD P=0.05	0.033	0.027	0.025	0.077	0.051	0.025

4.2.2.7 Approximate digestibility (AD) :

The AD values were high during first instar (52.792%) and reduced with the advancement of instars, lowest in fifth instar (28.822%). However, no significant variation was observed among the seasons except fifth instar. It was observed that AD had been drastically decreased in fifth instar during both the seasons (table 19 a, b).

4.2.2.8 Efficiency of conversion of ingested food (ECI) :

The ECI recorded highest in first instar (41.586 %) and lowest in fifth instar (13.576%) and the difference was significant from instar to instar. While calculating the ECI values for total larval period, no significant variation was observed during two different seasons. A drastic reduction of ECI value was observed from early instars (first, second and third) to late instars (fourth and fifth) (table 19 a, b).

4.2.2.9 Efficiency of conversion of digested food (ECD) :

The ECD values were very high in young ages (first, second and third) than the late ages (fourth and fifth). ECD observed higher during October – November (52.874%) than April – May (51.645%) having non- significant variation between them. There was no seasonal affect on ECD values in different instar and lowest ECD values was observed during April – May by fifth instar (45.949%) (table 19 a, b).

4.2.2.10 Consumption index :

Consumption index decreased from first instar (1.439) to fifth instar (0.929) and CI was recorded significantly higher during April – May (0.604) than October – November (0.512) (table 19 a, b).

4.2.2.11 Growth rate :

Highest growth rate was observed during first instar (0.599) which gradually decreased and lowest during fifth instar (0.126) and variation between different instars were significant. Growth rate was higher during April – May (0.096) than October – November (0.087) (table 19 a, b).

Table 19 (a) AD, ECI, ECD, CI and GR of the muga silkworm larvae fed on soalu leaves during two commercial rearing seasons

Soalu	Seasons	Larval Instar					Total
		I	II	III	IV	V	
AD	April-May	52.459	47.514	46.424	41.393	27.997	30.759
	Oct.-Nov.	53.125	48.148	46.939	42.230	29.647	32.238
	Mean	**52.792**	**47.831**	**46.682**	**41.812**	**28.822**	**31.499**
ECI	April-May	40.984	38.122	35.063	26.714	12.864	15.885
	Oct.-Nov.	42.188	38.095	35.374	26.721	14.287	17.046
	Mean	**41.586**	**38.109**	**35.219**	**26.718**	**13.576**	**16.466**
ECD	April-May	78.125	80.233	75.529	64.538	45.949	51.645
	Oct.-Nov.	79.412	79.121	75.362	63.276	48.189	52.874
	Mean	**78.769**	**79.677**	**75.446**	**63.907**	**47.069**	**52.260**
CI	April-May	1.502	1.090	0.972	0.940	0.978	0.604
	Oct.-Nov.	1.376	0.840	0.848	0.883	0.879	0.512
	Mean	**1.439**	**0.965**	**0.910**	**0.912**	**0.929**	**0.558**
GR	April-May	0.616	0.416	0.341	0.251	0.126	0.096
	Oct.-Nov.	0.581	0.320	0.300	0.236	0.126	0.087
	Mean	**0.599**	**0.368**	**0.321**	**0.244**	**0.126**	**0.092**

Table 19 (b) Statistical analysis of table 19 (a)

	AD	ECI	ECD	CI	GR
Season					
S Em (±)	0.283	0.542	0.852	0.007	0.005
CD P=0.05	0.835	1.598	2.512	0.021	0.015
Instar					
S Em (±)	0.448	0.857	1.347	0.011	0.008
CD P=0.05	1.32	2.527	3.972	0.033	0.024
Season x Instar					
S Em (±)	0.633	1.212	1.904	0.016	0.011
CD P=0.05	1.867	3.574	5.618	0.046	0.034

4.2.2.12 Mean daily food ingestion (MDFI) :

MDFI in total larval period was 0.958 gm, which increased from 0.022 gm in first instar to 2.122 gm in fifth instar. MDFI was higher in April – May (0.968 gm) than in October – November (0.947 gm) (table 20 a, b).

4.2.2.13 Mean daily food digestion (MDFD) :

MDFD in total larval period was 0.302 gm which increased from 0.011 gm in first instar to 0.612 gm in fifth instar. Higher MDFD was observed during October – November (0.305 gm) than during April – May (0.298 gm) (table 20 a, b).

Table 20 (a) MDFI, MDFD, Ing/Gr and Dig/Gr of the muga silkworm larvae fed on soalu leaves during two commercial rearing seasons

Soalu	Seasons	Larval Instar					Total
		I	II	III	IV	V	
MDFI	April-May	0.022	0.067	0.213	0.673	2.097	0.968
	Oct.-Nov.	0.021	0.055	0.196	0.678	2.147	0.947
	Mean	**0.022**	**0.061**	**0.205**	**0.676**	**2.122**	**0.958**
MDFD	April-May	0.011	0.032	0.099	0.279	0.587	0.298
	Oct.-Nov.	0.011	0.027	0.092	0.286	0.636	0.305
	Mean	**0.011**	**0.030**	**0.096**	**0.283**	**0.612**	**0.302**
Ing/Gr	April-May	2.440	2.623	2.852	3.743	7.773	6.295
	Oct.-Nov.	2.370	2.625	2.827	3.742	7.000	5.867
	Mean	**2.405**	**2.624**	**2.840**	**3.743**	**7.387**	**6.081**
Dig/Gr	April-May	1.280	1.246	1.324	1.549	2.176	1.936
	Oct.-Nov.	1.259	1.264	1.327	1.580	2.075	1.891
	Mean	**1.270**	**1.255**	**1.326**	**1.565**	**2.126**	**1.914**

Table 20 (b) Statistical analysis of table 20 (a)

	MDFI	MDFD	Ing / Gr	Dig / Gr
Season				
S Em (±)	0.001	0.001	0.031	0.013
CD P=0.05	0.004	0.002	0.093	0.038
Instar				
S Em (±)	0.002	0.001	0.05	0.02
CD P=0.05	0.006	0.003	0.147	0.06
Season x instar				
S Em (±)	0.003	0.002	0.07	0.029
CD P=0.05	0.009	0.005	0.207	0.085

4.2.2.14 Ingestion / Growth :

The ingesta required to produce one gram of larval growth was observed lower in early instars and maximum in fifth instar (7.387 gm). However, during total growth period 6.081 gm ingesta required to produce one gram of larval growth. Significant variation was observed in the two seasons under consideration (table 20 a, b).

4.2.2.15 Digestion / Growth :

The digesta required to produce one gram of larval growth was 1.914 gm of which during fifth instar it was 2.126 gm, showing maximum requirement and during second instar in was 1.255 gm, showing minimum requirement. Digesta per growth varied significantly between the two seasons, highest being from April – May (1.936 gm) (table 20 a, b).

So, from the overall results it could be said that 81% of food ingestion was from fifth instar and 95% was from fourth and fifth instar of which October – November showed 21.642 gm and April – May showed 20.157 gm. 94% food was digested during fourth and fifth instar of which 75% was from fifth instar. During October – November food digestion was recorded 6.977 gm and April – May it was 6.200 gm. RR was 1.46 and there observed no significant variation among the seasons. 67% weight gain was during fifth instar. Approximate digestibility, ECI and ECD were 31.499%, 16.466% and 52.26% respectively and seasonal variation were non-significant. Consumption index was 0.558 and higher during April – May growth rate was higher during April – May (0.096).

4 .2 .3 Correlation between food ingestion and other parameters

From the correlation studies (table 21) it was observed that ingesta had 0.1% level positive correlation with digesta, excreta, larval duration and ingesta/growth while showed 0.5% level positive correlation with weight gain and mean daily food ingesta and 0.5% negative correlation with approximate digestibility. 1% positive correlation was found between food ingesta and digesta per growth, while 5% negative correlation was observed between food ingesta and ECI, ECD and RR and positive correlation with mean daily food digesta.

Table 21 : Correlation between ingesta and other parameters

	Digesta	Excreta	Duration	Weight gain	RR	AD
Ingesta	0.997****	0.999****	0.999****	0.989***	-0.951*	-0.978***

	ECI	ECD	CI	GR	MDFI	MDFD	ING/GR	DIG/GR
Ingesta	-0.925*	-0.913*	0.342	-0.806	0.986***	0.951*	0.993****	0.963**

* Significant at 5 % level of confidence

** Significant at 1 % level of confidence

*** Significant at 0.5 % level of confidence

**** Significant at 0.1 % level of confidence

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

Nutritional efficiencies during all the larval instars utilizing som and soalu leaves in all possible combinations *i.e.* T_1 : 1st instar on som and rest on soalu, T_2 : upto 2nd instar on som and rest on soalu, T_3 : upto 3rd instar on som and rest on soalu, T_4 : upto 4th instar on som and rest on soalu, T_5 : 1st instar on soalu and rest on som, T_6 : upto 2nd instar on soalu and rest on som, T_7 : upto 3rd instar on soalu and rest on som and T_8 : upto 4th instar on soalu and rest on som, were observed during favourable seasons *i.e.* October – November and April – May.

4.3.1 Food ingestion :

Food ingestion varied significantly from treatment to treatment. Highest food ingestion was recorded from T_7 (22.750 gm) followed by T_6 (21.284 gm), T_8 (20.962 gm) and others. Lowest food ingestion was recorded from T_1 (17.738 gm). As the instar progressed food ingestion increased, maximum during fifth instar. During October – November the ingestion was significantly higher (21.464 gm) than April – May (18.793 gm) (table 22 a, b).

4.3.2 Food digestion :

Significantly highest digestion of food was observed in T_7 (7.982 gm) followed by T_6 (7.417 gm), T_8 (7.245 gm) and others and lowest in T_1 (5.099 gm). Digestion of food increased with the progression of instar, maximum during fifth instar. Significantly higher digesta was observed during October – November (7.205 gm) than April – May (5.735 gm), strikingly from T_6 to T_8 (table 23 a, b).

4.3.3 Excreta :

Treatments varied significantly, highest being from T_7 (14.768 gm) and lowest from T_1 (12.639 gm). Excretion was recorded significantly increased with the progression of instars. During October – November, the excreta amount was higher (14.260 gm) and during April – May (13.059 gm) (table 24 a, b).

4.3.4 Reference ratio (RR) :

RR varied significantly from treatment to treatment. Highest RR was observed in T_7 (1.536) followed by T_6 (1.531) and lowest RR was observed in T_4 (1.398) followed by T_1 (1.404). Reference ratio was observed highest in first instar and decreased gradually with a lowest in fifth instar. From seasonal standpoint, RR was higher in October – November (1.503) than in April – May (1.439) (table 25 a, b).

4.3.5 Weight Gain :

Weight gain varied significantly among the treatments lowest having from T_1 (2.618) and highest from T_7 (4.208 gm). As a whole, weight gain was higher during October – November (3.528 gm) which gradually increased as growth progressed (table 26 a, b).

4.3.6 Larval duration :

Significant variation was observed among treatments, highest having from T_5 (24.094 days) followed by T_3 (23.838 days). Lowest larval duration was observed 22.357 days in T_7. Larval duration was recorded longer during October – November than April – May. The early instars showed larval duration of around three days while in fourth instar it was around four days and in fifth instar it was around eight days (table 27 a, b).

Table 22 (a) : Food ingestion by muga silk worm larvae during favourable seasons in different combination of leaves

Ingesta	1st		2nd		3rd		4th		5th		whole		
	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Mean
T_1	0.057	0.060	0.172	0.173	0.684	0.688	2.590	2.962	13.424	14.665	16.927	18.548	17.738
T_2	0.057	0.060	0.165	0.180	0.695	0.708	2.780	2.966	15.553	16.205	19.250	20.119	19.685
T_3	0.057	0.060	0.165	0.180	0.685	0.720	2.791	2.980	15.960	17.202	19.658	21.142	20.400
T_4	0.057	0.060	0.165	0.180	0.685	0.720	2.832	3.600	14.022	15.552	17.761	20.112	18.937
T_5	0.061	0.064	0.162	0.178	0.660	0.695	2.750	3.542	14.440	16.002	18.073	20.481	19.277
T_6	0.061	0.064	0.181	0.189	0.642	0.689	2.785	3.582	15.550	18.825	19.219	23.349	21.284
T_7	0.061	0.064	0.181	0.189	0.713	0.735	2.820	3.562	16.524	20.650	20.299	25.200	22.750
T_8	0.061	0.064	0.181	0.189	0.713	0.735	2.800	3.050	15.405	18.725	19.160	22.763	20.962
Mean	**0.059**	**0.062**	**0.172**	**0.182**	**0.685**	**0.711**	**2.769**	**3.281**	**15.110**	**17.228**	**18.793**	**21.464**	**20.129**

Table 22 (b) : Statistical analysis of table 22 (a)

Season						
S Em (±)	0.001	0.001	0.001	0.002	0.001	0.020
CD P=0.05	0.001	0.002	0.002	0.005	0.004	0.006
Treatment						
S Em (±)	0.001	0.002	0.001	0.003	0.003	0.004
CD P=0.05	0.003	0.004	0.004	0.010	0.008	0.011
Season x Treatment						
S Em (±)	0.001	0.002	0.002	0.005	0.004	0.006
CD P=0.05	0.004	0.006	0.006	0.013	0.011	0.016

Table 23 (a) : Food digestion by muga silk worm larvae during favourable seasons in different combination of leaves

Digesta	1st		2nd		3rd		4th		5th		whole		
	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Mean
T_1	0.027	0.029	0.082	0.082	0.316	0.317	1.000	1.256	3.586	3.502	5.011	5.186	5.099
T_2	0.027	0.029	0.077	0.085	0.331	0.336	1.154	1.280	4.608	4.865	6.197	6.595	6.396
T_3	0.027	0.029	0.077	0.085	0.307	0.327	1.161	1.280	4.556	5.222	6.128	6.943	6.536
T_4	0.027	0.029	0.077	0.085	0.307	0.327	1.203	1.550	3.302	3.900	4.916	5.891	5.404
T_5	0.032	0.034	0.077	0.085	0.308	0.327	1.208	1.553	3.720	4.016	5.345	6.015	5.680
T_6	0.032	0.034	0.086	0.091	0.293	0.326	1.215	1.562	4.470	6.725	6.096	8.738	7.417
T_7	0.032	0.034	0.086	0.091	0.331	0.345	1.208	1.552	4.519	7.765	6.176	9.787	7.982
T_8	0.032	0.034	0.086	0.091	0.331	0.345	1.159	1.288	4.400	6.723	6.008	8.481	7.245
Mean	**0.030**	**0.032**	**0.081**	**0.087**	**0.316**	**0.331**	**1.164**	**1.415**	**4.145**	**5.340**	**5.735**	**7.205**	**6.470**

Table 23 (b) : Statistical analysis of table 23 (a)

Season						
S Em (±)	0.000	0.001	0.001	0.001	0.001	0.002
CD P=0.05	0.001	0.002	0.002	0.004	0.004	0.006
Treatment						
S Em (±)	0.001	0.001	0.001	0.003	0.003	0.004
CD P=0.05	0.002	0.004	0.004	0.007	0.008	0.012
Season x treatment						
S Em (±)	0.001	0.002	0.002	0.004	0.004	0.006
CD P=0.05	0.002	0.006	0.005	0.010	0.011	0.016

Table 24 (a) : Excretion by muga silk worm larvae during favourable seasons in different combination of leaves

Excreta	1st		2nd		3rd		4th		5th		whole		
	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Mean
T_1	0.030	0.031	0.090	0.091	0.368	0.371	1.590	1.706	9.838	11.163	11.916	13.362	12.639
T_2	0.030	0.031	0.088	0.095	0.364	0.372	1.626	1.686	10.945	11.340	13.053	13.524	13.289
T_3	0.030	0.031	0.088	0.095	0.378	0.393	1.630	1.700	11.404	11.980	13.530	14.199	13.865
T_4	0.030	0.031	0.088	0.095	0.378	0.393	1.629	2.050	10.720	11.652	12.845	14.221	13.533
T_5	0.029	0.030	0.085	0.093	0.352	0.368	1.542	1.989	10.720	11.986	12.728	14.466	13.597
T_6	0.029	0.030	0.095	0.098	0.349	0.363	1.570	2.020	11.080	12.100	13.123	14.611	13.867
T_7	0.029	0.030	0.095	0.098	0.382	0.390	1.612	2.010	12.005	12.885	14.123	15.413	14.768
T_8	0.029	0.030	0.095	0.098	0.382	0.390	1.641	1.762	11.005	12.002	13.152	14.282	13.717
Mean	**0.030**	**0.031**	**0.091**	**0.095**	**0.369**	**0.380**	**1.605**	**1.865**	**10.965**	**11.889**	**13.059**	**14.260**	**13.659**

Table 24 (b) : Statistical analysis of table 24 (a)

Season						
S Em (±)	0.001	0.001	0.001	0.001	0.002	0.002
CD P=0.05	0.001	0.002	0.003	0.004	0.005	0. 006
Treatment						
S Em (±)	0.001	0.001	0.002	0.003	0.003	0.004
CD P=0.05	0.003	0.003	0.005	0.007	0. 010	0.012
Season x treatment						
S Em (±)	0.001	0.002	0.003	0.004	0.005	0.006
CD P=0.05	0.004	0.005	0.007	0.011	0.014	0.017

Table 25 (a) : Reference ratio of muga silk worm larvae during favourable seasons in different combination of leaves

RR	1st		2nd		3rd		4th		5th		whole		
	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Mean
T_1	1.900	1.935	1.911	1.901	1.859	1.854	1.629	1.736	1.365	1.314	1.421	1.388	1.404
T_2	1.900	1.935	1.875	1.895	1.909	1.903	1.710	1.759	1.421	1.429	1.475	1.488	1.481
T_3	1.900	1.935	1.875	1.895	1.812	1.832	1.712	1.753	1.400	1.436	1.453	1.489	1.471
T_4	1.900	1.935	1.875	1.895	1.812	1.832	1.738	1.756	1.308	1.335	1.383	1.414	1.398
T_5	2.103	2.133	1.906	1.914	1.875	1.889	1.783	1.781	1.347	1.335	1.420	1.416	1.418
T_6	2.103	2.133	1.905	1.929	1.840	1.898	1.774	1.773	1.403	1.556	1.465	1.598	1.531
T_7	2.103	2.133	1.905	1.929	1.866	1.885	1.749	1.772	1.376	1.603	1.437	1.635	1.536
T_8	2.103	2.133	1.905	1.929	1.866	1.885	1.706	1.731	1.400	1.560	1.457	1.594	1.525
Mean	**2.002**	**2.034**	**1.895**	**1.911**	**1.855**	**1.872**	**1.725**	**1.758**	**1.377**	**1.446**	**1.439**	**1.503**	**1.471**

Table 25 (b) Statistical analysis of table 25 (a)

Season						
S Em (±)	0.021	0.011	0.003	0.001	0.0010	0.000
CD P=0.05	0.060	0.030	0.010	0.003	0.001	0.001
Treatment						
S Em (±)	0.042	0.021	0.007	0.002	0.000	0.000
CD P=0.05	0.120	0.060	0.020	0.006	0.001	0.001
Season x treatment						
S Em (±)	0.059	0.030	0.010	0.003	0.001	0.001
CD P=0.05	0.170	0.085	0.028	0.008	0.001	0.002

Table 26 (a) : Weight gain by muga silk worm larvae during favourable seasons in different combination of leaves

	1st		2nd		3rd		4th		5th		whole		
	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Mean
T_1	0.025	0.026	0.067	0.067	0.249	0.250	0.702	0.740	1.450	1.660	2.493	2.743	2.618
T_2	0.025	0.026	0.064	0.070	0.242	0.258	0.702	0.755	1.508	1.890	2.541	2.999	2.700
T_3	0.025	0.026	0.064	0.070	0.247	0.260	0.702	0.770	1.860	2.081	2.898	3.207	3.053
T_4	0.025	0.026	0.064	0.070	0.247	0.260	0.758	0.965	1.506	1.750	2.600	3.071	2.836
T_5	0.025	0.027	0.058	0.063	0.230	0.238	0.749	0.800	1.986	2.402	3.048	3.530	3.289
T_6	0.025	0.027	0.069	0.072	0.235	0.242	0.749	0.950	2.203	2.950	3.281	4.241	3.761
T_7	0.025	0.027	0.069	0.072	0.251	0.260	0.759	0.972	2.650	3.330	3.754	4.661	4.208
T_8	0.025	0.027	0.069	0.072	0.251	0.260	0.748	0.815	2.002	2.600	3.095	3.774	3.435
Mean	**0.025**	**0.027**	**0.066**	**0.070**	**0.244**	**0.254**	**0.734**	**0.846**	**1.896**	**2.333**	**2.964**	**3.528**	**3.246**

Table 26 (b) : Statistical analysis of table 26 (a)

Season						
S Em (±)	0.001	0.001	0.001	0.001	0.001	0.001
CD P=0.05	0.001	0.001	0.002	0.002	0.002	0.003
Treatment						
S Em (±)	0.001	0.001	0.001	0.001	0.002	0.002
CD P=0.05	0.002	0.002	0.003	0.004	0.004	0.006
Season x treatment						
S Em (±)	0.001	0.001	0.002	0.002	0.002	0.003
CD P=0.05	0.003	0.003	0.005	0.005	0.006	0.009

Table 27 (a) : Larval duration of muga silk worm larvae during favourable seasons fed on different combination of leaves

Duration	1st		2nd		3rd		4th		5th		whole		
	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Mean
T_1	3.616	4.200	2.800	3.460	3.350	3.800	4.200	4.600	7.980	8.300	21.946	24.360	23.153
T_2	3.616	4.200	3.050	4.300	3.400	3.820	4.180	4.600	7.920	8.300	22.170	25.226	23.698
T_3	3.616	4.200	3.050	4.300	3.380	4.200	4.200	4.700	7.820	8.200	22.069	25.607	23.838
T_4	3.616	4.200	3.000	4.300	3.380	4.200	4.260	4.000	7.980	8.700	22.303	25.270	23.786
T_5	2.800	3.000	3.200	4.400	3.380	4.300	4.300	4.600	8.700	9.500	22.384	25.804	24.094
T_6	2.800	3.000	2.700	3.410	3.350	4.190	4.265	4.200	8.340	8.900	21.455	23.694	22.575
T_7	2.800	3.000	2.700	3.410	3.350	3.750	4.265	4.200	8.340	8.900	21.455	23.259	22.357
T_8	2.800	3.000	2.700	3.410	3.350	3.750	4.160	4.500	8.900	9.200	21.912	23.864	22.888
Mean	**3.208**	**3.600**	**2.900**	**3.874**	**3.368**	**4.001**	**4.229**	**4.425**	**8.248**	**8.750**	**21.962**	**24.635**	**23.299**

Table 27 (b) : Statistical analysis of table 27 (a)

Season						
S Em (±)	0.002	0.001	0.001	0.001	0.002	0.002
CD P=0.05	0.005	0.003	0.003	0.004	0.005	0.006
Treatment						
S Em (±)	0.004	0.002	0.002	0.003	0.003	0.004
CD P=0.05	0.011	0.007	0.006	0.007	0.010	0.013
Season x Treatment						
S Em (±)	0.005	0.003	0.003	0.004	0.005	0.006
CD P=0.05	0.015	0.009	0.009	0.010	0.014	0.178

4.3.7 Approximate digestibility (AD) :

Significant difference was observed among treatments. Highest digestibility was observed in T_7 (34.631) followed significantly by T_6 (34.571) and by others. Lowest AD was observed in T_4 (28.485) followed by T_1 (28.782). Highest AD was observed in first instar and then decreased gradually and lowest being from April – May (27.679) by T_4 (table 28 a, b).

4.3.8 Efficiency of conversion of ingested food (ECI) :

Significantly, lowest ECI was observed in T_1 (14.295 %) and highest in T_7 (18.495 %). ECI decreased as the instar progressed. As a whole, October – November (16.326%) showed higher ECI than April – May (15.734%) (table 29 a, b).

4.3.9 Efficiency of conversion digested food (ECD) :

Significantly highest ECD was observed in T_5 (57.856%) followed by T_7 (54.204%), T_4 (52.510%) and others. Lowest ECD was observed in T_2 (44.651%) followed by T_3 (46.741%). As the instar progressed, ECD decreased. From the seasonal standpoint, ECD was higher in April – May (table 30 a, b).

4.3.10 Consumption index (CI) :

Significant variation was observed between the treatments. T_1 showed the highest CI (0.609) followed by T_4 (0.594) and T_2 (0.588). Lowest CI was observed in T_7 (0.463) followed by T_6 (0.483). In late instars, CI decreased and during October – November CI was lower than April – May (table 31 a, b).

4.3.11 Growth rate (GR) :

As a whole, no significant variation was observed among the treatments as well as among the seasons. In fifth instar, also the growth rate was non-significant. Growth rate was higher during April – May (table 32 a, b).

Table 28 (a) : Approximate digestibility by muga silk worm larvae during favourable seasons in different combination of leaves

AD	1st		2nd		3rd		4th		5th		whole		
	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Mean
T_1	47.368	48.333	47.674	47.399	46.199	46.076	38.610	42.404	26.713	23.880	29.604	27.960	28.782
T_2	47.368	48.333	46.667	47.222	47.626	47.458	41.511	43.156	29.628	30.022	32.192	32.780	32.486
T_3	47.368	48.333	46.667	47.222	44.818	45.417	41.598	42.953	28.546	30.357	31.173	32.840	32.006
T_4	47.368	48.333	46.667	47.222	44.818	45.417	42.479	43.056	23.549	25.077	27.679	29.291	28.485
T_5	52.459	53.125	47.531	47.753	46.667	47.050	43.927	43.845	25.762	25.097	29.575	29.369	29.472
T_6	52.459	53.125	47.514	48.148	45.639	47.315	43.627	43.607	28.746	35.724	31.719	37.423	34.571
T_7	52.459	53.125	47.514	48.148	46.424	46.939	42.837	43.571	27.348	37.603	30.425	38.837	34.631
T_8	52.459	53.125	47.514	48.148	46.424	46.939	41.393	42.230	28.562	35.904	31.357	37.258	34.307
Mean	**49.914**	**50.729**	**47.218**	**47.658**	**46.077**	**46.576**	**41.998**	**43.103**	**27.357**	**30.458**	**30.465**	**33.220**	**31.843**

Table 28 (b) : Statistical analysis of table 28 (a)

Season						
S Em (±)	0.500	0.287	0.097	0.032	0.008	0.008
CD P=0.05	1.441	0.083	0.278	0.091	0.022	0.024
Treatment						
S Em (±)	1.000	0.573	0.193	0.063	0.016	0.017
CD P=0.05	2.881	1.651	0.558	0.182	0.045	0.048
Season x treatment						
S Em (±)	1.415	0.810	0.273	0.090	0.022	0.024
CD P=0.05	4.075	2.334	0.787	0.258	0.063	0.068

Table 29 (a) : Efficiency of conversion of ingested food by muga silk worm larvae during favourable seasons fed on different combination of leaves

ECI	1st		2nd		3rd		4th		5th		whole		
	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Mean
T_1	43.860	43.333	38.953	38.728	36.404	36.337	26.834	24.983	9.684	11.319	13.800	14.789	14.295
T_2	43.860	43.333	38.788	38.889	34.820	36.441	25.252	25.455	10.821	11.663	14.109	14.906	14.508
T_3	43.860	43.333	38.788	38.889	36.058	36.111	25.152	25.839	11.654	12.097	14.742	15.169	14.956
T_4	43.860	43.333	38.788	38.889	36.058	36.111	26.766	26.806	10.740	11.253	14.639	15.269	14.954
T_5	40.984	42.188	35.802	35.393	34.848	34.245	27.236	22.586	13.753	15.011	16.865	17.235	17.050
T_6	40.984	42.188	38.122	38.095	36.604	35.123	26.894	26.521	14.167	15.671	17.072	18.164	17.618
T_7	40.984	42.188	38.122	38.095	35.203	35.374	26.915	27.288	16.037	16.126	18.494	18.496	18.495
T_8	40.984	42.188	38.122	38.095	35.203	35.374	26.714	26.721	12.996	13.885	16.153	16.580	16.367
Mean	**42.422**	**42.760**	**38.186**	**38.134**	**35.650**	**35.640**	**26.470**	**25.775**	**12.482**	**13.378**	**15.734**	**16.326**	**16.030**

Table 29 (b) : Statistical analysis of table 29 (a)

Season						
S Em (±)	0..549	0.299	0.082	0.028	0.004	0.003
CD P=0.05	1.581	0.862	0236	0.083	0.013	0.010
Treatment						
S Em (±)	1.098	0.599	0.164	0.057	0.009	0.007
CD P=0.05	3.162	1.725	0. 472	0.166	0.026	0.020
Season x treatment						
S Em (±)	1.552	0.847	0. 232	0. 081	0.013	0.009
CD P=0.05	4.472	2.439	0.668	0.235	0.037	0.028

Table 30 (a) : Efficiency of conversion of digested food by muga silk worm larvae during favourable seasons fed on different combination of leaves

ECD	1st		2nd		3rd		4th		5th		whole		
	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Mean
T_1	92.593	89.655	81.707	81.707	78.797	78.864	69.500	58.917	36.252	47.401	46.617	52.892	49.755
T_2	92.593	89.655	83.117	82.353	73.112	76.786	60.832	58.984	36.523	38.849	43.828	45.474	44.651
T_3	92.593	89.655	83.117	82.353	80.456	79.511	60.465	60.156	40.825	39.851	47.291	46.190	46.741
T_4	92.593	89.655	83.117	82.353	80.456	79.511	63.009	62.258	45.609	44.872	52.889	52.130	52.510
T_5	78.125	79.412	75.325	74.118	74.675	72.783	62.003	51.513	53.387	59.811	57.025	58.687	57.856
T_6	78.125	79.412	80.233	79.121	80.205	74.233	61.646	60.819	49.284	43.866	53.822	48.535	51.179
T_7	78.125	79.412	80.233	79.121	75.831	75.362	62.831	62.629	58.641	42.885	60.784	47.624	54.204
T_8	78.125	79.412	80.233	79.121	75.831	75.362	64.538	63.276	45.500	38.673	51.515	44.499	48.007
Mean	**85.359**	**84.533**	**80.885**	**80.031**	**77.420**	**76.552**	**63.103**	**59.819**	**45.753**	**44.526**	**51.721**	**49.504**	**50.613**

Table 30 (b) : Statistical analysis of table 30 (a)

Season						
S Em (±)	1.102	0.077	0.185	0.079	0.018	0.017
CD P=0.05	3.175	2.227	0.532	0.227	0.052	0.048
Treatment						
S Em (±)	2.205	1.546	0.369	0.157	0.036	0.033
CD P=0.05	6.350	4.455	1.063	0.455	0.105	0.095
Season x treatment						
S Em (±)	3.118	2.187	0.522	0.223	0.052	0.047
CD P=0.05	8.981	6.300	1.503	0.643	0.149	0.135

Table 31 (a) : Consumption index of muga silk worm larvae during favourable seasons fed on different combination of leaves

CI	1st		2nd		3rd		4th		5th		whole		
	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Mean
T_1	1.126	0.952	1.041	0.806	0.945	0.842	0.919	0.920	1.007	0.919	0.664	0.553	0.609
T_2	1.126	0.952	0.933	0.664	0.983	0.82	0.993	0.892	1.056	0.955	0.642	0.533	0.588
T_3	1.126	0.952	0.933	0.664	0.960	0.755	0.970	0.863	1.040	0.971	0.615	0.515	0.565
T_4	1.126	0.952	0.948	0.664	0.960	0.755	0.932	1.081	0.991	0.904	0.630	0.558	0.594
T_5	1.452	1.333	0.904	0.663	0.981	0.770	0.929	1.088	0.808	0.707	0.529	0.481	0.505
T_6	1.502	1.376	1.090	0.853	0.902	0.768	0.920	1.075	0.850	0.771	0.498	0.467	0.483
T_7	1.502	1.376	1.090	0.853	0.965	0.879	0.911	1.057	0.816	0.790	0.461	0.465	0.463
T_8	1.502	1.376	1.090	0.853	0.965	0.879	0.935	0.939	0.829	0.838	0.566	0.511	0.539
Mean	**1.308**	**1.159**	**1.004**	**0.753**	**0.958**	**0.809**	**0.939**	**0.989**	**0.925**	**0.857**	**0.576**	**0.510**	**0.543**

Table 31 (b) : Statistical analysis of table 31 (a)

Season						
S Em (±)	0.009	0.004	0.001	0.001	0.001	0.001
CD P=0.05	0.027	0.012	0.004	0.002	0.001	NS
Treatment						
S Em (±)	0.019	0.008	0.002	0.001	0.001	0.001
CD P=0.05	0.054	0.024	0.005	0.003	0.001	0.001
Season x treatment						
S Em (±)	0.026	0.012	0.003	0.002	0.001	0.001
CD P=0.05	0.076	0.033	0.007	0.005	0.001	0.001

Table 32 (a) : Growth rate o f muga silk worm larvae during favourable seasons fed on different combination of leaves

GR	1st		2nd		3rd		4th		5th		whole		
	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Mean
T_1	0.494	0.413	0.406	0.312	0.344	0.306	0.247	0.230	0.098	0.104	0.092	0.082	0.087
T_2	0.494	0.413	0.362	0.258	0.342	0.299	0.251	0.227	0.114	0.111	0.091	0.079	0.085
T_3	0.494	0.413	0.362	0.258	0.346	0.273	0.244	0.223	0.121	0.117	0.091	0.078	0.085
T_4	0.494	0.413	0.368	0.258	0.346	0.273	0.250	0.290	0.106	0.102	0.092	0.085	0.089
T_5	0.616	0.563	0.324	0.235	0.342	0.264	0.253	0.246	0.111	0.106	0.089	0.083	0.086
T_6	0.616	0.581	0.416	0.325	0.330	0.270	0.248	0.285	0.120	0.121	0.085	0.085	0.085
T_7	0.616	0.581	0.416	0.325	0.340	0.311	0.245	0.289	0.131	0.127	0.085	0.086	0.086
T_8	0.595	0.563	0.412	0.325	0.340	0.311	0.250	0.251	0.108	0.116	0.091	0.085	0.088
Mean	**0.552**	**0.493**	**0.383**	**0.287**	**0.341**	**0.288**	**0.249**	**0.255**	**0.114**	**0.113**	**0.090**	**0.083**	**0.086**

32 (b) : Statistical analysis of table 32 (b)

Season						
S Em (±)	0.006	0.002	0.001	0.001	0.001	0.001
CD P=0.05	0.019	0.006	0.002	0.001	NS	NS
Treatment						
S Em (±)	0.013	0.004	0.002	0.001	0.001	0.001
CD P=0.05	0.037	0. 012	0.004	0.001	NS	NS
Season x treatment						
S Em (±)	0.018	0.006	0.002	0.001	0.001	0.001
CD P=0.05	0.052	0.018	0.006	0.002	0.001	NS

4.3.12 Mean daily food ingesta (MDFI) :

Significantly highest MDFI was recorded in T_7 (1.015 gm) followed by T_6 (0.941 gm), T_8 (0.914 gm) and others. The lowest MDFI was found in T_1 (0.766 gm) followed significantly by T_4 (0.796 gm) and others. Seasonal variation was non-significant. Moreover, MDFI increased with the advancement of instar (table 33 a, b).

4.3.13 Mean daily food digesta (MDFD) :

MDFD was significantly highest in T_7 (0.354 gm) followed by T_6 (0.326 gm) and T_8 (0.315 gm) and others. Lowest MDFD was observed in T_1 (0.221 gm) followed significantly by T_4 (0.227 gm) and others. No significant seasonal variation was observed among seasons and MDFD increased with the advancement of instar (table 34 a, b).

Table 33 (a) : Mean daily food ingestion by muga silk worm larvae during favourable seasons fed on different combination of leaves

MDFI	1st		2nd		3rd		4th		5th		whole		
	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Mean
T_1	0.016	0.014	0.061	0.050	0.204	0.181	0.617	0.644	1.682	1.767	0.771	0.761	0.766
T_2	0.016	0.014	0.054	0.042	0.204	0.185	0.665	0.645	1.964	1.952	0.868	0.798	0.833
T_3	0.016	0.014	0.054	0.042	0.203	0.171	0.665	0.634	2.041	2.098	0.891	0.826	0.858
T_4	0.016	0.014	0.055	0.042	0.203	0.171	0.665	0.900	1.757	1.788	0.796	0.796	0.796
T_5	0.022	0.021	0.051	0.040	0.195	0.162	0.640	0.770	1.660	1.684	0.807	0.794	0.801
T_6	0.022	0.021	0.067	0.055	0.192	0.164	0.653	0.853	1.865	2.115	0.896	0.985	0.941
T_7	0.022	0.021	0.067	0.055	0.213	0.196	0.661	0.848	1.981	2.320	0.946	1.083	1.015
T_8	0.022	0.021	0.067	0.055	0.213	0.196	0.673	0.678	1.731	2.035	0.874	0.954	0.914
Mean	**0.019**	**0.018**	**0.060**	**0.048**	**0.203**	**0.178**	**0.655**	**0.746**	**1.835**	**1.970**	**0.856**	**0.875**	**0.865**

Table 33 (b) : Statistical analysis of table 33 (a)

Season						
S Em (±)	0.002	0.001	0.001	0.001	0.001	0.001
CD P=0.05	NS	0.001	0.001	0.001	0.001	NS
Treatment						
S Em (±)	0.001	0.001	0.001	0.001	0.001	0.003
CD P=0.05	0.001	0.001	0.002	0.003	0.003	0.001
Season x treatment						
S Em (±)	0.001	0.001	0.001	0.001	0.001	0.001
CD P=0.05	0.001	0.002	0.002	0.004	0.004	0.001

Table 34 (a) : Mean daily food digestion by muga silk worm larvae during favourable seasons fed on different combination of leaves

MDFD	1st		2nd		3rd		4th		5th		whole		
	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Mean
T_1	0.007	0.007	0.029	0.024	0.094	0.083	0.238	0.273	0.449	0.422	0.228	0.213	0.221
T_2	0.007	0.007	0.025	0.020	0.097	0.088	0.276	0.278	0.582	0.586	0.280	0.261	0.270
T_3	0.007	0.007	0.025	0.020	0.091	0.078	0.276	0.272	0.583	0.637	0.278	0.271	0.274
T_4	0.007	0.007	0.026	0.020	0.091	0.078	0.282	0.388	0.414	0.448	0.220	0.233	0.227
T_5	0.011	0.011	0.024	0.019	0.091	0.076	0.281	0.338	0.428	0.423	0.239	0.233	0.236
T_6	0.011	0.011	0.032	0.027	0.087	0.078	0.285	0.372	0.536	0.756	0.284	0.369	0.326
T_7	0.011	0.011	0.032	0.027	0.099	0.092	0.283	0.370	0.542	0.872	0.288	0.421	0.354
T_8	0.011	0.011	0.032	0.027	0.099	0.092	0.279	0.286	0.494	0.731	0.274	0.355	0.315
Mean	**0.009**	**0.009**	**0.028**	**0.023**	**0.094**	**0.083**	**0.275**	**0.322**	**0.503**	**0.609**	**0.261**	**0.295**	**0.278**

Table 34 (b) : Statistical analysis of table 34 (a)

Season						
S Em (±)	0.001	0.001	0.001	0.001	0.001	0.001
CD P=0.05	NS	0.001	0.001	NS	0.001	NS
Treatment						
S Em (±)	0.001	0.001	0.001	0.001	0.001	0.001
CD P=0.05	0.001	0.002	0.001	0.002	0.001	0.001
Season x treatment						
S Em (±)	0.001	0.001	0.001	0.001	0.001	0.001
CD P=0.05	0.001	0.002	0.001	0.002	0.002	0.001

4.3.14 Ingesta / Growth :

The ingesta to produce one gram of larval body growth was significantly highest in T_2 (7.142 gm) followed significantly by T_1 (6.776 gm) and lowest being from T_7 (5.407 gm). Significantly higher ingesta / growth was observed during April – May (6.421 gm) and ingesta / growth increased with the advancement of age (table 35 a, b).

4.3.15 Digesta / Growth :

The digesta to produce one gram of larval body growth was significantly highest in T_2 (2.319 gm) followed by T_3 (2.140 gm), T_8 (2.094 gm) and others and lowest being from T_5 (1.729 gm). Significantly, higher digesta / growth was observed during October – November (2.036 gm) and increased with the advancement of age (table 36 a, b).

Table 35 (a) Ingesta required for one unit growth of muga silk worm larvae during favourable seasons fed on different combination of leaves

Ing/gr	1st		2nd		3rd		4th		5th		whole		
	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Mean
T_1	2.280	2.308	2.567	2.582	2.747	2.752	3.727	4.003	10.326	8.834	6.790	6.762	6.776
T_2	2.280	2.308	2.578	2.571	2.872	2.744	3.960	3.928	9.241	8.574	7.576	6.709	7.142
T_3	2.280	2.308	2.578	2.571	2.773	2.769	3.976	3.870	8.581	8.266	6.783	6.592	6.688
T_4	2.280	2.308	2.578	2.571	2.773	2.769	3.736	3.731	9.311	8.887	6.831	6.549	6.690
T_5	2.440	2.370	2.793	2.825	2.870	2.920	3.672	4.428	7.271	6.662	5.929	5.802	5.866
T_6	2.440	2.370	2.623	2.625	2.732	2.847	3.718	3.771	7.059	6.381	5.858	5.506	5.682
T_7	2.440	2.370	2.623	2.625	2.841	2.827	3.715	3.665	6.235	6.201	5.407	5.406	5.407
T_8	2.440	2.370	2.623	2.625	2.841	2.827	3.743	3.742	7.695	7.202	6.191	6.032	6.111
Mean	**2.360**	**2.339**	**2.620**	**2.624**	**2.806**	**2.807**	**3.781**	**3.892**	**8.215**	**7.626**	**6.421**	**6.170**	**6.295**

Table 35 (b) : Statistical analysis of table 35 (a)

Season						
S Em (±)	0.032	0.022	0.007	0.004	0.002	0.001
CD P=0.05	0.091	0.063	0.019	0.012	0.007	0.004
Treatment						
S Em (±)	0.063	0.043	0.013	0.008	0.005	0.003
CD P=0.05	0.182	0.126	0.037	0. 025	0.014	0.008
Season x treatment						
S Em (±)	0.089	0.062	0.018	0.012	0.007	0.004
CD P=0.05	0.257	0.178	0.053	0.035	0.020	0.011

Table 36 (a) Digesta required for one unit growth of muga silk worm larvae during favourable seasons fed on different combination of leaves

Dig/gr	1st		2nd		3rd		4th		5th		whole		
	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Apr.-May	Oct.-Nov.	Mean
T_1	1.080	1.115	1.224	1.224	1.269	1.268	1.439	1.697	2.758	2.110	2.010	1.891	1.950
T_2	1.080	1.115	1.203	1.214	1.368	1.302	1.644	1.695	2.738	2.574	2.439	2.199	2.319
T_3	1.080	1.115	1.203	1.214	1.243	1.258	1.654	1.662	2.449	2.509	2.115	2.165	2.140
T_4	1.080	1.115	1.203	1.214	1.243	1.258	1.587	1.606	2.193	2.229	1.891	1.918	1.905
T_5	1.280	1.259	1.328	1.349	1.339	1.374	1.613	1.941	1.873	1.672	1.754	1.704	1.729
T_6	1.280	1.259	1.246	1.264	1.247	1.347	1.622	1.644	2.029	2.280	1.858	2.060	1.959
T_7	1.280	1.259	1.246	1.264	1.319	1.327	1.592	1.597	1.705	2.332	1.645	2.100	1.872
T_8	1.280	1.259	1.246	1.264	1.319	1.327	1.549	1.580	2.198	2.586	1.941	2.247	2.094
Mean	**1.180**	**1.187**	**1.237**	**1.251**	**1.293**	**1.308**	**1.588**	**1.678**	**2.243**	**2.287**	**1.957**	**2.036**	**1.996**

Table 36 (b) : Statistical analysis of table 36 (a)

Season						
S Em (±)	0.016	0.013	0.003	0.002	0.001	0.001
CD P=0.05	0.045	0.037	0.110	0.006	0.002	0.002
Treatment						
S Em (±)	0.031	0.026	0.007	0.004	0.002	0.002
CD P=0.05	0.090	0.074	0.019	0.012	0.005	0.004
Season x Treatment						
S Em (±)	0.044	0.036	0.009	0.006	0.003	0.002
CD P=0.05	0.127	0.104	0.027	0.017	0.007	0.006

4.4 Nutritional efficiencies of larval instars fed on better selected host plant as well as better combination of leaves during different seasons :

Larval nutritional efficiencies in the form of leaf ingestion, digestion, reference ratio, weight gain, mean daily food ingestion and digestion as well as efficiencies of conversion of ingested and digested food, AD, CI and GR were recorded and calculated on som (T_1) and better combination of leaves namely, first and second instar on soalu and rest on som (T_2) and early instars (first, second and third) on soalu and late instars (fourth and fifth) on som (T_3) during the two main commercial crop rearing season (October – November and April – May), seed crop rearing season (August – September and February – March) and the main adverse period, June – July.

4.4.1 Food ingestion :

Significant difference was observed among the treatments. Food ingestion was found highest in T_3 (20.558 gm) and lowest in T_2 (19.618 gm). From the seasonal standpoint, leaf ingestion was significantly higher during October – November followed by April – May and lowest in June – July. Significantly food ingestion increased with the progression of instars highest being from fifth instar. Upon interaction between treatment and season, significant variation was observed, highest being from T_3 x October – November (25.200 gm) and lowest in T_1 x June – July (17.754 gm) having non- significant variation with T_2 x June - July (17.760 gm). During seed crop rearing season (August – September and February – March), though food ingestion was highest in T_3 there observed significant variation among other interactions. During T_1 x February – March (19.179 gm) showed higher than T_2 (19.105 gm) while during August – September T_2 (18.656 gm) showed higher ingestion than T_1 (18.648 gm). Upon interaction between treatment and instar, though fifth instar showed higher ingestion, significantly highest ingestion on T_3 (16.792 gm) followed by T_1 (16.260 gm) and T_2 (15.903 gm). In the fourth instar T_1 (2.875 gm) replaced T_3 (2.858 gm) having non-significant variation among them. Instar wise seasonal variation was significant showing highest in fifth instar during October – November and lowest in first instar during June – July. No significant variation was observed upon three factor (treatment – season – instar) interaction (table 37).

Table 37 : Food ingestion by muga silk worm larvae fed on better selected host plant as well as better combination of leaves during different seasons

Treatments	Seasons	Larval Instar					Total
		I	II	III	IV	V	
T_1	Feb. – Mar.	0.056	0.161	0.670	2.772	15.520	19.179
	April – May	0.057	0.165	0.685	2.832	15.560	19.299
	June - July	0.049	0.147	0.588	2.480	14.490	17.754
	Aug. – Sept.	0.052	0.158	0.618	2.690	15.130	18.648
	Oct. – Nov.	0.060	0.180	0.720	3.600	20.600	25.160
	Mean	**0.055**	**0.162**	**0.656**	**2.875**	**16.260**	**20.008**
T_2	Feb. – Mar.	0.059	0.174	0.642	2.710	15.520	19.105
	April – May	0.061	0.181	0.642	2.785	15.550	19.219
	June - July	0.055	0.155	0.580	2.480	14.490	17.760
	Aug. – Sept.	0.057	0.161	0.618	2.690	15.130	18.656
	Oct. – Nov.	0.064	0.189	0.689	3.582	18.825	23.349
	Mean	**0.059**	**0.172**	**0.634**	**2.849**	**15.903**	**19.618**
T_3	Feb. – Mar.	0.059	0.174	0.700	2.724	16.125	19.782
	April – May	0.061	0.181	0.713	2.820	16.524	20.299
	June - July	0.055	0.155	0.603	2.491	14.820	18.124
	Aug. – Sept.	0.057	0.161	0.633	2.692	15.840	19.383
	Oct. – Nov.	0.064	0.189	0.735	3.562	20.650	25.200
	Mean	**0.059**	**0.172**	**0.677**	**2.858**	**16.792**	**20.558**
Seasonal average	Feb. – Mar.	0.058	0.170	0.671	2.735	15.722	19.355
	April – May	0.060	0.176	0.680	2.812	15.878	19.606
	June - July	0.053	0.152	0.590	2.484	14.600	17.879
	Aug. – Sept.	0.055	0.160	0.623	2.691	15.367	18.896
	Oct. – Nov.	0.063	0.186	0.715	3.581	20.025	24.570

	Treatment (T)	Season (S)	Instar (I)	T x S	T x I	S x I	T x S x I
S Em (±)	0.013	0.017	0.017	0.030	0.030	0.039	0.067
CD (P = 0.05)	0.037	0.048	0.048	0.083	0.083	0.108	NS

4.4.2 Food digestion :

Digesta observed significantly highest in T_3 (6.779 gm) followed by T_2 (6.410 gm) and lowest in T_1 (6.388 gm) having non- significant variation with T_1 and T_2. Among the seasons, food digesta was observed as October – November > April – May > August – September > February – March > June – July. Digesta increased with the progression of instars. Seasonal affect on treatments shows significantly highest digesta in October – November x T_3 (9.787 gm) followed by October – November x T_2 (8.738 gm) and lowest in June – July x T_1 (5.320 gm). The digesta in another commercial crop rearing season (April – May) was found highest in T_3 (6.176 gm) followed non- significantly by T_2 (6.096 gm) and T_1 (6.084 gm) but significant variation were recorded between T_1 and T_3. In February – March highest digesta was observed in T_1 (6.102 gm) followed by T_2 (6.030 gm) and T_3

(5.695 gm) while another seed crop rearing season *i.e.* during August – September the digesta was highest in T_3 (6.565 gm) followed by T_2 (5.863 gm) and T_1 (5.845 gm). In adverse season, June – July x T_3 (5.670 gm) remain highest followed by T_2 (5.325 gm). In fifth instar though T_3 (5.149 gm) showed highest digesta followed by T_2 (4.803 gm), in fourth instar highest digesta was observed in T_1 (1.217 gm) followed non- significantly by T_3 (1.213 gm) and T_2 (1.210 gm). No significant variation was observed upon three factor (treatment – season – instar) interaction (table 38).

Table 38 : Food digestion by muga silk worm larvae fed on better selected host plant as well as better combination of leaves during different seasons

Treatments	Seasons	Larval Instar					Total
		I	II	III	IV	V	
T_1	Feb. – Mar.	0.027	0.077	0.318	1.162	4.518	6.102
	April – May	0.027	0.077	0.307	1.203	4.470	6.084
	June - July	0.022	0.065	0.253	1.030	3.950	5.320
	Aug. – Sept.	0.024	0.072	0.269	1.140	4.340	5.845
	Oct. – Nov.	0.029	0.085	0.327	1.550	6.600	8.591
	Mean	**0.026**	**0.075**	**0.295**	**1.217**	**4.776**	**6.388**
T_2	Feb. – Mar.	0.030	0.081	0.293	1.100	4.525	6.030
	April – May	0.032	0.086	0.293	1.215	4.470	6.096
	June - July	0.027	0.069	0.247	1.032	3.950	5.325
	Aug. – Sept.	0.028	0.074	0.273	1.143	4.345	5.863
	Oct. – Nov.	0.034	0.091	0.326	1.562	6.725	8.738
	Mean	**0.030**	**0.080**	**0.286**	**1.210**	**4.803**	**6.410**
T_3	Feb. – Mar.	0.030	0.081	0.322	1.122	4.140	5.695
	April – May	0.032	0.086	0.331	1.208	4.519	6.176
	June - July	0.027	0.069	0.258	1.041	4.275	5.670
	Aug. – Sept.	0.028	0.074	0.275	1.140	5.048	6.565
	Oct. – Nov.	0.034	0.091	0.345	1.552	7.765	9.787
	Mean	**0.030**	**0.080**	**0.306**	**1.213**	**5.149**	**6.779**
Seasonal average	Feb. – Mar.	0.029	0.080	0.311	1.128	4.394	5.942
	April – May	0.030	0.083	0.310	1.209	4.486	6.119
	June - July	0.025	0.068	0.253	1.034	4.058	5.438
	Aug. – Sept.	0.027	0.073	0.272	1.141	4.578	6.091
	Oct. – Nov.	0.032	0.089	0.333	1.555	7.030	9.039

	Treatment (T)	Season (S)	Instar (I)	T x S	T x I	S x I	T x S x I
S Em (±)	0.013	0.017	0.017	0.030	0.030	0.039	0.067
CD (P = 0.05)	0.037	0048	0.048	0.083	0.083	0.108	NS

4.4.3 Excreta :

As a whole excreta in T_3 was highest (13.779 gm) followed by T_1 (13.620gm) and lowest in T_2 (13.208 gm). Excreta were highest during October - November and lowest in

June – July and in the fifth instar the excreta recorded highest. In October - November the excretion was highest in T_1 (16.569 gm) followed by T_3 (15.413 gm). During April –May, August – September and February - March excretion was highest in T_3 (14.123 gm, 12.818 gm, 14.087gm respectively) followed by T_1 (13.215 gm, 12.803 gm and 13.077 gm respectively) and T_2 (13.123 gm, 12.793 gm and 13.076 gm respectively). In June - July

Table 39 : Excretion by muga silk worm larvae fed on better selected host plant as well as better combination of leaves during different seasons

Treatments	Seasons	Larval Instar					Total
		I	II	III	IV	V	
T_1	Feb. – Mar.	0.029	0.084	0.352	1.610	11.002	13.077
	April – May	0.030	0.088	0.378	1.629	11.090	13.215
	June - July	0.027	0.082	0.335	1.450	10.540	12.434
	Aug. – Sept.	0.028	0.086	0.349	1.550	10.790	12.803
	Oct. – Nov.	0.031	0.095	0.393	2.050	14.000	16.569
	Mean	**0.029**	**0.087**	**0.361**	**1.658**	**11.484**	**13.620**
T_2	Feb. – Mar.	0.029	0.093	0.349	1.610	10.995	13.076
	April – May	0.029	0.095	0.349	1.570	11.080	13.123
	June - July	0.028	0.086	0.333	1.448	10.540	12.435
	Aug. – Sept.	0.029	0.087	0.345	1.547	10.785	12.793
	Oct. – Nov.	0.030	0.098	0.363	2.020	12.100	14.611
	Mean	**0.029**	**0.092**	**0.348**	**1.639**	**11.100**	**13.208**
T_3	Feb. – Mar.	0.029	0.093	0.378	1.602	11.985	14.087
	April – May	0.029	0.095	0.382	1.612	12.005	14.123
	June - July	0.028	0.086	0.345	1.450	10.545	12.454
	Aug. – Sept.	0.029	0.087	0.358	1.552	10.792	12.818
	Oct. – Nov.	0.030	0.098	0.390	2.010	12.885	15.413
	Mean	**0.029**	**0.092**	**0.371**	**1.645**	**11.642**	**13.779**
Seasonal average	Feb. – Mar.	0.029	0.090	0.360	1.607	11.327	13.413
	April – May	0.029	0.093	0.370	1.604	11.392	13.487
	June - July	0.028	0.085	0.338	1.449	10.542	12.441
	Aug. – Sept.	0.029	0.087	0.351	1.550	10.789	12.805
	Oct. – Nov.	0.030	0.097	0.382	2.027	12.995	15.531

	Treatment (T)	Season (S)	Instar (I)	T x S	T x I	S x I	T x S x I
S Em (±)	0.001	0.001	0.001	0.001	0.001	0.001	0.002
CD (P = 0.05)	0.001	0.001	0.001	0.002	0.002	0.003	NS

excretion was highest in T_3 (12.454 gm) followed by T_2 (12.435 gm). Except June – July in all the season lowest excreta was observed in T_2, while in June - July it was in T_1 (12.434 gm) having non-significant variation with T_2 (12.435 gm). In the late instars excretion was highest in T_3 followed by T_1, lowest being from T_2 (1.639 gm) in fourth instar and as well as in fifth instar (11.100 gm). No significant variation was observed upon three factor (treatment – season – instar) interaction (table 39).

4.4.4 Reference ratio (RR) :

Reference ratio was calculated highest in T_3 (1.489) followed non-significantly by T_2 (1.482) and T_1 (1.466). Among the seasons, significantly higher RR was observed in October

Table 40 : Reference ratio of muga silk worm larvae fed on better selected host plant as well as better combination of leaves during different seasons

Treatments	Seasons	Larval Instar					Total
		I	II	III	IV	V	
T_1	Feb. – Mar.	1.931	1.917	1.903	1.722	1.411	1.467
	April – May	1.900	1.875	1.812	1.738	1.403	1.460
	June - July	1.815	1.793	1.755	1.710	1.375	1.428
	Aug. – Sept.	1.857	1.837	1.771	1.735	1.402	1.457
	Oct. – Nov.	1.935	1.895	1.832	1.756	1.471	1.518
	Mean	**1.888**	**1.863**	**1.815**	**1.732**	**1.412**	**1.466**
T_2	Feb. – Mar.	2.034	1.871	1.840	1.684	1.412	1.461
	April – May	2.103	1.905	1.840	1.774	1.403	1.465
	June - July	1.964	1.802	1.742	1.713	1.375	1.428
	Aug. – Sept.	1.966	1.851	1.791	1.739	1.403	1.458
	Oct. – Nov.	2.133	1.929	1.898	1.773	1.556	1.598
	Mean	**2.040**	**1.872**	**1.822**	**1.736**	**1.430**	**1.482**
T_3	Feb. – Mar.	2.034	1.871	1.852	1.700	1.345	1.404
	April – May	2.103	1.905	1.866	1.749	1.376	1.437
	June - July	1.964	1.802	1.748	1.718	1.405	1.455
	Aug. – Sept.	1.966	1.851	1.768	1.735	1.468	1.512
	Oct. – Nov.	2.133	1.929	1.885	1.772	1.603	1.635
	Mean	**2.040**	**1.872**	**1.824**	**1.735**	**1.440**	**1.489**
Seasonal average	Feb. – Mar.	2.000	1.886	1.865	1.702	1.389	1.444
	April – May	2.035	1.895	1.839	1.754	1.394	1.454
	June - July	1.914	1.799	1.748	1.714	1.385	1.437
	Aug. – Sept.	1.930	1.846	1.777	1.736	1.424	1.476
	Oct. – Nov.	2.067	1.918	1.872	1.767	1.543	1.584

	Treatment (T)	Season (S)	Instar (I)	T x S	T x I	S x I	T x S x I
S Em (±)	0.006	0.007	0.007	0.013	0.016	0.016	0.028
CD (P = 0.05)	0.016	0.020	0.020	0.035	0.045	0.045	NS

- November followed significantly by August – September, April - May and non-significantly by February – March and June – July. RR decreased with the progression of instars highest being from first instar and lowest in fifth instar. Upon treatment - season interaction October - November x T_3 showed highest RR (1.635) followed significantly by October - November x T_2 (1.598). During April - May there was no significant variation among treatments. In February – March there is no significant variation between T_1 (1.467) and T_2 (1.461) which were significantly higher than T_3 (1.404). In August - September no significant variation was observed between T_1 (1.457) and T_2 (1.458) and significantly highest was in T_3 (1.512). In June – July no significant variation was observed between T_1 (1.428), T_2 (1.428) and T_3 (1.455). Upon treatment – instar interaction, in fourth instar no significant variation was observed between T_1 (1.732), T_3 (1.735) and T_2 (1.736). In fifth instar highest RR was recorded in T_3 (1.440) and lowest in T_1 (1.412), having non-significant variation between T_1, T_2 (1.430) and T_3. In all the season first instar, showed highest RR and fifth instar showed lowest. No significant variation was observed upon three factor (treatment – season – instar) interaction (table 40).

4.4.5 Approximate digestibility (AD) :

Approximate digestibility was highest in T_3 (32.641%) followed non-significantly by T_2 (32.422%) and lowest in T_1 (31.759%). Significantly highest AD was observed in October – November followed significantly by August – September and April - May and non-significantly by February - March and June-July. 1st instar showed highest AD which decreased gradually and lowest in 5th instar. Upon treatment - season interaction, the result shows significantly highest AD during October - November x T_3 (38.837%) followed by October - November x T_2 (37.423%) and others. While in April - May highest AD was observed in T_2 (31.719%) varies non-significantly with T_1 (31.525%) and significantly by T_3 (30.425%). During February - March the AD decreased from T_1 (31.816%) to T_2 (31.560%), varies non- significantly and significantly lowest in T_3 (28.789%). During August - September and June - July highest AD was observed in T_3 (33.870 and 31.284%) and lowest in T_1 (31.344 and 29.965%) while non-significant variation was observed between T_2 (31.427 and 29.983%) and T_1. No significant variation was observed in 4th instar among T_1 (42.273%), T_2 (42.388%) and T_3 (42.374%) and in 5th instar also there is no significant variation among the treatments, highest being from T_3 (30.268%) and lowest in T_1 (29.164%). In all the seasons 1st instar showed highest AD and 5th instar showed the lowest. No significant variation was observed upon 3 factor (Treatment x Season x Instar) interaction (table 41).

Table 41 : Approximate food digestibility by muga silk worm larvae fed on better selected host plant as well as better combination of leaves during different seasons

Treatments	Seasons	Larval Instar					Total
		I	II	III	IV	V	
T1	Feb. – Mar.	48.214	47.826	47.463	41.919	29.111	31.816
	April – May	47.368	46.667	44.818	42.479	28.728	31.525
	June - July	44.898	44.218	43.027	41.532	27.260	29.965
	Aug. – Sept.	46.154	45.570	43.528	42.379	28.685	31.344
	Oct. – Nov.	48.333	47.222	45.417	43.056	32.039	34.145
	Mean	**46.994**	**46.300**	**44.850**	**42.273**	**29.164**	**31.759**
T2	Feb. – Mar.	50.847	46.552	45.639	40.603	29.157	31.560
	April – May	52.459	47.514	45.639	43.627	28.746	31.719
	June - July	49.091	44.516	42.586	41.613	27.260	29.983
	Aug. – Sept.	49.123	45.963	44.175	42.491	28.718	31.427
	Oct. – Nov.	53.125	48.148	47.315	43.607	35.724	37.423
	Mean	**50.929**	**46.539**	**45.071**	**42.388**	**29.921**	**32.422**
T3	Feb. – Mar.	50.847	46.552	46.000	41.189	25.674	28.789
	April – May	52.459	47.514	46.424	42.837	27.348	30.425
	June - July	49.091	44.516	42.786	41.790	28.846	31.284
	Aug. – Sept.	49.123	45.963	43.444	42.348	31.869	33.870
	Oct. – Nov.	53.125	48.148	46.939	43.571	37.603	38.837
	Mean	**50.929**	**46.539**	**45.118**	**42.347**	**30.268**	**32.641**
Seasonal average	Feb. – Mar.	49.969	46.977	46.367	41.237	27.981	30.722
	April – May	50.762	47.232	45.627	42.981	28.274	31.223
	June - July	47.693	44.417	42.800	41.645	27.789	30.411
	Aug. – Sept.	48.133	45.832	43.716	42.406	29.757	32.214
	Oct. – Nov.	51.528	47.839	46.557	43.411	35.122	36.802

	Treatment (T)	Season (S)	Instar (I)	T x S	T x I	S x I	T x S x I
S Em (±)	0.146	0.189	0.189	0.327	0.327	0.422	0.730
CD (P = 0.05)	0.408	0.527	0.527	0.913	0.913	1.179	NS

4.4.6 Weight Gain :

Weight gain observed significantly highest in T_3 (3.677gm) followed by T_1 (3.506 gm) and T_2 (3.362 gm). Weight gain was significantly better during October - November, followed by April-May, February – March, August - September and June - July. Weight gain increased as the instar progressed, highest in 5^{th} instar. Upon treatment -season interaction, T_3 x October - November (4.661 gm) showed significantly highest weight gain followed by T_1 x October - November (4.451 gm) and others, lowest being from T_2 x June - July (2.879

Table 42 : Weight gain by muga silk worm larvae fed on better selected host plant as well as better combination of leaves during different seasons

Treatments	Seasons	Larval Instar					Total
		I	II	III	IV	V	
T_1	Feb. – Mar.	0.023	0.061	0.230	0.730	2.290	3.334
	April – May	0.025	0.064	0.247	0.758	2.307	3.401
	June - July	0.020	0.055	0.210	0.653	2.123	3.061
	Aug. – Sept.	0.022	0.060	0.222	0.720	2.260	3.284
	Oct. – Nov.	0.026	0.070	0.260	0.965	3.130	4.451
	Mean	**0.023**	**0.062**	**0.234**	**0.765**	**2.422**	**3.506**
T_2	Feb. – Mar.	0.025	0.063	0.222	0.730	2.190	3.230
	April – May	0.025	0.069	0.235	0.749	2.203	3.281
	June - July	0.022	0.058	0.199	0.640	1.960	2.879
	Aug. – Sept.	0.023	0.061	0.215	0.700	2.180	3.179
	Oct. – Nov.	0.027	0.072	0.242	0.950	2.950	4.241
	Mean	**0.024**	**0.065**	**0.223**	**0.754**	**2.297**	**3.362**
T_3	Feb. – Mar.	0.025	0.063	0.235	0.736	2.400	3.459
	April – May	0.025	0.069	0.251	0.759	2.650	3.754
	June - July	0.022	0.058	0.198	0.675	2.180	3.133
	Aug. – Sept.	0.023	0.061	0.215	0.730	2.350	3.379
	Oct. – Nov.	0.027	0.072	0.260	0.972	3.330	4.661
	Mean	**0.024**	**0.065**	**0.232**	**0.774**	**2.582**	**3.677**
Seasonal average	Feb. – Mar.	0.024	0.062	0.229	0.732	2.293	3.341
	April – May	0.025	0.067	0.244	0.755	2.387	3.479
	June - July	0.021	0.057	0.202	0.656	2.088	3.024
	Aug. – Sept.	0.023	0.061	0.217	0.717	2.263	3.281
	Oct. – Nov.	0.027	0.071	0.254	0.962	3.137	4.451

	Treatment (T)	Season (S)	Instar (I)	T x S	T x I	S x I	T x S x I
S Em (±)	0.001	0.001	0.001	0.001	0.001	0.001	0.001
CD (P = 0.05)	0.001	0001	0.001	0.002	0.002	0.002	NS

gm). Treatment - instar interaction showed $T_3 > T_1 > T_2$ manner in both the later stages having significant variations. In all the season 5th instar showed better weight gain and 1st instar showed lowest. No significant variation was observed upon 3 factor (Treatment x Season x Instar) interaction (table 42).

4.4.7 Efficiency of conversion of ingested food (ECI) :

Significant variation was observed among the treatments, highest in T_3 (17.839%) fallowed by T_1 (17.510%) and lowest in T_2 (17.078%). Among the seasons, October-November showed highest ECI followed significantly by April-May, August.-September, February -March and June - July and the variation between August - September and February

- March was non-significant. ECI decreased as the instar progressed. Upon Treatment -season interaction, highest ECI was observed in October- November x T_3 (18.496%) followed non-significantly by October – November x T_2 (18.164%) and significantly by T_1 (17.691%). During April-May ECI was highest in T_3 (18.494%) followed significantly by T_1 (17.623%) and T_2 (17.072%), in February - March and June-July also highest ECI were observed in T_3 (17.486%) and (17.286%) followed non-significantly by T_1 (17.384%) and (17.241%) and lowest in T_2 (16.906 and 16.211%). Upon treatment-instar interaction, in 5th instar T_3 (15.319%) followed significantly by T_1 (14.873%) and in 4th Instar also T_3 (27.087%) followed by T_1 (26.600%) having non significant variation between T_1, T_2 and T_3. No significant variation was observed upon 3 factor (Treatment x Season x Instar) interaction (table 43).

Table 43 : Efficiency of conversion of ingested food by muga silk worm larvae fed on better selected host plant as well as better combination of leaves during different seasons

Treatments	Seasons	Larval Instar					Total
		I	II	III	IV	V	
T_1	Feb. – Mar.	41.071	37.888	34.328	26.335	14.755	17.384
	April – May	43.860	38.788	36.058	26.766	14.826	17.623
	June - July	40.816	37.415	35.714	26.331	14.651	17.241
	Aug. – Sept.	42.308	37.975	35.922	26.766	14.937	17.610
	Oct. – Nov.	43.333	38.889	36.111	26.806	15.194	17.691
	Mean	**42.278**	**38.191**	**35.627**	**26.600**	**14.873**	**17.510**
T_2	Feb. – Mar.	42.373	36.207	34.579	26.937	14.111	16.906
	April – May	40.984	38.122	36.604	26.894	14.167	17.072
	June - July	40.000	37.419	34.310	25.806	13.527	16.211
	Aug. – Sept.	40.351	37.888	34.790	26.022	14.408	17.040
	Oct. – Nov.	42.188	38.095	35.123	26.521	15.671	18.164
	Mean	**41.179**	**37.546**	**35.081**	**26.436**	**14.377**	**17.078**
T_3	Feb. – Mar.	42.373	36.207	33.571	27.019	14.884	17.486
	April – May	40.984	38.122	35.203	26.915	16.037	18.494
	June - July	40.000	37.419	32.836	27.098	14.710	17.286
	Aug. – Sept.	40.351	37.888	33.965	27.117	14.836	17.433
	Oct. – Nov.	42.188	38.095	35.374	27.288	16.126	18.496
	Mean	**41.179**	**37.546**	**34.190**	**27.087**	**15.319**	**17.839**
Seasonal average	Feb. – Mar.	41.939	36.767	34.159	26.764	14.583	17.259
	April – May	41.943	38.344	35.955	26.858	15.010	17.730
	June - July	40.272	37.418	34.287	26.412	14.296	16.913
	Aug. – Sept.	41.003	37.917	34.892	26.635	14.727	17.361
	Oct. – Nov.	42.570	38.360	35.536	26.872	15.664	18.117

	Treatment (T)	Season (S)	Instar (I)	T x S	T x I	S x I	T x S x I
S Em (±)	0.079	0.102	0.102	0.177	0.177	0.228	0.395
CD (P = 0.05)	0.221	0.285	0.285	0.494	0.494	0.638	NS

4.4.8 Efficiency of conversion of digested food (ECD) :

ECD was highest in T_1 (55.214%) followed non-significantly by T_3 (55.174%) and significantly by T_2 (52.843%). ECD was highest in April-May followed non-significantly by

Table 44 : Efficiency of conversion of digested food by muga silk worm larvae fed on better selected host plant as well as better combination of leaves during different seasons

Treatments	Seasons	Larval Instar					Total
		I	II	III	IV	V	
T1	Feb. – Mar.	85.185	79.221	72.327	62.823	50.686	54.638
	April – May	92.593	83.117	80.456	63.009	51.611	55.901
	June - July	90.909	84.615	83.004	63.398	53.747	57.538
	Aug. – Sept.	91.667	83.333	82.528	63.158	52.074	56.185
	Oct. – Nov.	89.655	82.353	79.511	62.258	47.424	51.810
	Mean	**90.002**	**82.528**	**79.565**	**62.929**	**51.108**	**55.214**
T2	Feb. – Mar.	83.333	77.778	75.768	66.344	48.394	53.568
	April – May	78.125	80.233	80.205	61.646	49.284	53.822
	June - July	81.481	84.058	80.567	62.016	49.620	54.066
	Aug. – Sept.	82.143	82.432	78.755	61.242	50.173	54.221
	Oct. – Nov.	79.412	79.121	74.233	60.819	43.866	48.535
	Mean	**80.899**	**80.724**	**77.905**	**62.413**	**48.267**	**52.843**
T3	Feb. – Mar.	83.333	77.778	72.981	65.597	57.971	60.737
	April – May	78.125	80.233	75.831	62.831	58.641	60.784
	June - July	81.481	84.058	76.744	64.841	50.994	55.256
	Aug. – Sept.	82.143	82.432	78.182	64.035	46.553	51.470
	Oct. – Nov.	79.412	79.121	75.362	62.629	42.885	47.624
	Mean	**80.899**	**80.724**	**75.820**	**63.987**	**51.409**	**55.174**
Seasonal average	Feb. – Mar.	83.950	78.259	73.692	64.921	52.350	56.314
	April – May	82.948	81.194	78.831	62.495	53.179	56.836
	June - July	84.624	84.244	80.105	63.418	51.454	55.620
	Aug. – Sept.	85.318	82.732	79.822	62.812	49.600	53.959
	Oct. – Nov.	82.826	80.198	76.369	61.902	44.725	49.323

	Treatment (T)	Season (S)	Instar (I)	T x S	T x I	S x I	T x S x I
S Em (±)	0.343	0.442	0.442	0.766	0.766	.989	1.713
CD (P = 0.05)	0.958	1.236	1.236	2.141	2.141	2.764	NS

February - March, June-July and significantly by others. ECD decreased as the instar progressed, highest from 1st instar and lowest in 5th instar. Upon treatment-season interaction, April-May x T_3 (60.784%) showed highest ECD followed by February-March x T_3 (60.737%), in August – September ECD was highest in T_1 (56.185%) and there was no significant variation with T_2 (54.221%) and significantly lowest in T_3 (51.470%). October - November follow the same trend highest in T_1 (51.810%) followed by T_2 (48.535%) and T_3

(47.624%) having non-significant variation between T_2 and T_3. During April-May and February - March T_3 (60.784 and 60.737%) fallowed by T_1 (55.901 54.638%) and lowest in T_2 (53.822 and 53.568%). In 4th and 5th instar T_3 (63.987 and 51.409%) was followed by T_1 (62.929 and 51.108%) and lowest in T_2 (62.413 and 48.267%). In all the season 1st instar showed highest ECD and 5th instar showed lowest. No significant variation was observed upon 3 factor (Treatment x Season x Instar) interaction (table 44).

4.4.9 Larval duration :

Laval duration was found significantly highest in T_1 (22.909 days) followed by T_2 (21.565 days), significantly lowest duration was observed in T_3 (21.424 days). Larval

Table 45 : Larval duration of muga silk worm fed on better selected host plant as well as better combination of leaves during different seasons

Treatments	Seasons	Larval Instar					Total
		I	II	III	IV	V	
T_1	Feb. – Mar.	3.620	3.120	3.400	4.380	8.390	22.910
	April – May	3.616	3.050	3.380	4.260	8.375	22.681
	June - July	3.245	3.000	3.225	3.895	8.300	21.665
	Aug. – Sept.	3.250	2.950	3.180	3.900	8.310	21.590
	Oct. – Nov.	4.200	4.300	4.200	4.000	9.000	25.700
	Mean	**3.586**	**3.284**	**3.477**	**4.720**	**8.475**	**22.909**
T_2	Feb. – Mar.	2.810	2.710	3.400	4.386	8.350	21.656
	April – May	2.800	2.700	3.350	4.265	8.340	21.455
	June - July	2.500	2.520	3.200	3.895	8.290	20.405
	Aug. – Sept.	2.600	2.650	3.150	3.910	8.300	20.610
	Oct. – Nov.	3.000	3.410	4.190	4.200	8.900	23.700
	Mean	**2.742**	**2.798**	**3.458**	**4.131**	**8.436**	**21.565**
T_3	Feb. – Mar.	2.810	2.710	3.362	4.386	8.350	21.618
	April – May	2.800	2.700	3.350	4.265	8.340	21.455
	June - July	2.500	2.520	2.980	3.895	8.290	20.185
	Aug. – Sept.	2.600	2.650	3.000	3.910	8.300	20.460
	Oct. – Nov.	3.000	3.410	3.750	4.200	8.900	23.260
	Mean	**2.742**	**2.798**	**3.317**	**4.131**	**8.436**	**21.424**
Seasonal average	Feb. – Mar.	3.080	2.847	3.387	4.384	8.363	22.061
	April – May	3.072	2.817	3.360	4.263	8.352	21.864
	June - July	2.748	2.680	3.135	3.895	8.293	20.752
	Aug. – Sept.	2.817	2.750	3.110	3.907	8.303	20.887
	Oct. – Nov.	3.400	3.707	4.047	4.133	8.933	24.220

	Treatment (T)	Season (S)	Instar (I)	T x S	T x I	S x I	T x S x I
S Em (±)	0.001	0.001	0.001	0.001	0.001	0.002	0.003
CD (P = 0.05)	0.001	0.002	0.002	0.003	0.003	0.004	NS

duration was observed significantly highest during October – November followed by February – March, April – May, August – September and June – July. During fifth instar the larval duration was significantly higher than others and lowest larval duration observed in second instar. No remarkable change in larval duration was observed in two-point interaction. No significant variation was observed upon 3 point (Treatment x Season x Instar) interaction (table 45).

4.4.10 Consumption index (CI):

Significantly highest CI was observed in T_2 (0.537) followed by T_1 (0.501) and T_3 (0.499) having non-significant variation between T_1 and T_3. June-July and August.-

Table 46 : Consumption index of muga silk worm larvae fed on better selected host plant as well as better combination of leaves during different seasons

Treatments	Seasons	Larval Instar					Total
		I	II	III	IV	V	
T_1	Feb. – Mar.	1.146	0.930	0.985	0.933	0.846	0.502
	April – May	1.087	0.917	0.949	0.931	0.828	0.501
	June - July	1.258	0.990	1.007	1.043	0.874	0.536
	Aug. – Sept.	1.231	0.992	1.002	1.039	0.846	0.526
	Oct. – Nov.	0.952	0.664	0.755	1.075	0.799	0.442
	Mean	**1.135**	**0.899**	**0.940**	**1.004**	**0.839**	**0.501**
T_2	Feb. – Mar.	1.448	1.098	0.989	0.926	0.875	0.548
	April – May	1.502	1.090	0.902	0.920	0.850	0.498
	June - July	1.692	1.161	1.004	1.061	0.920	0.604
	Aug. – Sept.	1.624	1.095	1.019	1.058	0.872	0.569
	Oct. – Nov.	1.376	0.853	0.768	1.075	0.771	0.467
	Mean	**1.529**	**1.059**	**0.936**	**1.008**	**0.858**	**0.537**
T_3	Feb. – Mar.	1.448	1.098	1.060	0.911	0.858	0.502
	April – May	1.502	1.090	0.965	0.911	0.816	0.461
	June - July	1.692	1.161	1.130	1.053	0.878	0.546
	Aug. – Sept.	1.624	1.095	1.096	1.035	0.866	0.520
	Oct. – Nov.	1.376	0.853	0.879	1.057	0.790	0.465
	Mean	**1.529**	**1.059**	**1.026**	**0.994**	**0.842**	**0.499**
Seasonal average	Feb. – Mar.	1.347	1.042	1.011	0.923	0.860	0.517
	April – May	1.364	1.032	0.939	0.921	0.831	0.487
	June - July	1.547	1.104	1.047	1.052	0.891	0.562
	Aug. – Sept.	1.493	1.061	1.039	1.044	0.861	0.538
	Oct. – Nov.	1.235	0.790	0.801	1.069	0.787	0.458

	Treatment (T)	Season (S)	Instar (I)	T x S	T x I	S x I	T x S x I
S Em (±)	0.002	0.003	0.003	0.005	0.005	0.007	0.012
CD (P = 0.05)	0.007	0.008	0.008	0.015	0.015	0.019	NS

September showed significantly higher CI than others, lowest being from October - November. All the treatments during June-July showed significantly highest CI than other seasons in treatment-season interaction. In June-July, T_2 (0.604) showed significantly higher CI than T_3 (0.546) and T_1 (0.536) having non-significant variation among the later two. In August - September and February- March T_2 (0.569 and 0.548) followed significantly by T_1 (0.526 and 0.502) and non- significantly by T_3 (0.520 and 0.502). During April - May T_1 (0.501) followed non-significantly by T_2 (0.498) and in October – November T_2 (0.467) followed non-significantly by T_3 (0.465). During April-May lowest CI was observed in T_3 (0.461) and during October – November it was lowest in T_1 (0.442) Treatment - instar interaction showed that there was no significant variation among treatments in 4^{th} instar while in 5^{th} instar T_2 (0.858) showed highest CI than others while there observed no significant variation among T_3 (0.842) and T_1 (0.839). In all the season 1^{st} instar showed highest CI and 5^{th} instar showed lowest. No significant variation was observed upon 3 factor (Treatment x Season x Instar) interaction (table 46).

4.4.11 Growth rate (GR) :

There observed no significant variation between in the treatments. June-July and August – September showed higher GR having significant variation with April-May, February-March and October.-November. GR decreased as the instar progressed. In Treatment-season interaction, June-July x T_2 showed highest GR (0.098) followed significantly by T_3 (0.094) and T_1 (0.092) having non-significant variation among the later two. GR during August September followed the same trend except T_1 (0.093) non-significantly followed by T_3 (0.091). During April-May and February – March, T_1 Showed highest GR (0.088 and 0.087) and lowest in T_2 (0.085). During fifth and fourth instar, treatment -instar interaction showed highest GR on T_3 (0.129 and 0.269) followed by T_1 (0.125 and 0.267) and T_2 (0.123 and 0.266). However, upon 3 point interaction (Treatment x Season x Instar) there observed no significant variation (table 47).

Table 47: Growth rate of muga silkworm larvae fed on better selected host plant as well as better combination of leaves during different seasons

Treatments	Seasons	Larval Instar					Total
		I	II	III	IV	V	
T_1	Feb. – Mar.	0.471	0.352	0.338	0.246	0.125	0.087
	April – May	0.477	0.356	0.342	0.249	0.123	0.088
	June - July	0.514	0.370	0.360	0.275	0.128	0.092
	Aug. – Sept.	0.521	0.377	0.360	0.278	0.126	0.093
	Oct. – Nov.	0.413	0.258	0.273	0.288	0.121	0.078
	Mean	**0.479**	**0.343**	**0.335**	**0.267**	**0.125**	**0.088**
T_2	Feb. – Mar.	0.614	0.397	0.342	0.250	0.123	0.085
	April – May	0.616	0.416	0.330	0.248	0.120	0.085
	June - July	0.677	0.434	0.345	0.274	0.124	0.098
	Aug. – Sept.	0.655	0.415	0.355	0.275	0.126	0.097
	Oct. – Nov.	0.581	0.325	0.270	0.285	0.121	0.085
	Mean	**0.628**	**0.397**	**0.328**	**0.266**	**0.123**	**0.090**
T_3	Feb. – Mar.	0.614	0.397	0.356	0.246	0.128	0.087
	April – May	0.616	0.416	0.340	0.245	0.131	0.085
	June - July	0.677	0.434	0.371	0.285	0.129	0.094
	Aug. – Sept.	0.655	0.415	0.372	0.281	0.128	0.091
	Oct. – Nov.	0.581	0.325	0.311	0.289	0.127	0.086
	Mean	**0.627**	**0.397**	**0.350**	**0.269**	**0.129**	**0.089**
Seasonal average	Feb. – Mar.	0.566	0.382	0.345	0.247	0.125	0.086
	April – May	0.570	0.396	0.337	0.247	0.125	0.086
	June - July	0.623	0.413	0.359	0.278	0.127	0.095
	Aug. – Sept.	0.610	0.402	0.362	0.278	0.127	0.094
	Oct. – Nov.	0.525	0.303	0.285	0.287	0.123	0.083

	Treatment (T)	Season (S)	Instar (I)	T x S	T x I	S x I	T x S x I
S Em (±)	0.001	0.001	0.001	0.001	0.007	0.001	0.002
CD (P = 0.05)	0.001	0.001	0.001	0.002	0.002	0.003	NS

4.4.12 Mean daily food ingesta (MDFI) :

The MDFI was highest in T_3 (0.958 gm) followed significantly by T_2 (0.908 gm) and T_1 (0.870 gm). MDFI was observed highest during October – November followed significantly by August – September, April - Ma y, February - March and June - Ju ly. Significantly lowest MDFI was observed in 1^{st} instar which increased gradually, highest being from 5^{th} instar. Upon treatment- season interaction, T_3 x October – November (1.083 gm) showed significantly highest MDFI followed by T_2 x October - November (0.985 gm) and T_1 x October - November (0.979 gm) having non-significant variation with T_2 and T_1. However in all other season *i.e.,* August - September, April - May, February - March and

June - July T_3 showed highest MDFI (0.947, 0.946, 0.915 and 0.898 gm respectively) followed significantly by T_2 (0.905, 0.896, 0.882 and 0.870 gm respectively) and T_1 (0.864,

Table 48 : Mean daily food ingestion by muga silk worm larvae fed on better selected host plant as well as better combination of leaves during different seasons

Treatments	Seasons	Larval Instar					Total
		I	II	III	IV	V	
T_1	Feb. – Mar.	0.015	0.052	0.197	0.633	1.850	0.837
	April – May	0.016	0.054	0.203	0.665	1.858	0.851
	June - July	0.015	0.049	0.182	0.637	1.746	0.819
	Aug. – Sept.	0.016	0.054	0.194	0.690	1.821	0.864
	Oct. – Nov.	0.014	0.042	0.171	0.900	2.289	0.979
	Mean	**0.015**	**0.050**	**0.190**	**0.705**	**1.913**	**0.870**
T_2	Feb. – Mar.	0.021	0.064	0.189	0.618	1.859	0.882
	April – May	0.022	0.067	0.192	0.653	1.865	0.896
	June - July	0.022	0.062	0.181	0.637	1.748	0.870
	Aug. – Sept.	0.022	0.061	0.196	0.688	1.823	0.905
	Oct. – Nov.	0.021	0.055	0.164	0.853	2.115	0.985
	Mean	**0.022**	**0.062**	**0.184**	**0.690**	**1.882**	**0.908**
T_3	Feb. – Mar.	0.021	0.064	0.208	0.621	1.931	0.915
	April – May	0.022	0.067	0.213	0.661	1.981	0.946
	June - July	0.022	0.062	0.202	0.640	1.788	0.898
	Aug. – Sept.	0.022	0.061	0.211	0.688	1.908	0.947
	Oct. – Nov.	0.021	0.055	0.196	0.848	2.320	1.083
	Mean	**0.022**	**0.062**	**0.206**	**0.692**	**1.986**	**0.958**
Seasonal average	Feb. – Mar.	0.019	0.060	0.198	0.624	1.880	0.878
	April – May	0.020	0.063	0.203	0.660	1.901	0.898
	June - July	0.020	0.058	0.188	0.638	1.761	0.862
	Aug. – Sept.	0.020	0.059	0.200	0.689	1.851	0.905
	Oct. – Nov.	0.019	0.051	0.177	0.867	2.241	1.016

	Treatment (T)	Season (S)	Instar (I)	T x S	T x I	S x I	T x S x I
S Em (±)	0.002	0.002	0.002	0.003	0.003	0.004	0.007
CD (P = 0.05)	0.004	0.005	0.005	0.009	0.009	0.012	NS

0.851, 0.837 and 0.819 gm respectively). Treatment - instar interaction showed significant variation in 4th instar where MDFI in T_1 (0.705 gm) was significantly higher than others and in 5th instar T_3 (1.986 gm) showed significantly higher MDFI than others. No significant variation was observed upon 3 factor (Treatment x Season x Instar) interaction(table 48).

4.4.13. Mean daily food digesta (MDFD) :

The MDFD was observed highest in T_3 (0.315 gm) followed significantly by T_2 (0.295 gm) and lowest in T_1 (0.277 gm). MDFD was highest in October - November followed by August - September and others and lowest in June - July. MDFD increased significantly, highest in 5th instar and lowest in 1st instar. Upon treatment-season interaction, October - November x T_3 (0.421 gm) showed significantly highest MDFD. In August-

Table 49 : Mean daily food digestion by muga silk worm larvae fed on better selected host plant as well as better combination of leaves during different seasons

Treatments	Seasons	Larval Instar					Total
		I	II	III	IV	V	
T₁	Feb. – Mar.	0.007	0.025	0.094	0.265	0.538	0.266
	April – May	0.007	0.025	0.091	0.282	0.534	0.268
	June - July	0.007	0.022	0.078	0.264	0.476	0.246
	Aug. – Sept.	0.007	0.024	0.085	0.292	0.522	0.271
	Oct. – Nov.	0.007	0.020	0.078	0.388	0.733	0.334
	Mean	**0.007**	**0.023**	**0.085**	**0.298**	**0.561**	**0.277**
T₂	Feb. – Mar.	0.011	0.030	0.086	0.251	0.542	0.278
	April – May	0.011	0.032	0.087	0.285	0.536	0.284
	June - July	0.011	0.027	0.077	0.265	0.476	0.261
	Aug. – Sept.	0.011	0.028	0.087	0.292	0.523	0.284
	Oct. – Nov.	0.011	0.027	0.078	0.372	0.756	0.369
	Mean	**0.011**	**0.029**	**0.083**	**0.293**	**0.567**	**0.295**
T₃	Feb. – Mar.	0.011	0.030	0.096	0.256	0.496	0.263
	April – May	0.011	0.032	0.099	0.283	0.542	0.288
	June - July	0.011	0.027	0.087	0.267	0.516	0.281
	Aug. – Sept.	0.011	0.028	0.092	0.292	0.608	0.321
	Oct. – Nov.	0.011	0.027	0.092	0.370	0.872	0.421
	Mean	**0.011**	**0.029**	**0.093**	**0.293**	**0.607**	**0.315**
Seasonal average	Feb. – Mar.	0.010	0.028	0.092	0.257	0.525	0.269
	April – May	0.010	0.030	0.092	0.283	0.537	0.280
	June - July	0.010	0.025	0.081	0.265	0.489	0.263
	Aug. – Sept.	0.010	0.027	0.088	0.292	0.551	0.292
	Oct. – Nov.	0.010	0.025	0.083	0.377	0.787	0.375

	Treatment (T)	Season (S)	Instar (I)	T x S	T x I	S x I	T x S x I
S Em (±)	0.002	0.002	0.002	0.003	0.003	0.004	0.007
CD (P = 0.05)	0.004	0.005	0.005	0.009	0.009	0.012	NS

September, June-July and April-May T_3 (0.321 and 0.281, 0.288 gm) showed highest MDFD, during February - March T_2 (0.278 gm) showed highest. Upon treatment-Instar interaction, 4th instar showed highest MDFD in T_1 (0.298 gm) while during 5th instar it was

T_3 (0.607 gm). In 4^{th} instar MDFD was lowest in T_2 (0.293 gm) and in 5^{th} instar lowest was in T_1 (0.561 gm). No significant variation was observed upon 3 factor (Treatment x Season x Instar) interaction (table 49).

4.4.14 Ingestion/ growth :

Ingesta required to produce 1 gm body weight was found highest in T_2 (5.863) followed significantly by T_1 (5.712) and lowest was in T_3 (5.611). Ingesta/growth was

Table 50 : Ingesta required for unit growth of muga silk worm larvae fed on better selected host plant as well as better combination of leaves during different seasons

Treatments	Seasons	Larval Instar					Total
		I	II	III	IV	V	
T_1	Feb. – Mar.	2.435	2.639	2.913	3.797	6.777	5.753
	April – May	2.280	2.578	2.773	3.736	6.745	5.675
	June - July	2.450	2.673	2.800	3.798	6.825	5.800
	Aug. – Sept.	2.364	2.633	2.784	3.736	6.695	5.678
	Oct. – Nov.	2.308	2.571	2.769	3.731	6.581	5.653
	Mean	**2.367**	**2.619**	**2.808**	**3.760**	**6.725**	**5.712**
T_2	Feb. – Mar.	2.360	2.762	2.892	3.712	7.087	5.915
	April – May	2.440	2.623	2.732	3.718	7.059	5.858
	June - July	2.500	2.672	2.915	3.875	7.393	6.169
	Aug. – Sept.	2.478	2.639	2.874	3.843	6.940	5.869
	Oct. – Nov.	2.370	2.625	2.847	3.771	6.381	5.506
	Mean	**2.430**	**2.664**	**2.852**	**3.784**	**6.972**	**5.863**
T_3	Feb. – Mar.	2.360	2.762	2.979	3.701	6.719	5.719
	April – May	2.440	2.623	2.841	3.715	6.235	5.407
	June - July	2.500	2.672	3.045	3.690	6.798	5.785
	Aug. – Sept.	2.478	2.639	2.944	3.688	6.740	5.736
	Oct. – Nov.	2.370	2.625	2.827	3.665	6.201	5.406
	Mean	**2.430**	**2.664**	**2.927**	**3.692**	**6.539**	**5.611**
Seasonal average	Feb. – Mar.	2.385	2.721	2.928	3.737	6.861	5.796
	April – May	2.387	2.608	2.782	3.723	6.680	5.647
	June - July	2.483	2.672	2.920	3.788	7.005	5.918
	Aug. – Sept.	2.440	2.637	2.867	3.756	6.792	5.761
	Oct. – Nov.	2.349	2.607	2.814	3.722	6.388	5.522

	Treatment (T)	Season (S)	Instar (I)	T x S	T x I	S x I	T x S x I
S Em (±)	0.007	0.009	0.009	0.015	0.015	0.019	0.032
CD (P = 0.05)	0.018	0.024	0.024	0.041	0.041	0.053	NS

highest in June- July followed significantly February - March, August - September, April-may and October - November. Ingesta required to produce 1 gm body weight was significantly highest in 5^{th} instar and lowest in 1^{st} instar. Upon treatment -season interaction it was observed that ingesta required to produce 1gm body weight was highest in June-July x T_2 (6.169) followed significantly by T_1 (5.800) and non-significantly by T_3 (5.785). Except August – September during all the season lowest ingesta/growth was observed in T_3 (February - March 5.719, April-May 5.407, June- July 5.785, October – November 5.406). Upon treatment-Instar interaction both the late instars showed highest ingesta/growth in T_2 (3.784 and 6.972) and lowest in T_3 (3.692 and 6.539). No significant variation was observed upon 3 factor (Treatment x Season x Instar) interaction (table 50).

4.4.15 Digestion/ growth :

Digesta required to produce 1gm body weight was highest in T_2 (1.896) followed significantly by T_3 (1.829) and T_1 (1.813) having non-significant variation among the later two. October - November showed significantly highest digesta/growth followed significantly by others and having non-significant variation among June – July, February - March and April - May. Digesta/growth increased as the instar progressed. Upon treatment-season interaction, October – November x T_3 (2.100) showed highest digesta/growth followed non-significantly by T_2 (2.060) and significantly by T_1 (1.930). During August – September, T_3 (1.943) showed highest ECD followed significantly by others. During June - July higher digesta/growth was observed in T_2 (1.850) having non-significant variation with T_3 (1.810) and lowest in T_1 (1.738). During February - March and April - May the T_2 (1.867 and 1.858) showed highest digesta/growth and T_3 (1.646 and 1.645) showed lowest. Upon treatment-instar interaction, digesta requirement per growth in 4th instar was highest in T_2 (1.604) and lowest in T_3 (1.563) and in 5th stages lowest digesta/growth was observed in T_1 (1.960) having non-significant variation with T_3 (1.974). In all the season 5th instar showed better digesta/growth and 1st instar showed lowest. No significant variation was observed upon three factor (Treatment x Season x Instar) interaction (table 51).

Table 51 : Digesta required for unit growth of muga silk worm larvae fed on better selected host plant as well as better combination of leaves during different seasons

Treatments	Seasons	Larval Instar					Total
		I	II	III	IV	V	
T_1	Feb – Mar	1.174	1.262	1.383	1.592	1.973	1.830
	April – May	1.080	1.203	1.243	1.587	1.938	1.789
	June - July	1.100	1.182	1.205	1.577	1.861	1.738
	Aug – Sept	1.091	1.200	1.212	1.583	1.920	1.780
	Oct – Nov	1.115	1.214	1.258	1.606	2.109	1.930
	Mean	**1.112**	**1.212**	**1.260**	**1.589**	**1.960**	**1.813**
T_2	Feb – Mar	1.200	1.286	1.320	1.507	2.066	1.867
	April – May	1.280	1.246	1.247	1.622	2.029	1.858
	June - July	1.227	1.190	1.241	1.613	2.015	1.850
	Aug – Sept	1.217	1.213	1.270	1.633	1.993	1.844
	Oct – Nov	1.259	1.264	1.347	1.644	2.280	2.060
	Mean	**1.237**	**1.240**	**1.285**	**1.604**	**2.077**	**1.896**
T_3	Feb – Mar	1.200	1.286	1.370	1.524	1.725	1.646
	April – May	1.280	1.246	1.319	1.592	1.705	1.645
	June - July	1.227	1.190	1.303	1.542	1.961	1.810
	Aug – Sept	1.217	1.213	1.279	1.562	2.148	1.943
	Oct – Nov	1.259	1.264	1.327	1.597	2.332	2.100
	Mean	**1.237**	**1.240**	**1.320**	**1.563**	**1.974**	**1.829**
Seasonal average	Feb – Mar	1.191	1.278	1.358	1.541	1.921	1.781
	April – May	1.213	1.232	1.270	1.600	1.891	1.764
	June - July	1.185	1.187	1.250	1.577	1.946	1.799
	Aug – Sept	1.175	1.209	1.254	1.593	2.020	1.856
	Oct – Nov	1.211	1.247	1.311	1.616	2.240	2.030

	Treatment (T)	Season (S)	Instar (I)	T x S	T x I	S x I	T x S x I
S Em (±)	0.006	0.008	0.008	0.014	0.014	0.019	0.032
CD (P = 0.05)	0.018	0.023	0.023	0.040	0.040	0.052	NS

4.4.16. Economic parameters influenced by seasons and leaf

4.4.16.1. Single cocoon weight

Single cocoon weight was observed significantly highest in T_3 (5.559 gm) followed by T_1 (5.544 gm) and T_2 (5.518 gm). Among the seasons single cocoon weight varied significantly and during October – November it was highest (5.748 gm) followed by April – May (5.616 gm) and others.

4.4.16.2. Effective rate of rearing

Effective rate of rearing was observed significantly highest in T_3 (40.414%) followed by T_1 (37.608%) and T_2 (34.054%). Among the seasons single cocoon weight varied significantly and during October – November it was highest (52.673%) followed by April – May (50.320%) and others.

4.4.16.3. Fecundity

Fecundity was observed significantly highest in T_3 (155.56) followed by T_1 (148.12) and T_2 (139.88). Among the seasons single cocoon weight varied significantly and during October – November it was highest (170.200) followed by April – May (158.000) and others.

Table 52. Economic parameters influenced by seasons and leaf

	Season	Cocoon Wt (gm)	ERR (%)	Fecundity (nos.)
T_1	February – March	5.420	30.010	125.200
	April – May	5.620	51.960	160.000
	June – July	5.310	23.000	135.200
	August – September	5.620	30.050	150.000
	October - November	5.750	53.020	170.200
	Mean	**5.544**	**37.608**	**148.120**
T_2	February – March	5.380	28.020	120.000
	April – May	5.590	46.000	148.000
	June – July	5.302	20.200	130.200
	August – September	5.587	27.050	139.000
	October - November	5.730	49.000	162.200
	Mean	**5.518**	**34.054**	**139.880**
T_3	February – March	5.435	32.020	132.200
	April – May	5.638	53.000	166.000
	June – July	5.321	25.050	142.200
	August – September	5.635	36.000	159.200
	October - November	5.764	56.000	178.200
	Mean	**5.559**	**40.414**	**155.560**
Seasonal average	February – March	5.412	30.017	125.800
	April – May	5.616	50.320	158.000
	June – July	5.311	22.750	135.867
	August – September	5.614	31.033	149.400
	October - November	5.748	52.673	170.200
Statistical analysis				
Treatment (T)				
S Em (±)		0.001	0.011	0.322
CD (P = 0.05)		0.003	0.032	0.931
Season (S)				
S Em (±)		0.001	0.014	0.416
CD (P = 0.05)		0.004	0.042	1.202
T x S				
S Em (±)		0.002	0.025	0.721
CD (P = 0.05)		0.007	0.072	2.082

4.5 Conversion efficiency of ingested and digested food to cocoon, cocoon shell and egg of best-performed host plant and combination during different season

Efficiency of conversion of ingested and digested dry matter into cocoon, cocoon shell and egg fed from leaves of som (T_1), combinations as upto 2nd instar soalu and then som (T_2) and upto 3rd instar on soalu and rest on som (T_3) during February – March, April – May, June – July, August – September and October – November were recorded.

4.5.1 Conversion efficiency of cocoon

4.5.1.1 Efficiency of conversion of ingested food into cocoon

T_3 recorded significantly higher ECI (7.755%) than others and lowest in T_2 (7.488%). During October – November ECI was found significantly highest (8.366%) followed by August – September (7.523%) and others and lowest was observed in June – July (7.252%). Upon interaction, T_3 in October – November (8.730%) was significantly highest followed by T_1 x October - November (8.188%) and T_2 x October – November (8.180%) having non-significant variation between them and others. T_2 x June – July (7.151%) was observed significantly lowest (table 53).

Table 53 : Efficiency of conversion of ingested food into cocoon

Season	T_1	T_2	T_3	Mean
Feb. – Mar.	7.300	7.223	7.562	7.362
April – May	7.513	7.408	7.587	7.503
June - July	7.266	7.151	7.338	7.252
Aug. – Sept.	7.534	7.477	7.558	7.523
Oct. – Nov.	8.188	8.180	8.730	8.366
Mean	**7.560**	**7.488**	**7.755**	**7.601**

	Treatment (T)	Season (S)	T x S
S Em (±)	0.022	0.028	0.049
CD (P = 0.05)	0.063	0.081	0.140

4.5.1.2 Efficiency of conversion of digested food into Cocoon

ECD into Cocoon was found highest in T_3 (23.891%) and followed non-significantly by T_1 (23.808%) and significantly by T_2 (23.176%). ECD during April – May was highest (24.085%) which was non-significantly followed by February – March (24.034) and significantly by others, lowest being From October – November (22.772%). Upon interaction, T_3 x February – March (26.269%) showed highest ECD followed significantly by T_3 x April – May (24.935%) and by others, lowest being from T_2 x October – November (21.859%) (table 54).

Table 54 : Efficiency of conversion of digested food into cocoon

Season	T_1	T_2	T_3	Mean
Feb. – Mar.	22.943	22.889	26.269	24.034
April – May	23.833	23.487	24.935	24.085
June - July	24.248	23.850	23.457	23.852
Aug. – Sept.	24.038	23.793	22.315	23.382
Oct. – Nov.	23.979	21.859	22.479	22.772
Mean	**23.808**	**23.176**	**23.891**	**23.625**

	Treatment (T)	Season (S)	T x S
S Em (±)	0.188	0.243	0.422
CD (P = 0.05)	0.545	0.704	1.219

4.5.1.3 Ingesta required to produce 1 gm Cocoon

Highest requirement was observed in T_2 (13.385 gm) followed non-significantly by T_1 (13.252 gm) and lowest being from T_3 (12.943 gm). Seasonal variation was also found significant except April – May and August-September. June – July required more ingesta to produce 1gm Cocoon (13.791 gm) than February – March (13.589 gm), April – May (13.330 gm) having significant variation and followed by others. Lowest ingesta requirement was observed from October – November (11.965 gm). Upon interaction, T_2 x June- July (13.984 gm) showed highest ingesta requirement followed non-significantly by T_2 x February – March (13.844) and significantly by others, lowest being from T_3 x October – November (11.455 gm) (table 55).

Table 55 : Ingesta required to produce 1 gm cocoon

Season	T_1	T_2	T_3	Mean
Feb. – Mar.	13.699	13.844	13.223	13.589
April – May	13.310	13.499	13.181	13.330
June - July	13.763	13.984	13.627	13.791
Aug. – Sept.	13.273	13.373	13.231	13.292
Oct. – Nov.	12.214	12.225	11.455	11.965
Mean	**13.252**	**13.385**	**12.943**	**13.193**

	Treatment (T)	Season (S)	T x S
S Em (±)	0.032	0.041	0.072
CD (P = 0.05)	0.093	0.121	0.208

4. 5.1.4 Digesta required to produce 1 gm Cocoon

Digest requirement was significantly highest in T_2 (4.319 gm) followed by T_1 (4.202 gm) and T_3 (4.202 gm). During October – November digesta requirement was maximum (4.398 gm) followed non- significantly by August – September (4.281) and June – July (4.193 gm) having non-significant variation with others and lowest in April – May (4.155 gm). Upon interaction, T_2 x October – November (4.575 gm) showed highest requirement followed non significantly by T_3 x August – September (4.481 gm) and T_3 x October – November (4.449 gm) and significantly by others. Lowest requirement was from T_3 x February – March (3.807 gm) followed non-significantly by T_3 x April-May (4.010 gm.) and significantly by others (table 56).

Table 56 : Digesta required to produce 1 gm cocoon

Season	T_1	T_2	T_3	Mean
Feb. – Mar.	4.359	4.369	3.807	4.178
April – May	4.196	4.258	4.010	4.155
June - July	4.124	4.193	4.263	4.193
Aug. – Sept.	4.160	4.203	4.481	4.281
Oct. – Nov.	4.170	4.575	4.449	4.398
Mean	**4.202**	**4.319**	**4.202**	**4.241**

	Treatment (T)	Season (S)	T x S
S Em (±)	0.032	0.042	0.072
CD (P = 0.05)	0.093	0.120	0.208

4.5.2 Conversion efficiency to cocoon shell :

4.5.2.1 Efficiency of conversion of ingested food into cocoon shell

ECI into cocoon shell was recorded highest in T_3 (1.863%) followed significantly by T_1 (1.840%) and lowest being from T_2 (1.804%). During April – May (1.917%) the ECI was highest followed non-significantly by October – November (1.899%) and significantly by others, lowest from February – March (1.763%) and June – July (1.776%) having non-significant variation between them. Upon interaction, T_3 x October – November (1.948%) showed highest ECI followed non-significantly by T_3 x April – May (1.931 %) and T_1 x April – May (1.917%) and significantly by T_2 x April – May (1.904%) having non-significant variation among later three. Lowest ECI to cocoon shell was observed in T_2 x February – March (1.733 %) followed non-significantly by T_2 x June-July (1.762 %) (table 57).

Table 57 : Efficiency of conversion of ingested food into cocoon shell

Season	T_1	T_2	T_3	Mean
Feb. – Mar.	1.783	1.733	1.774	1.763
April – May	1.917	1.904	1.931	1.917
June - July	1.774	1.762	1.793	1.776
Aug. – Sept.	1.823	1.769	1.868	1.820
Oct. – Nov.	1.900	1.850	1.948	1.899
Mean	**1.840**	**1.804**	**1.863**	**1.836**

	Treatment (T)	Season (S)	T x S
S Em (±)	0.005	0.007	0.001
CD (P = 0.05)	0.015	0.018	0.033

4.5.2.2 Efficiency of conversion of digested food into cocoon shell

Highest ECD into cocoon shell (table 58) was observed in T_1 (5.798%) followed non-significantly by T_3 (5.755%) and significantly by T_2 (5.596%). During April – May the ECD was highest (6.155%) followed significantly by others. Lowest was observed during October – November (5.175%). Upon interaction, ECD was highest in T_3 x April – May (6.347%) followed non significantly by T_3 x February - March (6.163%) and T1 x April – May (6.082) and

Table 58 : Efficiency of conversion of digested food into cocoon shell

Season	T_1	T_2	T_3	Mean
Feb. – Mar.	5.605	5.490	6.163	5.753
April – May	6.082	6.037	6.347	6.155
June - July	5.921	5.878	5.732	5.844
Aug. – Sept.	5.817	5.629	5.514	5.653
Oct. – Nov.	5.564	4.944	5.017	5.175
Mean	**5.798**	**5.596**	**5.755**	**5.716**

	Treatment (T)	Season (S)	T x S
S Em (±)	0.044	0.057	0.098
CD (P = 0.05)	0.127	0.164	0.283

significantly by others. Lowest ECD was observed in T_2 x October – November (4.944%) followed non-significantly by T_3 x October – November (5.017%) and significantly by others.

4.5.2.3 Ingesta required to produce 1 gm Cocoon shell

Ingesta required to produce 1 gm shell was observed highest in T_2 (55.512 gm) followed significantly by T_1 (54.417 gm) and T_3 (53.755 gm). From seasonal standpoint, highest ingesta requirement was recorded in February – March (56.719 gm) followed non-significantly by June

Table 59 : Ingesta required to produce 1 gm cocoon shell

Season	T_1	T_2	T_3	Mean
Feb. – Mar.	56.079	57.719	56.359	56.719
April – May	52.159	52.518	51.783	52.153
June - July	56.362	56.741	55.766	56.290
Aug. – Sept.	54.847	56.533	53.544	54.975
Oct. – Nov.	52.636	54.049	51.324	52.670
Mean	**54.417**	**55.512**	**53.755**	**54.561**

	Treatment (T)	Season (S)	T x S
S Em (±)	0.139	0.179	0.311
CD (P = 0.05)	0.402	0.519	0.899

– July (56.290 gm) and significantly by others. Lowest ingesta requirement was observed during April - May (52.153 gm) followed non-significantly by October – November (52.670 gm). Upon interaction, highest requirement was observed from T_2 x February – March (57.719%) followed non -significantly by T_2 x June – July (56.741 gm), T_2 x August – September (56.533 gm), T_1 x

June – July (56.362 gm), T_3 x February – March (56.359 gm) and T_1 x February – March (56.079%) and significantly by others. Lowest observed in T_3 x October – November (51.324 gm) followed non- significantly by T_3 x April – May (51.783 gm) and significantly by others (table 59).

4.5.2.4. Digesta required to produce 1 gm cocoon shell

Digesta requirement was highest in T_2 (17.957 gm) followed significantly by T_3 (17.499 gm) and other. During October – November (19.378 gm) the digesta requirement was significantly highest followed by August – September (17.698) and others. Upon interaction, highest requirement was recorded in T_2 x October – November (20.277 gm) followed non-significantly by T_3 x October – November (19.933 gm) and significantly by others. Lowest requirement was observed in T_3 x April – May (15.755 gm) followed non-significantly by and T_3 x February – March (16.225 gm), T_1 x April – May (16.443 gm), T_2 x April – May (16.564 gm) and significantly by others (table 60).

Table 60 : Digesta required to produce 1 gm shell

Season	T_1	T_2	T_3	Mean
Feb. – Mar.	17.842	18.215	16.225	17.427
April – May	16.443	16.564	15.755	16.254
June - July	16.889	17.013	17.446	17.116
Aug. – Sept.	17.191	17.767	18.135	17.698
Oct. – Nov.	17.973	20.227	19.933	19.378
Mean	**17.268**	**17.957**	**17.499**	**17.575**

	Treatment (T)	Season (S)	T x S
S Em (±)	0.139	0.179	0.311
CD (P = 0.05)	0.402	0.518	0.897

4.5.3 Conversion efficiency to egg

4.5.3.1 Efficiency of conversion of ingested food into egg

ECI into egg (table 61) was observed highest in T_3 (1.552%) followed non-significantly by T_1 (1.550%) and significantly by T_2 (1.533%). October – November showed highest ECI (1.702%) followed significantly by April – May (1.646%) and others. There observed no significant variation between February - March (1.627%) and August – September (1.618%) and lowest was from June – July (1.134%). Upon interaction, T_3 in October – November (1.710%) had highest ECI having non-significant variation with T_1 x October – November (1.707%) and T_2 x October – November (1.689%) and significant variation with others. Significantly, lowest ECI was observed in T_2 x June – July (1.111%).

Table 61 : Efficiency of conversion of ingested food into egg

Season	T_1	T_2	T_3	Mean
Feb. – Mar.	1.629	1.621	1.630	1.627
April – May	1.651	1.635	1.652	1.646
June - July	1.145	1.111	1.147	1.134
Aug. – Sept.	1.621	1.610	1.622	1.618
Oct. – Nov.	1.707	1.689	1.710	1.702
Mean	**1.550**	**1.533**	**1.552**	**1.545**

	Treatment (T)	Season (S)	T x S
S Em (±)	0.005	0.006	0.010
CD (P = 0.05)	0.013	0.017	0.029

4.5.3.2 Efficiency of conversion of digested food into egg

ECD into egg (table 62) was observed highest in T_2 (5.153%) followed significantly by T_3 (4.912%) and lowest being from T_1 (4.868%). Highest ECD was observed during February – March (5.569%) followed non- significantly by April – May (5.555%) and significantly by others. Lowest ECD was observed during June – July (4.087%) followed non- significantly by October – November (4.167%). Upon interaction, T_2 x February – March (6.974%) showed highest ECD followed significantly by T_3 x August - September (5.935%) and others lowest ECD was observed in T_2 x October – November (3.613%).

Table 62 : Efficiency of conversion of digested food into egg

Season	T_1	T_2	T_3	Mean
Feb. – Mar.	5.119	6.974	4.614	5.569
April – May	5.236	5.536	5.894	5.555
June - July	3.820	4.213	4.227	4.087
Aug. – Sept.	5.170	5.428	5.935	5.511
Oct. – Nov.	4.998	3.613	3.891	4.167
Mean	**4.868**	**5.153**	**4.912**	**4.978**

	Treatment (T)	Season (S)	T x S
S Em (±)	0.039	0.051	0.088
CD (P = 0.05)	0.114	0.147	0.254

4.5.3.3 Ingesta required to produce 1 gm egg :

Ingesta requirement to produce 1 gm egg was highest in T_2 (66.835 gm) followed significantly by T_1 (65.933 gm) and non-significantly by T_3 (65.850 gm). Among the seasons, ingesta requirement was highest during June – July (88.197 gm) followed significantly by August – September (61.830 gm) and February – March (61.484 gm) having non-significant variation and lowest being from October – November (58.758 gm). Upon interaction, T_2 x June – July (90.000 gm) showed highest ingesta requirement followed significantly by T_1 x June – July (87.372) and others. Lowest ingesta requirement was recorded from T_3 x October – November (58.469 gm) followed by T_1 x October – November (58.595 gm) having non- significant variation between them (table 63).

Table 63 : Ingesta required to produce 1 gm egg

Season	T_1	T_2	T_3	Mean
Feb. – Mar.	61.406	61.695	61.351	61.484
April – May	60.587	61.152	60.546	60.762
June - July	87.372	90.000	87.218	88.197
Aug. – Sept.	61.707	62.118	61.664	61.830
Oct. – Nov.	58.595	59.211	58.469	58.758
Mean	**65.933**	**66.835**	**65.850**	**66.206**

	Treatment (T)	Season (S)	T x S
S Em (±)	0.155	0.200	0.347
CD (P = 0.05)	0.448	0.579	1.002

4.5.3.4 Digesta required to produce 1 gm egg :

Digesta requirement to produce 1 gm egg was highest in T_3 (20.970 gm) followed by T_1 (20.833 gm) having non-significant variation between them and followed significantly by T_2 (20.448 g m). June – July recorded highest digesta r equirement (24.525 gm) followed non-significantly by October -November (24.462 gm) and others, lowest being from April – May (18.044 gm). Upon interaction, T_2 x October – November (27.677 gm) showed highest digesta requirement followed significantly by T_1 x June – July (26.181 gm) and others and lowest being from T_2 x February – March (14.338 gm) (table 64).

Table 64 : Digesta required to produce 1 gm egg

Season	T_1	T_2	T_3	Mean
Feb. – Mar.	19.537	14.338	21.675	18.517
April – May	19.100	18.065	16.966	18.044
June - July	26.181	23.736	23.659	24.525
Aug. – Sept.	19.341	18.423	16.848	18.204
Oct. – Nov.	20.008	27.677	25.701	24.462
Mean	**20.833**	**20.448**	**20.970**	**20.750**

	Treatment (T)	Season (S)	T x S
S Em (±)	0.155	0.200	0.346
CD (P = 0.05)	0.448	0.578	1.001

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).

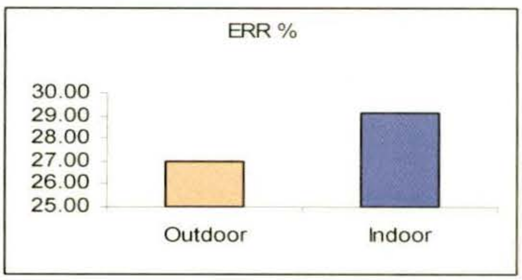


Fig. 2. Effective rate of rearing in outdoor and indoor condition

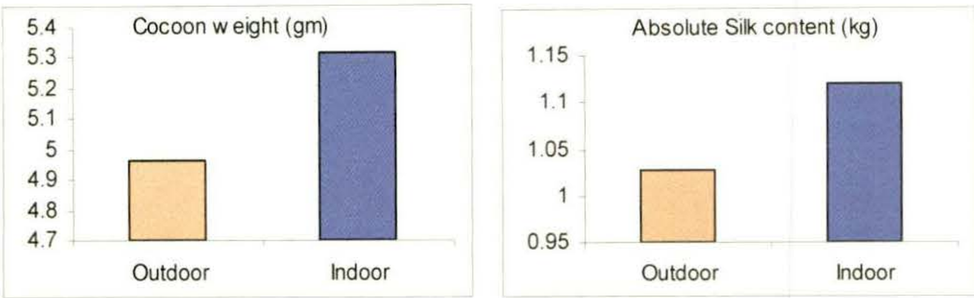


Fig. 3a and 3b : Cocoon weight and absolute silk content in outdoor and indoor condition

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.

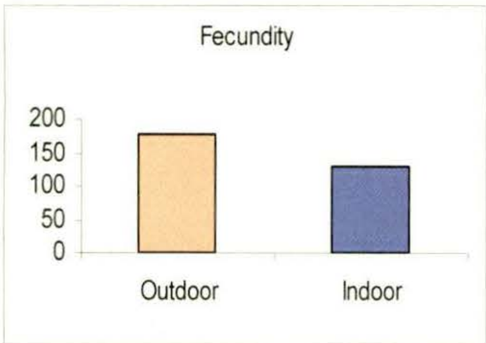


Fig. 4. Fecundity in outdoor and indoor condition

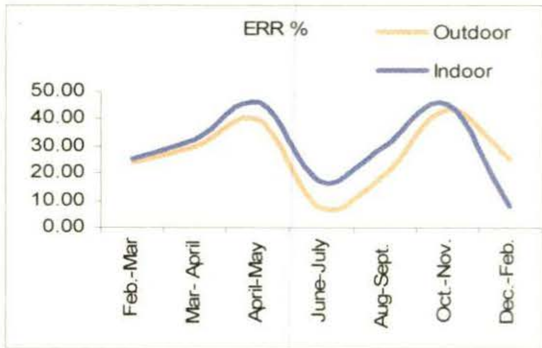


Fig. 5. Effective rate of rearing in outdoor and indoor condition

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.

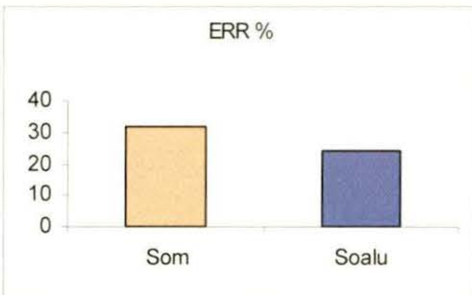


Fig. 6 : Effective rate of rearing in indoor condition on som and soalu

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.

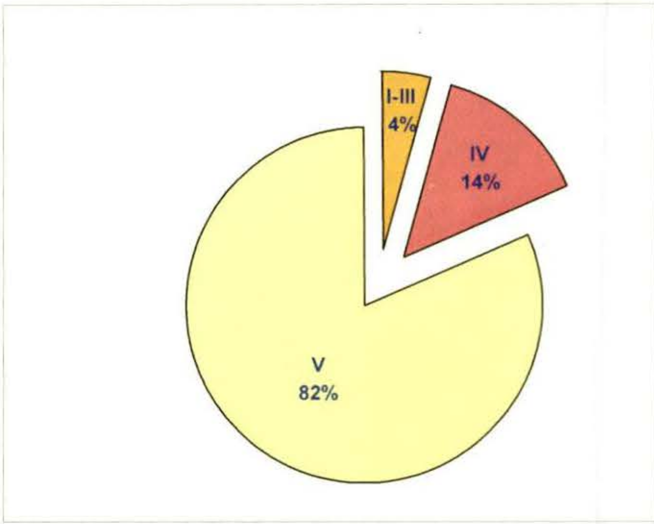


Fig. 7 : Instarwise food ingestion by muga silkworm

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).

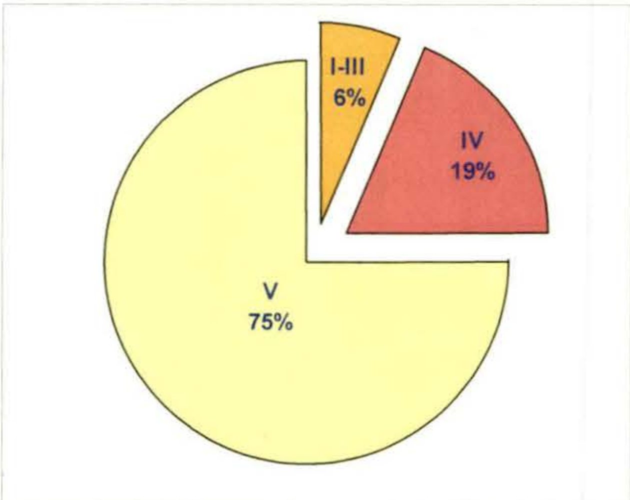


Fig 8. Instarwise food digestion by muga silkworm

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.

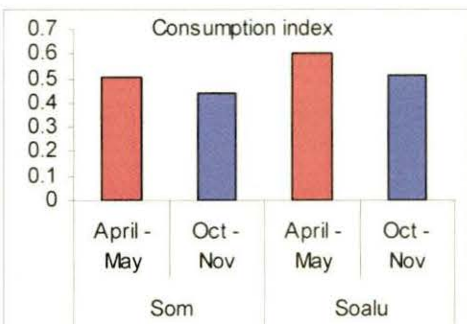


Fig. 9. Consumption index of larvae fed on som and soalu during favourable seasons

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

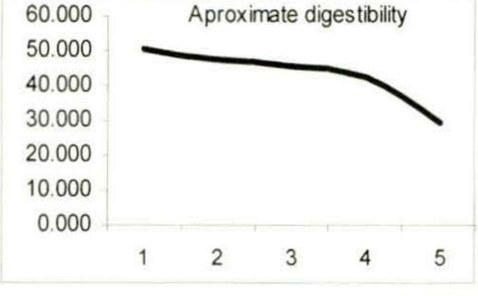


Fig 10 Approximate digestibility of muga silkworm larvae

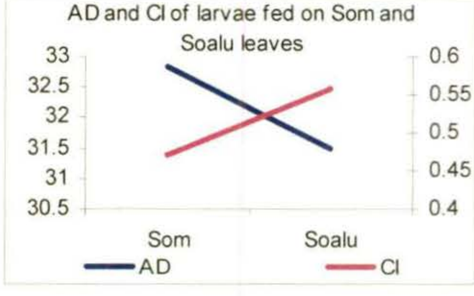


Fig. 11 AD and CI of larvae fed on som and soalu

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).

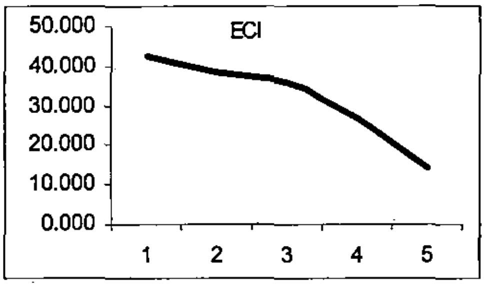


Fig 12 Efficiency of conversion of ingested food of muga silkworm larvae

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).

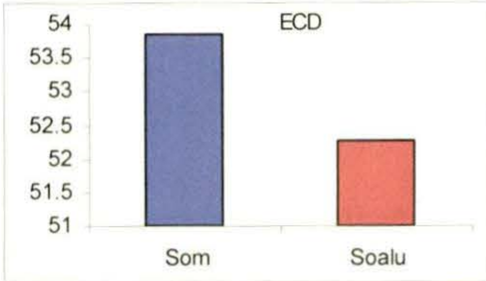


Fig. 13 ECD of larvae fed on som and soalu leaves

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).

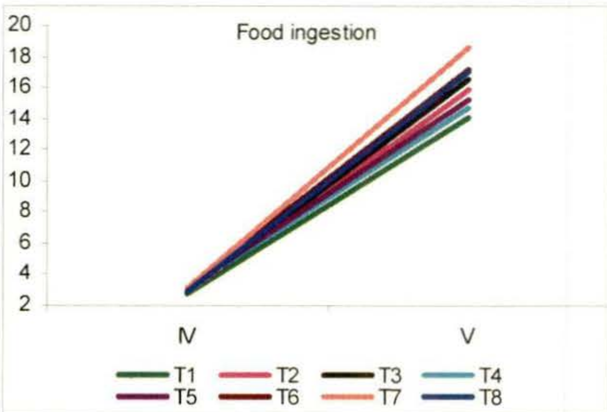


Fig. 15 : Food ingestion in different combination of leaves during IV and V instar

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).

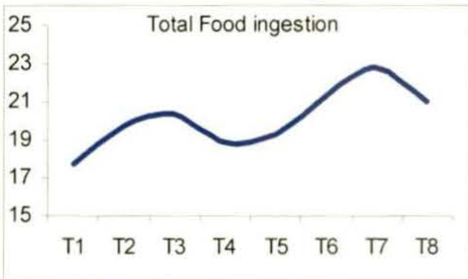


Fig. 16 : Food ingestion in different combination of leaves during total larval period

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).

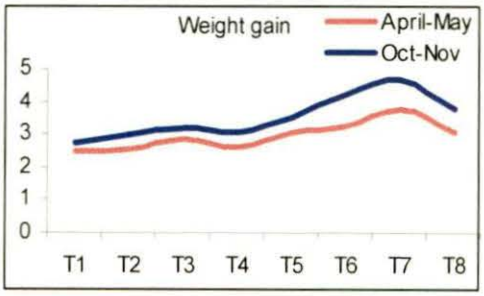


Fig. 17 : Weight gain by larvae fed on different combination of leaves

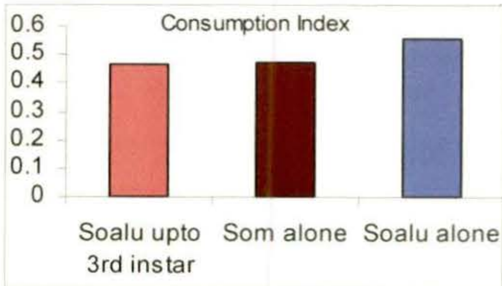


Figure 18 : Consumption index fed on som, soalu and different combination of leaves

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.

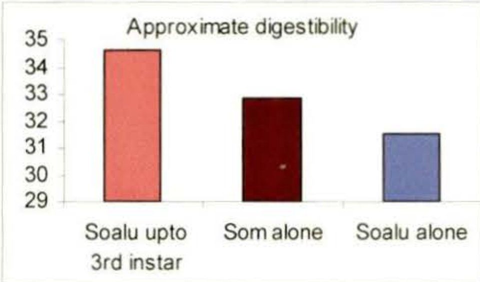


Figure 19 : Approximate digestibility of the larvae fed on Som, Soalu and better combination of leaves

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.

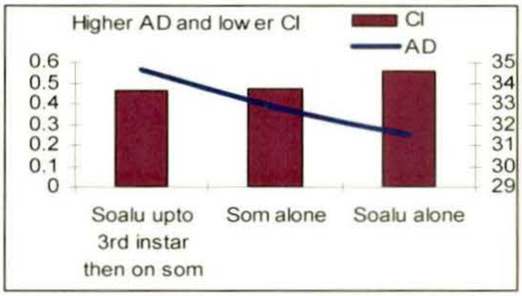
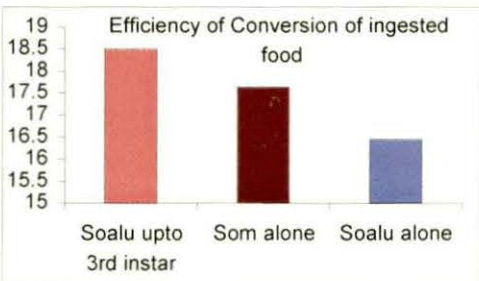


Figure 20 : AD and CI of larvae fed on som, soalu and better combination of leaves

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.



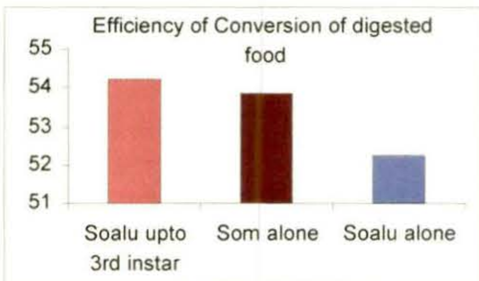


Fig 21 and Fig 22 : ECI and ECD of larvae fed on som, soalu and better combination of leaves

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).

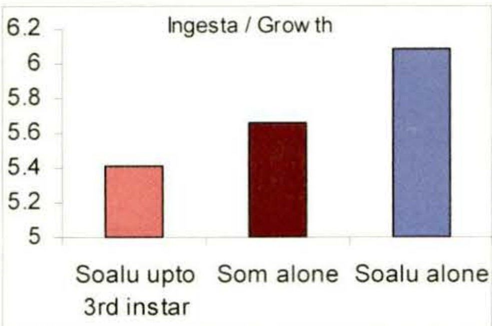


Fig 23 and Fig 24 : Ingesta and Digesta required for one unit growth of larvae fed on som, soalu and better combination of leaves

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.

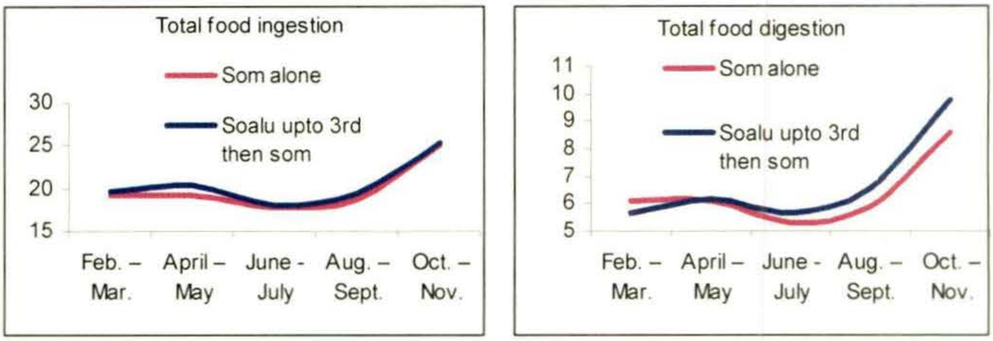


Fig. 25 and 26 : Total food ingestion and digestion by larvae fed on som, and better combination of leaves

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.

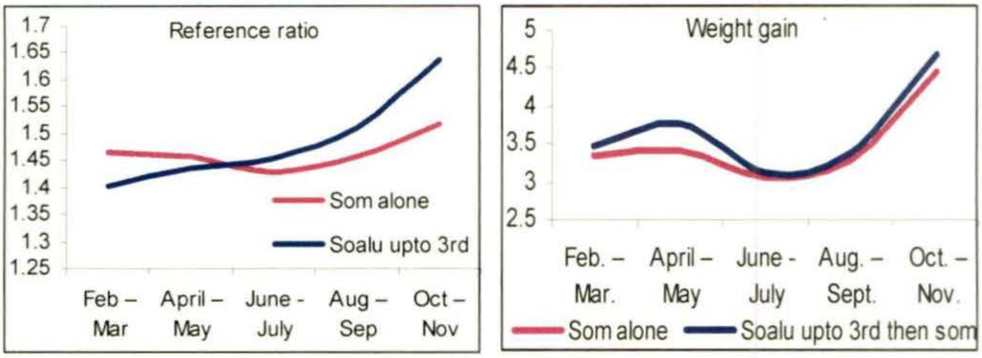


Fig. 27 and 28 : Reference ratio and weight gain by larvae fed on som, and better combination of leaves

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.

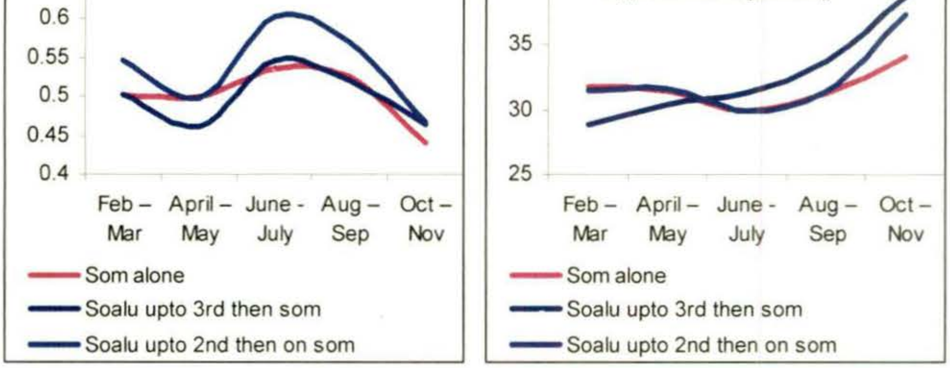


Fig. 29 and 30 : Consumption index and approximate digestibility by larvae fed on som, and better combinations of leaves

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).

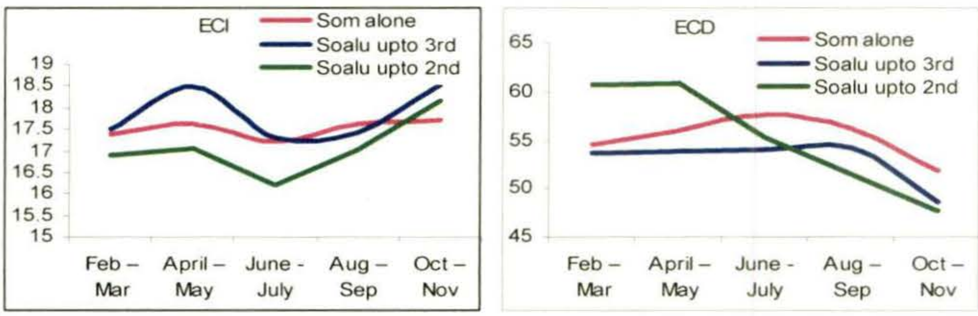


Fig. 31 and 32 : ECI and ECD by larvae fed on som, and better combinations of leaves

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.

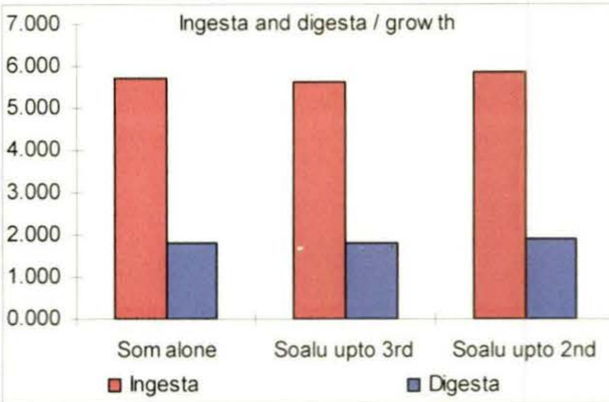


Fig. 33 : Ingesta and digesta required per unit growth of larvae fed on som, and better combinations of leaves

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.

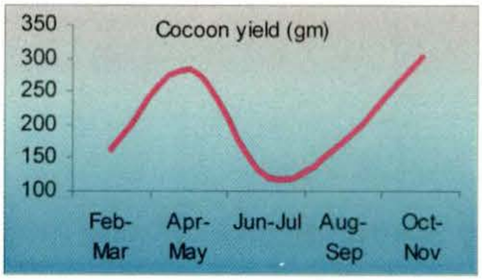


Fig. 34 a : Cocoon yield during different season from 100 brushed larvae

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.

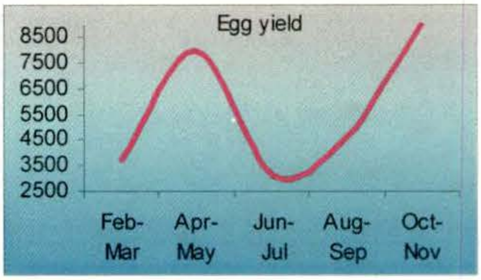


Fig. 34 b : Egg yield during different season from 100 brushed larvae

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

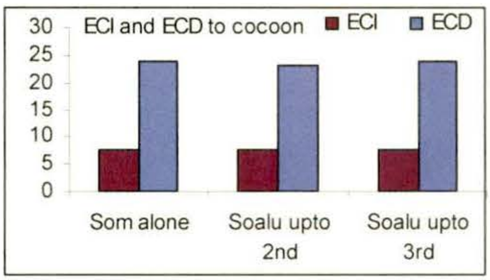


Fig. 35 : ECI and ECD to cocoon by larvae fed on som, and better combination of leaves

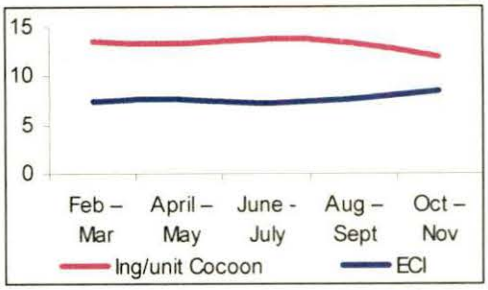


Fig. 36 : Seasonal variation of ECI and ingesta required per unit cocoon production

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.

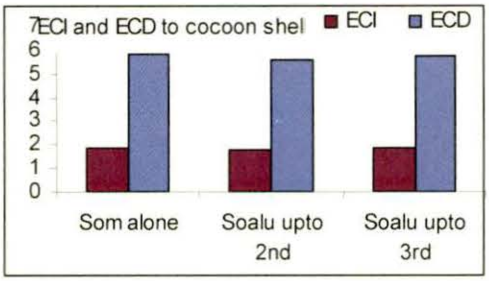


Fig. 37 : ECI and ECD to cocoon shell by larvae fed on som and better combination of leaves

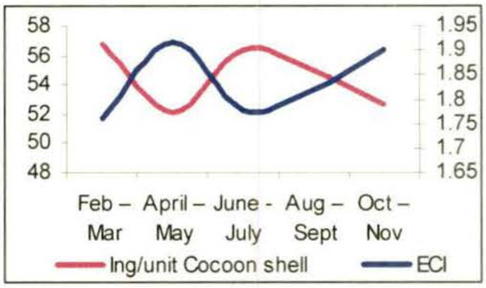


Fig. 38. Seasonal variation of ECI and ingesta required per unit cocoon shell production

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).

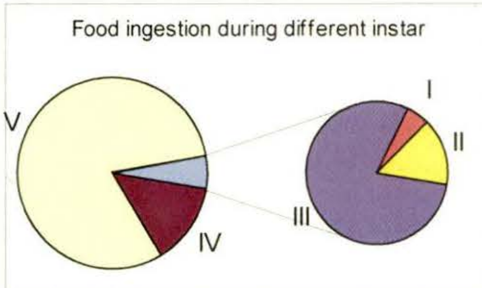


Fig. 39. Larval feeding in different instars

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

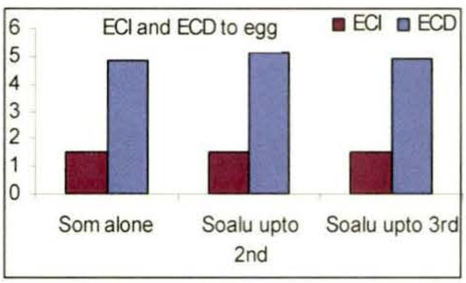


Fig. 40 : ECI and ECD to egg by larvae fed on som and better combinations of leaves

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).

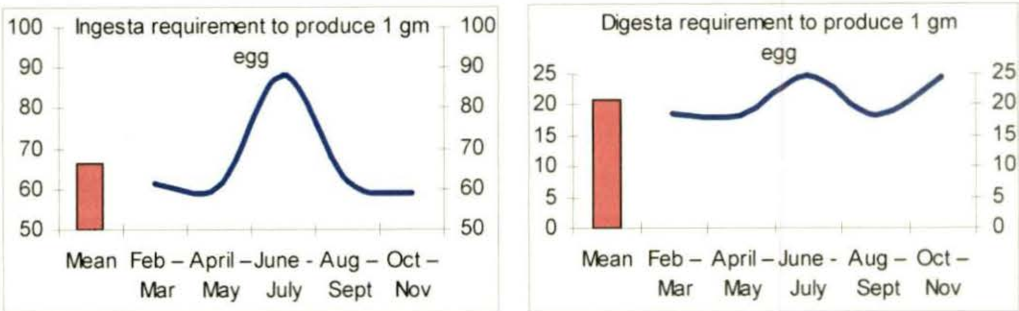


Fig. 41a and 41b. Ingesta and digesta required to produce 1 gm egg during different season

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.

Chapter - VI

SUMMARY AND CONCLUSION

An investigation was made in Cooch Behar district of West Bengal to identify the rearing condition, host plant and season for muga silkworm (*Antheraea assama* Westwood) rearing in the non-traditional, newly explored area of mugaculture with special reference to nutritional efficiency of the silkworm. Muga silkworm, *Antheraea assama* Westwood, being wild, reared outdoors, and hence prone to natural hazard such as high temperature, heavy winds or rain, hail storms etc. apart from falling prey to pests and predators. Attempts were made to compare the natural outdoor rearing and indoor rearing on both the principal host plants namely som and soalu during seven periods in a year to avoid crop loss due to natural hazards in field condition with special reference to host plant effect on rearing ; to evaluate the consumption of leaves of two principal host plants and their combinations for selection of better food supply as well as to measure the leaf requirement and to identify seasons for muga silkworm rearing in the zone under consideration with reference to nutritional efficiencies into body, cocoon and egg.

The rearing and grainage were carried out at adopted farmer's field and Muga Research Laboratory of A. B. N. Seal College, Cooch Behar during seven seasons in a year. During out door rearing in the field 4-6 big trees together, cover with a mosquito net (rearing net) to kept them away from the natural enemies like birds, snakes, wasps, beetle, lizard etc. At the same time as for indoor rearing the branches of the food plant, som and soalu were kept immerged in water contained in earthen pots, these were kept in a stand in three tiers, and the whole setup was covered with polythene cover except the ground surface. The polythene cover was knitted on all sides except on the front and the front sheet was used like door curtain enabling rearing operation and these also facilitated maintaining the desired level of crop loss in outdoor rearing. In each seasons, eggs after hatching were reared following the proposed plan of work schedule until the attainment of cocoon, adult moth and egg.

For outdoor and indoor rearing, the larvae were fed with the leaves of som (*Machilus bombycina*) and (*Litsea polyantha*). Trees were used after two months of pruning. For nutritional efficiency besides pure som and pure soalu, eight different combinations were utilized as 1^{st} instar on som and rest on soalu, 1^{st} and 2^{nd} instar on som and rest on soalu, 1^{st} to 3^{rd} instar on som and rest on soalu, 1^{st} to 4^{th} instar on som and rest on soalu, 1^{st} instar on soalu and rest on som, 1^{st}

and 2nd instar on soalu and rest on som, 1st to 3rd instar on soalu and rest on som and 1st to 4th instar on soalu and rest on som.

All the parameters were recorded on fresh weight basis. Twenty larvae as well as cocoons (10 males and 10 females) were taken for each of the three replications for assessment of quality of cocoon. For fecundity, twenty gravid females were taken for each of the three replications. All values of rearing results comprising rearing performance as well as quality of cocoons were subjected to suitable statistical analysis.

In order to determine the consumption and utilization of som and soalu leaves a colony of muga silkworm was raised in the laboratory and was maintained from brushing till spinning in indoor. Three replication with fifty larvae per replication were maintained for the study of nutritional efficiencies. Aliquot was kept for dry weight determination. An additional larval batch was also maintained as above for determining dry weight values. The healthy larvae were counted daily in each replication and unequal, weak, unhealthy if any, were replaced by healthy ones of the same age from the reserve stock. The left over leaf (LOL) and excreta were collected carefully and separated daily at 9 AM. The excreta and leaf were dried at 60^{0}C to a constant weight.

For pure som, pure soalu and different combinations the experiments were conducted during two main commercial crop rearing season (April – May and October – November). Later on pure som and better combinations were conducted during five different seasons namely February – March, April – May, June – July, August – September and October – November.

1. Consequences indicated that almost all the rearing parameters namely larval weight, cocoon weight, shell weight, effective rate of rearing and absolute silk content were better in indoor condition while shell ratio and fecundity were higher in outdoor. Moreover, better cocoon weight and absolute silk content in indoor condition also reflected no deleterious effect on silk due to indoor rearing. However, oviposition was not completely inhibited due to indoor rearing but a considerable reduction in fecundity due to domestication might further be studied in future.

Effective rate of rearing (ERR) varied greatly during the different rearing seasons and the same was quite high during April – May and October – November both in indoor and outdoor condition, repr esenting t he spring and autumn commercial crops respectively and the other seasons were found unfavorable for mugaculture utilizing only to augment seed multiplication.

The performance among the two important food plants viz. som and soalu were studied in indoor rearing. The study indicated higher effective rate of rearing and all other rearing parameters with som than with soalu except larval weight.

2. The efficiency of converting the ingested and digested food varied among silkworm under the influence of season and host plant. Food ingestion during fifth instar was 82% of the total consumption. Total food ingestion was higher in larvae fed on som than on soalu and higher consumption was during October – November. Digesta values followed the similar trend. Reference ratio was higher in the larvae fed on som leaves. 69% and 67% weight gain in fifth instar by larvae fed on som and soalu respectively which was maximum and 22-23 % weight gain was recorded in fourth instar. CI was less when fed on som leaves and during October – November showing higher utilization efficiency in som especially during October – November. When CI decreased, the passage of food through gut was slow and facilitated increased digestion and assimilation, which ultimately resulted in improved AD and other corresponding efficiency parameters.

The ECI and ECD values were higher in early instars and higher when fed on som leaves. The mean daily food ingesta (MDFI) and digesta (MDFD) in each instar increased as the larval growth progressed. The values were low in young instars and higher in late instars. MDFI and MDFD were higher when fed on soalu leaves. One-gram larval dry weight production required 5.664 gm. ingesta and 1.860 gm. digesta in som and 6.081gm.ingesta and 1.914 gm. digesta in soalu.

Overall observation reflected that for a unit larval growth, larv a fed on som leaves required less ingesta and digesta compared to soalu leaves. This indicated that larva fed on som leaves had a better efficiency of converting ingested and digested food into body substances.

3. Nutritional efficiencies of the larvae fed on som leaves were 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 by utilizing soalu leaves in different combinations with som leaves. Soalu upto third instar in combination with som for fourth and fifth instar when fed showed better food ingestion. Combination of leaves showed lower excreta than single type food which increased the digesta values. Reference ratio and weight gain were also observed higher in the aforementioned combination. Lower consumption index and higher AD, ECI and ECD were observed in the combination soalu upto third instar and then som

Lowest ingesta requirement to produce one gram larval body weight was 5.407 gm in the combination soalu upto third instar followed by som which was even lower than the som alone (lower than soalu) where the value was 5.664 gm. Digesta requirement to produce one gram larval body weight was also lowest in combination soalu upto third instar followed by som (1.873 gm), which was close to the som alone (lower than soalu) where the value was 1.860 gm.. Lesser ingesta and digesta requirement to produce unit larval dry weight was due to efficient assimilation by the aforementioned combination of leaves. Better season was observed October – November so far as nutritional efficiency.

Still, this combination and slightly lower performing combination i.e. soalu upto second instar followed by som (third, fourth and fifth instar) along with the som leaf feeding alone should be assessed 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 source selection.

4. Food ingestion was highest in combination where soalu and som were in combination of up to 3rd instar and 4th and 5th instar respectively followed by som alone. Seasonal variation showed 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 was lowest from som. Moreover, food ingestions were higher during commercial crop rearing seasons followed

by seed crop rearing season. As a whole digesta values were higher in upto 3rd instar and then som; only during February-March, digesta values were higher in som alone. Like ingesta, digesta values were higher during commercial crop rearing seasons. Reference ratio, the expression of absorption and assimilation of food was highest in the combination soalu upto 3rd instar then in som. Non-significant variation among the treatments in all the seasons except during October – November where combination of leaves showed higher than som alone reflecting similar rate of absorption and assimilation of food through out the seasons and seasonal average in RR varied from 1.466 to 1.489 among the treatments. Weight gain by the larvae was best in combination soalu up to 3rd instar then som in all the seasons and highest during October - November due to higher larval duration coupled with higher food consumption and digestion. Som alone when fed to the larvae showed better weight gain.

Lowest consumption index in the larvae fed on soalu up to 3rd instar and then som in the present investigation reflected. higher efficiency in feed utilization than from any other food source. Feed utilization efficiency by som alone was also better due to lower consumption index and during October - November the lowest consumption index reflected highest feed utilization efficiency during that time.

Efficiency of conversion of ingested food (ECI) was highest in combination of leaf in the form of soalu up to 3rd instar and then som reflecting larvae had the highest ability to utilized the ingested food when fed on that combination of leaves and it was also noticed that higher ability to utilized that ingested food was from som fed larvae. Efficiency of conversion of digested food (ECD) showed significant variation among som leaf feeding and combination as soalu up to 3rd instar then som. However, during October – November ECD was higher in single leaf fed larvae than the larvae fed on combination of leaves.

The present study revealed that nutritional efficiencies in the form of approximate digestibility, efficiency of conversion of ingested and digested food and better when fed on leaves in combination in the form of soalu up to 3rd instar and som in 4th and 5th 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, were also in the combination in a year round observation. ECI/ECD can be considered as indices for the physiological efficiency of any breed. The economic parameters namely single cocoon weight, ERR and fecundity were observed better during October – November and April – May and fed on the combination of leaves in the form of soalu upto third and som for fourth and fifth instar.

So, for commercial crop rearing as well as for seed crop rearing soalu upto 3rd instar and then som leaf utilization might 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.

5. The percentage of ECI and ECD to cocoon was highest when larvae fed on soalu upto 3rd then som were utilized in last two instars. Lowest values of ECI and ECD were observed in the combination where som leaves were utilized in last three instars. Ingesta and digesta requirement to produce one gram cocoon was less in the combination where som were utilized in last two instars. Efficiency of conversion of ingested food to cocoon was higher during October – November and April – May and at the same time during these periods, ingesta requirement to produce one-gram cocoon was lower. This observation justified the commercial crop rearing during these periods.

So, for silk production, October – November and April – May were found better and soalu upto third instar followed by som leaves in forth and fifth instar was found the best food source followed by only som leaves. Moreover, as only 5% of total leaf consumption was recorded as the requirement for early instars (1st to 3rd), plantation of soalu in a small portion might be recommended.

For seed production, ECI and ECD to egg were the two efficiency parameters to be considered. ECI to egg was also the highest when soalu upto 3rd instar and rest on som was utilized as food. However, som alone when supplied although the instars showed better ECI to egg. Moreover, though during October – November the conversion efficiency of ingested food to egg was higher than February – March and August – September, efficiency of conversion of digested food to egg was better during the later two seasons. Ingesta requirement to produce one-gram egg was less in the combination where soalu upto third instar and rest on som was used and som alone. Ingesta requirement was lower during October – November and April – May while digesta requirement to produce one-gram egg was less during August – September and February – March.

So, for seed production, August – September and February – March was found successful to supply the egg for commercial rearing during October – November and April – May and soalu upto 3rd instar followed by som during 4th and 5th instar was found superior to utilize for better silk and seed yield as the nutritional efficiencies of muga silk worm larvae were better on the particular feed as well as during those particular seasons. So, for silk or for seed, soalu in early stage and som at late stage should be recommended for better production and successful mugaculture in terai region of West Bengal, a newly explored area.

Chapter - VII

REFERENCES

Aftab Ahamed, C.A.; Chandrakala, M.V.; Shivakumar, C. and Raghuraman, R. (1998). Food and water utilization patterns under restricted feeding durations in *Bombyx mori* of pure mysore race. *J. Exp. Zool.*, **1**(1) : 29-34.

Akai, H. (2005). The potential for non-mulberry silks (wild silks). Proc. of 20th International Congress on Wild Silk Moths, Bangalore, **2** : 6-7.

Alam, M.D.; Suresh, M.R.; Sit, S.C.; Girip Mohan Naik, B. and Rajaram, S. (1991). Indoor rearing of tasar silkworm in Orissa. *Indian Silk.*, **30**(14) : 16-18.

Anantha Raman, K.V.; Benchamin, K.D.; Magadum, S.B.; Remadevi, O.K. and Dutta, R.K. (1992). Studies on the nutritional efficiency of the hybrid PM x NB_4D_2 silkworm, *Bombyx mori* L . National conference on mulberry sericulture research, December, 10-11.

Anantha Raman, K.V.; Benchamin, K.D.; Magadum, S.B.; Remadevi, O.K. and Dutta, R.K. (1993). Studies on the nutritional efficiency in silkworm, *Bombyx mori* L. *Indian J. Seric.*, **32**(1): 43-49.

Anantha Raman, K.V.; Mala, V.R.; Magadum, S.B. and Dutta, R.K. (1995). Effect of season and mulberry varieties on feed conversion efficiencies on different silkworm hybrids of *Bombyx mori* L. *Uttar Pradesh J. Zool.*, **15**(3) : 157-161.

Anonymous (1972). Hand book of silkworm rearing. Fuji Pub. Co. Ltd. Tokyo, Japan : **Pp**. 105-108.

Anonymous, (1996). Studies on rearing techniques, Annual report (1995-96), CMRS, CSB, Boko, Assam. : **Pp**. 5-6.

Azad, M.R.H.; Deka, J.; Borkotoki, A.; Sharma, D.K.; Dutta, A. and Goswami, U.C. (2000). Indoor rearing of muga silkworm (*Antheraea assama* Westwood). *Environ. and Ecol.*, **18**(4) : 884-887.

Bailey, C.C. (1976). A quantitative study of consumption and utilization of varies diets in the bertha army worm *Mamestra configurata* (Lep. Noct.). *Can. Entomol.*, **108** : 1319-1326.

Balakrishna, R.; Mogili, T.; Prasad, R.N. and Sarkar, A. (2005). Combining ability for leaf yield and some yield attributing characters in Mulberry (*Morus* spp.). *Indian J. Seric.*, **44**(1) : 127-130.

Barah, A.; Goswami, M.C. and Samson, M.D. (1989). Consumption and utilization of food in different instars of muga silkworm *Antheraea assama* Westwood. Proc. of the Indian Academy of Science. **98**(2) : 99-103.

Barah, A.; Phukan, S.M. and Samson, M.V. (1988). Variation in cocoon characters on *Antheraea assama* Westwood during different seasons. *Sericologia.*, **28**(2) : 215-218.

Basavaraju, C.D.; Laxmikumari, B. and Anantha narayana, S.R. (1998). Effect of temperature on consumption and utilization of food in two races of *Bombyx mori* L. *Sericoligia.*, **38**(4) : 615-621.

Benchamin, K.V. and Giridhar, K. (2005). Sericulture industry in India. Proc. Of 20th International Congress on Wild Silk Moth, Bangalore, vol. III. **Pp.** 158-161.

Benchamin, K.V. and Jolly, H.S. (1984). Studies on ingestion, digestion and conversion efficiency in polyvoltine and bivoltine silkworm breeds (*B. mori* L.). Proc. III Oriental Entomological Symposium, Feb 21-24. Trivandrum. **2** : 195-206.

Bhattacharya, A.K. and Pant, N.C. (1976). Studies on the insect host plant relationship : consumption and utilization profile in insect. Proc. Nat. Acad. Sci. India Sect., **46**(B) : 273-299.

Bhattacharyya, U. and Ray, N. (2006). Studies on the nutritional efficiency in muga silkworm *Antheraea assama* Ww. fed on som plant (*Machilus bombycina*). *Proc. First national seminar on M. S. B. M. B. B.* Jorhat,Assam . Nov. 18-19, 2004. **Pp.** 34-40.

Biren, R.; Prasad, B. and Nigam, M.P. (1987). Consumption and utilization of food by Oak-tasar silkworm, *Antheraea proylei* (Lepidoptera : Saturniidae). *Sericologia.*, **27**(1) :11-19.

Biswas, I. And Ray, N. (2003). Exploitation of muga culture in terai region of West Bengal, A non traditional area. Proc. of 4th all India peoples technology congress. February, 23-24, Kolkata, **Pp.** 86-90.

Biswas, S.; Hath, T.K. and Ray, N. (2008). Comparative studies of som (*Persea bombycina*) and soalu (*Litsea polyantha*) and their possible combination on commercial and seed crop rearing of muga silkworm (*Antheraea assama* Ww.). *J. Ent. Res.*, **32**(2) : 139-142.

Bodenheimer, F.S. (1928). Welche Faktoren regulieren die Individuenzahl einer Insektenalt in der Nature ? *Biol. Zentrolbl.*, **48** : 714-739.

Bose, P.C. and Bindroo, B.B. (2001). A comparative biochemical study of seven promising mulberry (*Morus alba* L.) varieties under rainfed condition of sub-tropical region. *Indian J. Seric.*, **40**(2): 171-173.

Choudhury, S.N.; Ahmed, R.; Bhattacharya, P.R.; Dutta, S.; Das, A.M. and Rajkhowa, A. (1998). Performance of muga silkworm (*Antheraea assama* Ww.) on different som (*Persea bombycina* King. Ex Hook (F) Kost) plant collected from Assam, India. Proc. of the third International conference on wild silkmoth. November, 11-14. Bhubaneswar, India. **Pp.** 66-69.

Dar, H.U.; Singh, T.P. and Das, B.C. (1988). Evaluation of mulberry varieties by feeding to *Bombyx mori. Sericologia.*, **24** : 501-511.

Das, K. and Das, R. (2003). Growth and development of muga silkworm fed on different food plants. *Indian Silk.*, **42**(7) : 19-21.

Das, P.; Bhattacharya, P. R.; Unni, B.G. and Deka, P.C. (2004). Consumption and utilization of food (*Persea bombycina*) in relation to larval development and silk protein biosynthesis by semi-domesticated muga silkworm *Antheraea assama. Indian J. Seric.*, **43**(1) : 57-65.

Delvi, M.R. and Naik, P.R. (1984). Effect of permethrin on dietary water budget in silkworm Bombyx mori. *Sericologia.*, **24** : 501-511.

Devaiah, M.C.; Gowda, R. and Suhas, Y. (1988). Effect of castor, tapioca and their combination on the growth and development of larvae and cocoon characters of *Samia cynthia ricni* Boisduval. International congress on tropical sericulture practices, Bangalore February, 18-23.

Dey, S. (1999). Scanning electron microscopic detection of an unusual giant sensilla on the abdominal cuticle of muga silkworm, *Antheraea assamensis* Ww. (Lepidoptera : Saturniidae). *Micron,* **30** : 339-348.

Dey, S.; Horoo, R.N.K. and Biswas, N. (1997). Dentritic organization of prominent sensory structure on the body of the first instar larvae of the muga silkworm (*Antheraea assamensis*). *Cytobios.*, **92** : 99-110.

Dey, S.; Horoo, R.N.K.; Biswas, N.; Raghu Varman, A. and Choudhury, S. (1999). Cellular features of the muga silkworm *Antheraea assamensis* Ww., (Lepidoptera : Saturniidae) midgut and its possible impact on indoor rearing. *Sericologia.*, **39**(4) : 529-535.

Dey, S.; Singh, S.; Dhar, N.J.; Biswas, N.; Chakraborty, R.; Das, P.K. and Sharma, D.K. (2002). Possible relationship between dorsal campaniform sensilla in head surface and preferred feeding posture of muga silkworm, *Antheraea assamensis* during indoor rearing. *Sericologia.*, **42**(1) : 57-64.

Dhaliwal, G.S. and Dilawari, V.K. (1993). *Advances in Host Plant Resistance to Insects*. Kalyani Publishers, New Delhi.

Dutta, L.C.; Saikia, M.K. and Dutta, S.K. (1996). Nutritional efficiency of two multivoltine breeds of *Bombyx mori* L. native to Assam. *Indian J. Seric.*, **35**(1) : 32-34.

Fukuda, T.; Kamegama, T. and Matsuda, M. (1963). A correlation between the mulberry leaves consumed by the silkworm larva in different ages of larval growth and production of cocoon fibre spun by the silkworm larva and the eggs laid by the silkworm. Bull. Seric. Exp. Stn. **18**(1) : 165-171.

Gokulamma, K. and Reddy, Y.S. (2005). Role of nutrition and environment on the consumption growth and utilization indices of selected silkworm races of *Bombyx mori* L.. *Indian J. Seric.*, **44**(2) : 165-170.

Hassanein, M.H.; El-Shaaraway, M.F. and El-Garthy, A.T. (1972). Food assimilation and output of silk in the different races of silkworm *Bombyx mori* L. *Bull. Soc. Ent.* Egypt, **56** : 333-337.

Hazarika, L.K. and Bardoloi, S. (1998). Antennal and mouth part sensilla of the muga silkworm, *Antheraea assamensis* (Lepidoptera : Saturniidae). *Sericologia.*, **38**(1) : 55-63.

Hazarika, L.K. and Deka, P.C. (2002). Indoor rearing of muga silkworm, *Antheraea assama* using detached leaves and artificial diet. Proc. The 4[th] international conference on wild silk moths. 23-27, April. Indonesia. **P**. 30.

Hazarika, L.K.; Kataky, A. and Bhuyan, M. (2006). A note on wild silkworm and indoor rearing of its counterpart . *Proc. First national seminar on M. S. B. M. B. B.* Jorhat,Assam . Nov. 18-19, 2004. **Pp.** 75-78.

Heinrichs, E.A. (1998). IPM in the 21st century : Challenges and opportunities. In : G.S. Dhaliwal and E.A. Heinrichs (eds). *Critical Issues in Insect Pest Management*. Commonwealth Publishers, New Delhi, India, **Pp.** 267-276.

Hiratsuka, E. (1920). Researches on the nutrition of silkworm. *Bull Seric. Exp. Stn.* Jpn. **I** : 257-315.

Horie, Y. (1978). Quantitative requirements of nutrients for growth of the silkworm *Bombyx mori* L. *J.A.R.O.*, **12** : 212-217.

Horie, Y. and Watanabe, K. (1983). Daily utilization and consumption of dry matter in food by silkworm *B. mori* L. (Lepidoptera: Bombycidae). *Appl. Entomol. Zool.*, **18**(1) : 70-80.

Horie, Y.; Inokuchi, T.; Watanabe, K.; Nakasone, S. and Yanagawa, H. (1976). Quantitative studies on food utilization by the silkworm *B. mori* L. through its life cycle, I. Economy of dry matter, Energy and Carbon. *Bull. Seric. Exp. Jpn.*, **26**(6) : 413-442.

Horie, Y.; Nakasone, S.; Watanabe, K.; Nakamura, M. and Suda, H. (1985). Daily ingestion and utilization of various kinds of nutrients by the silkworm *B. mori* L. (Lepidoptera : Bombycidae). *Appl. Entomol. Zool.*, **20**(2) : 159-172.

Hussain, A. and Shahjahan, M. (1997). Effect of different types of diet of castor and cassava leaves on the rearing of eri silkworm *Samia cynthia ricini* (Boisd) *Pak. J. Sci. Ind. Res.*, **34**(10) : 395-398.

Ito, T. (1972). An approach to nutritional control mechanism in silkworm *Bombyx mori* L. *Israel J. Entomol.* **7** : 1-6.

Ito, T. (1978). Silkworm nutrition. In : the silkworm : an important laboratory tool. (eds.) Y. Tarima, Kodansha Ltd., Tokyo, Japan, **Pp.** 121-157.

Ito, T. and Arai, N. (1963). Food values of mulberry leaves for the silkworm, *Bombyx mori* L, determined by means of artificial diets. 1. Relationship between kinds of mulberry leaves and larval growth.Bull. *Seric. Export. Stn.*, **18** : 209-229.

Ito, T. and Kobayashi, M. (1978). Rearing of the silkworm. In : The silkworm: an important laboratory tool, Y. Tazima (eds.), Kodansha Ltd., Tokyo, **Pp.** 83-102.

Jaksheva, V. and Genova, E. (1991). Daily ingestion and utilization of various kinds of nutrients in mulberry leaves by the silkworm *Bombyx mori* L. *Sericologia.*, **31**(1) : 167-172.

Jayaprakash, P.; Naidu, W.D. and Vijay Kumar, M. (1993). Indoor rearing of tasar silkworm, *A. mylitta* – A new technology. Proc. of the workshop on tasar culture, Warangal, Andhra Pradesh, **Pp.** 19-24.

Joshi, K.L and Misra, S.D. (1979). Studies live weights of larvae, cocoon and pupae and silk content of eri silkmoth, *Philosamia ricini* Hutt. (Lepidoptera : Saturniidae) reared on inter changed two host plants. Truns sdt. and UCDS,. **4**(2) : 97-100.

Joshi, K.L. (1984). Sex specific consumption and utilization of food by Eri silkworm, *Philosamia ricini* Hutt. (Lepi : Satur). *Sericologia.*, **24** : 21-24.

Joshi, K.L. (1985). Rel ationship between food consumption and fecundity of eri sik moth, *Philsamia ricini* Hutt. (Lep. : Sat). *Sericologia.*, **25** : 301-305.

Junliang, Xu. and Xiaoffeng, Wu. (1992). Research on improvement of efficiency transforming leaf ingested into silk of the silkworm *Bombyx mori*,. Proc. International Congress of Entomology, Beijing, China. Abs. No. 169-003, 623(b).

Kalode, M.B. and Sharma, H.C. (1993). Host-plant resistance to insect : Progress, problems and future needs. In : H.C. Sharma and Veerabhadra Rao, M. (eds). *Pests and Pest Management in India – The Changing Scenario*. Plant Protection Association of India, Hydrabad, India, Pp. 229-243.

Khalequzaaman, M. (1990). Studies on the consumption and utilization of castor (*Ricinus communis* L.) leaves by larvae of eri silkworm *Samia cynthia ricini* (Boisd). *Pak. J. Zool.*, **22**(2) : 149-157.

Kogure, M. (1933). The influence of light and temperature on certain characters of silkworm *Bombyx mori* L, *J. Dept. Agri. Kyusu. Uni.*, **4** : 1-93.

Krishnaswami, S.; Asan, M. and Sriharan, T.P. (1970). Studies on the quality of mulberry leaves and silkworm cocoon production. Part II. Quality differences due to leaf maturity. *Indian J. Seric.*, **9**(1) : 11-25.

Kurubayashi, S.; Suda, Y: and Kousaka, T. (1990). Studies on the food utilization efficiency in the silkworm *Bombyx mori* L. reared on mulberry leaves. Bull. Nat. Inst. Seric. *Entomol. Sci.*, **1** : 81-102.

Latheef, M.A. and Harcourt, D.C. (1972). Quantitative study of food consumption, assimilation and growth in *Leptinotarsa decemlineata* (Col : Chrysom.) on two host plants. *Can. Entomol.*, **104** : 1271-1278.

Legay, J.M. (1958). Recent advances in silkworm nutrition. *Ann. Rev. Entomol.*, **3 :** 75-86.

Machii, H. and Katagiri, K. (1991). Varietal differences in nutritive values of mulberry leaves for rearing silkworm. JARQ, **25**(3) : 202-208.

Magadum, S.B.; Remadevi, O.K.; Datta, R.K. and Shivashankar, N. (1996, b). Correlation between various nutritional parameters of silkworm *Bombyx mori* L. during V instar. *Indian J. Seric.*, **35**(2) : 138-141.

Magadum, S.B.; Remadevi, O.K.; Shivashankar and Datta, R.K. (1996 a). Nutritional indices in some bivoltine breeds of silkworm, *Bombyx mori* L. *Indian J. Seric.*, **35**(2) : 95-98.

Mathavan, S. and Pandian, T.J. (1974). Use of faecal weight as an indicator of food consumption in some Lepidopteran. *Oecologia,* (Berl.), **15** : 177-185.

Junliang, Xu. and Xiaoffeng, Wu. (1992). Research on improvement of efficiency transforming leaf ingested into silk of the silkworm *Bombyx mori*,. Proc. International Congress of Entomology, Beijing, China. Abs. No. 169-003, 623(b).

Kalode, M.B. and Sharma, H.C. (1993). Host-plant resistance to insect : Progress, problems and future needs. In : H.C. Sharma and Veerabhadra Rao, M. (eds). *Pests and Pest Management in India – The Changing Scenario*. Plant Protection Association of India, Hydrabad, India, Pp. 229-243.

Khalequzaaman, M. (1990). Studies on the consumption and utilization of castor (*Ricinus communis* L.) leaves by larvae of eri silkworm *Samia cynthia ricini* (Boisd). *Pak. J. Zool.*, **22**(2) : 149-157.

Kogure, M. (1933). The influence of light and temperature on certain characters of silkworm *Bombyx mori* L, *J. Dept. Agri. Kyusu. Uni.*, **4** : 1-93.

Krishnaswami, S.; Asan, M. and Sriharan, T.P. (1970). Studies on the quality of mulberry leaves and silkworm cocoon production. Part II. Quality differences due to leaf maturity. *Indian J. Seric.*, **9**(1) : 11-25.

Kurubayashi, S.; Suda, Y: and Kousaka, T. (1990). Studies on the food utilization efficiency in the silkworm *Bombyx mori* L. reared on mulberry leaves. Bull. Nat. Inst. Seric. *Entomol. Sci.*, **1** : 81-102.

Latheef, M.A. and Harcourt, D.C. (1972). Quantitative study of food consumption, assimilation and growth in *Leptinotarsa decemlineata* (Col : Chrysom.) on two host plants. *Can. Entomol.*, **104** : 1271-1278.

Legay, J.M. (1958). Recent advances in silkworm nutrition. *Ann. Rev. Entomol.*, **3** : 75-86.

Machii, H. and Katagiri, K. (1991). Varietal differences in nutritive values of mulberry leaves for rearing silkworm. JARQ, **25**(3) : 202-208.

Magadum, S.B.; Remadevi, O.K.; Datta, R.K. and Shivashankar, N. (1996, b). Correlation between various nutritional parameters of silkworm *Bombyx mori* L. during V instar. *Indian J. Seric.*, **35**(2) : 138-141.

Magadum, S.B.; Remadevi, O.K.; Shivashankar and Datta, R.K. (1996 a). Nutritional indices in some bivoltine breeds of silkworm, *Bombyx mori* L. *Indian J. Seric.*, **35**(2) : 95-98.

Mathavan, S. and Pandian, T.J. (1974). Use of faecal weight as an indicator of food consumption in some Lepidopteran. *Oecologia,* (Berl.), **15** : 177-185.

Matsumara, S. and Ishizuka, (1929). The effect of temperature on development of *Bombyx mori. Report Nagano. Seri . Exp. Sta. JPN* . **P.** 19.

Matsumara, S.; Takeuchi, Y. and Kousaka, T. (1955). Studies on nutrition of the recent commercial races of silkworm *B. mori* L. *Tech. Bull. Seric. Exp. Stn.* **69** : 1-47.

Matsumara, S.; Takeuchi, Y.; Kousaka, T. and Suzuki, S. (1958). Relation of rearing conditions to the ingestion and digestion of mulberry leaves in the silkworm. Sanshi Shikenjo Hokoku, Tech. Bull., **73** : 1-40.

Mukherjee, M.K. and Guppy, J.C. (1970). Quantitative study of food consumption and growth in *Pseudaletia unipuncta* (Lep : Noct.). *Can Entomol.*, **102** : 1179-1188.

Muniraju, E. (1995). Studies of standardization of rearing methods of young a ge silkworm *Bombyx mori* L. Ph. D thesis submitted to Bangalore university, Bangalore, India. **Pp.** 54-83.

Muniraju, E.; Sekharappa, B.M. and Raghuraman, R. (1999). Effect of temperature on leaf silk conversion in silkworm *Bombyx mori* L. *Indian J.Seric.*, **39**(2) : 225-231.

Muthukrishnan, J. and Pandian, T.J. (1987). Relation between feeding and egg production in some insects. Proc. Indian Acad. Sci. (*Anim. Sci.*), **96** : 171-179.

Naik, P. and Delvi, M.R. (1987). Food utilization in different races of silkworm, *Bombyx mori* L. (Lepidoptera : Bombycidae) *Sericologia.*, **27**(3) : 391-397.

Narayanaprakash, R.; Periaswamy, K. and Radhakrishnan, S. (1985). Effect of dietary water content on food utilization and silk production in *Bombyx mori* L. (Lepidoptera : Bombycidae). *Indian J. Seric.*, 24 : 12-17.

Nath, T.; Nath, S.; Shamsuddin, M. and Rao, G. (1990a). Effect of food deprivation on dry matter utilization, shell and cocoon weight and fecundity of multivoltine silkworm, *Bombyx mori*, race nistari. *Indian J. Seric.*, **29**(2) : 174-181.

Nath, T.N.; Biswas, S.N.; Sen, S.K. and Subba Rao, G. (1990b). Effect of consumption, digestion and utilization of food in larvae of silkworm, *Bombyx mori* L. due to parasitism by Uzi fly, *Tricholyga bombycis* Beck. *Indian J. Seric.*, **29**(1) : 8-12.

Naveen, S.P. and Savanurmath, C.J. (1998). Innovations in indoor maintenance of tasar silkmoth, *A. mylitta.* Drury. Proc. of 3rd International Conference on Wild Silkmoth. 11-14, November. Bhubneswar, Orissa. **Pp.** 16.

Nayak, B.K. and Jagannatha Rao, C.B. (1998). Domestication of wild tasar silkmoth by natural and artificial diet. Proc. of 3rd International Conference on Wild Silkmoth. 11-14, November. Bhubneswar, Orissa. **Pp.** 19.

Panda, N. and Khush, G.S. (1995). Host Plant Resistance to Insects. CAB International, Wallingford, UK.

Pant, R. and Katiyar, S.K. (1983). Effect of malathion and acetylcholine on the developing larvae of *Philosamia ricini* (Lepidoptera : Saturniidae). *J. Biol. Sci.*, **5** : 89-95.

Pant, R.; Raman, D. and Sarkar, A. (1986). Consumption and utilization of food in *Philosamia ricini* larva during development. *Sericologia.*, **26**(1) : 49-54.

Paul, D.C.; Subba Rao, G. and Deb, D.C. (1992). Impact of dietary moisture on nutritional indices and growth of *Bombyx mori* and concomitant larval duration. *J.Insect Physiology.* **38**(3) : 229-235.

Periaswamy, K. and Radhakrishnan, S. (1985). A quantitative study of food utilization and silk production in *Bombyx mori* L. for evaluation of superior varieties of mulberry. *Sericologia.*, **25** : 491-500.

Periaswamy, K.; Narayanaprakash, R. and Radhakrishnan, S. (1984). Food utilization in exotic and indigenous races of *Bombyx mori* L. *Sericologia.*, **24** : 43-50.

Petkov, N. and Mircheva, D. (1979). Study on the consumption and digestibility of nutrients in leaves of different mulberry varieties in silkworm trials. L - Spring silkworm feeding. *Animal Science.*, **16**(3) : 123-128.

Poonia, F.S. (1978). Studies on food utilization and rate of growth during the developmental stages of eri silkworm *Philosamia ricini* Hutt. (Lepi : Satur). *Indian J. Seric.*, **17** : 48-60.

Poonia, F.S. (1985). Consumption, digestion and utilization of castor leaves by larvae of eri silkworm *Philosamia ricini* Hutt. (Lepidoptera : Saturniidae). *Indian J. Seric.*, **47**(3) : 225-267.

Prabhakar, M.K.; Reddy, D.N.R. and Narayana Swamy, K.C. (2000). Consumption and utilization of mulberry leaves by the silkworm, *Bombyx mori* L. *Bull. Ind. Acad. Seri.* **4**(1) : 52-60.

Price, P.W.; Bouton, C.C.; Gross, P.; Mc Pherson, B.A.; Thompson, J.N. and Weiss, A.E. (1980). Interaction among three tropic levels : Influence of plants on interactions between insect herbivores and natural enemies. *Annu. Rev. Ecol. Syst.*, **11** : 41-65.

Radhakrishnan, P.G. and Delvi, M.R. (1992). Effect of organophosphorous insecticides on food utilization in different races of *Bombyx mori* L. (Lepidoptera : Bombycidae), *Sericologia.*, **32**(1) : 71-79.

Radhakrishnan, P.G.; Delvi, M.R. (1987). Effect of ration level on food utilization in the silkworm *Bombyx mori* L. (Lepidoptera : Bombycidae). *Sericologia.*, **27** : 347-354.

Rahamathulla, V.K.; Suresh, H.M.; Mathur, V.B. and Geetha Devi, R.G. (2002). Feed conversion efficiency of elite bivoltine CSR hybrid silkworm *Bombyx mori* L. reared under different environmental conditions. *Sericologia.*, **42**(2) : 197-203.

Rahman, M.S.; Bari, M.A. and Joarder, O.I. (2004). Studies on genetic variability and correlation of leaf yield and its contributing characters is Mulberry varieties *Morus* sp. *Indian J. Seric.*, **43**(2) : 151-154.

Rahmathulla, V.K.; Rajini Devi; Rajan, R.K.; Vindhya, G.S. and Himantharaj, M.T. (2006). Food ingestion, digestion and conversion pattern of new bivoltine hybrid silkworm, *Bombyx mori* L. *Utter Pradesh J.Zool.*, **26**(1) : 135-141.

Raja Ram and Samson, M.V. (1998). Effect of different types of diet of dighloti, majankuri, som and soalu leaves on the rearing of muga silkworm, *Antheraea assama* Westwood. The third international conference on wild silk moths, 11-14 November. Bhubaneswar, Orissa : 95-96.

Raja Ram and Sinha, B.R.R.P. (2004). Indoor rearing of muga silkworm. Proc. National workshop on potential and strategies for sustainable development of vanya silks in Himalayan states. November, 8-9. : **Pp**. 242-244.

Rana, B.; Prasad, B. and Nigam, M.P. (1987). Consumption and utilization of food by oak tasar silkworm *Antheraea proylei* (Lepi : Satur). *Sericologia.*, **27** : 11-19.

Rapusas, H.R. and Gabrial, B.P. (1976). Suitable temperature, humidity and larval density in the rearing of *Bombyx mori*. *Philippine Agriculturists.*, **60**(3/4) : 130-138.

Ray, N. (2003). Muga steps in West Bengal. Recent Advances in Animal Science Research., *Orion Press International*, India. **2** : 284-288.

Ray, N. and Deb, D.C. (2007). Growth stage oriented leaf-feeding to the bivoltine silkworm of *Bombyx mori* (L) with different high-yielding mulberry varieties to minimize quality-yield gap. *NBU J. Anim. Sc.*, **1**: 63-69.

Ray, N.; Bhattacharya, A.; Senapati, S.K. and Deb, D.C. (1998). Selection of mulberry varieties (*Morus* sp.) based on yield, nutritional elements and its rearing upon bivoltine silkworm (*Bombyx mori* L.) for larval traits. *Environ. Ecol.*, **16**(1) : 91-94.

Ray, N.; Biswas, I.; Bhattacharya, U.; Das, S.K. and Das, P.K. (2005). Studies on rearing performance of muga silkworm (*Antheraea assama* Ww.) in terai region of West Bengal (India) - A newly explored area. *Indian J. Seric.*, **44**(1) : 107-112.

Ray, N.; Senapati, S.K. and Deb D.C. (2000). Comparative studies on food utilization efficiency in some bivoltine strains of *Bombyx mori* L. under different varieties leaf feeding in terai zone of West Bengal. *Indian J. Appl. Ent.* **14** : 27-33.

Reddy, M.V. (1983). The consumption and utilization of the castor leaves by the larvae of *Philosamia ricini*. In : Insect Ecology and Resource Management. (eds). S.C. Goel, NE . Hill Univ., Kohima : 251-255.

Reddy, M.V. and Alfred, J.R.B. (1979). Utilization of castor *Ricinus Communis* Linn. leaves by the last instar larvae of the silk moth *Philosamia ricini* Hutt. (Lepidoptera : Saturniidae). *Indian Biol.*, **2** : 35-40.

Remadevi, O.K.; Magadum, S.B.; Shivshankar, N. and Benchamin, K.V. (1992). Evaluation of the food utilization efficiency in some polyvoltine breeds of silkworm *Bombyx mori* L. *Sericologia.*, **30**(1) : 61-66.

Scitz, A. (1933). The macro Lepidoptera of the world, Alfred Kerner Publishers, Stuttgart, **10** : 909.

Scriber, J.M. and Slansky, F. (Jr.). (1981). The nutritional ecology of insects. *Ann. Rev. Ent.* **26** : 183-211.

Sharma, B.; Badan, P. and Tara, J.S. (1986). Comparative consumption, utilization, % pupation and silk production in silkworms (*Bombyx mori*) fed on various varieties of mulberry existing in Jammu division of Jammu and Kashmir state. *Sericologia.*, **26**(4) : 419-429.

Shyamala, M.B.; Sharada, K.; Bhat, M.G. and Bhat, J.V. (1960). Chloromycetin in the nutrition of silk worm *Bombyx mori* L. II. Influence on digestion and utilization of protein, fat and minerals. *J. Insect Physiol.*, **4** : 229-234.

Sigematsu, H. and Takeshita, H. (1967). On the growth of silk glands and silk proteins production by silkworms reared at various temperatures during the fifth instar. *Acta. Sericologia, Jap.* **65** : 125-128.

Singh, G.B. and Ninagi, O. (1995). Comparative studies on food utilization efficiency in some silkworm strains under different feeding levels. *Sericologia.,* **35**(4) : 667-675.

Singha, B.B.; Lepcha, S.T. and Pramanik, A.T. (1991). Muga finds its way to West Bengal. *Indian silk,* Sept. **Pp.** 41-43.

Sinha, U.P.S.; Sinha, A.K.; Srastava, P. and Brahmachari, B.N. (1993). Variation on chemical constituents in relation to maturity of leaves in mulberry varieties S_1 and K_1 under the agro-climatic condition of Ranchi District. *Indian J. Seric.,* **32**(2) : 196-200.

Sinha, U.S.P.; Bajpeyi, C.M.; Brahmachari, B.N. and Sinha, B.R.R.P. (1998). Food consumption and utilization in *Antheraea mylitta* Drury larvae. Proc. of The third international conference on wild silk moths. : 182-186.

Sinha, U.S.P.; Mathur, S.K. and Sinha, A.K. (2000). Studies on consumption and utilization of *Shorea robusta* leaves in laria larvae. *Sericologia.,* **40**(4) : 671-676.

Sinha, U.S.P.; Mathur, S.K.; Sinha, A.K. and Brahmachari, B.N. (2001). Quantitative studies on the consumption and utilization of *Terminalia tomentosa* leaves by laria larvae. *Sericologia.,* **41**(3) : 507-512.

Slansky, F. (Jr). and Scriber, J.M. (1985). Food consumption and utilization, In : Comprehensive physiology, Biochemistry and Pharmacology (Karkut, G.A. and Gilbert, L.I. eds). **3** : 87-163.

Somioka, H.; Kuroda, S. and Yashitake, N. (1982). Relationship among food ingestion, food utilization and body weight gain in the silkworm larvae, *Bombyx mori*, under the restricted feeding by indexes. *J. Seric. Sci . Jpn.,* **51**(1) : 51-56.

Soo Hoo, C.F. and Fraenkel, G. (1966). The consumption, digestion and utilization of plants by polyphagous insects, *Prodenia eridania. J. Insect Physiology.,* **12** : 711-730.

Srivastava, A.; Geetika Prakash, D.; Singh, R.; Siddique, A.A.; Das, P.K. and Raghuvanshi, S.S. (1998). Nutritional status of the muga food plant *Litsea polyantha* (soalu). *Sericologia.,* **38**(4) : 693-695.

Sudhakar Babu, Ch. and Rao, P.A. (1998). Indoor chawki rearing tray – A new device for tasar silkworm. *A. mylitta* Drury. Proc. the 3rd International Conference on Wild Silkmoth, 11-14 November, Bhubaneswar, Orissa. **Pp.** 87-91.

Takano, K. and Arai, N. (1978). Studies on the food value on the basis of feeding and cocoon productivity in the silkworm, *Bombyx mori* L. treatment of food intake and cocoon productivity. *J. Seric. Sci. Jpn.* **47**(1) : 134-142.

Takeuchi, Y. and Kosaka, T. (1961). On the amount of food ingested and digested during the first instar in the silkworm, *Bombyx mori* L. *Acta. Seri.* **37** : 65-72.

Thangavelu, K. and Sahu, A.K. (1983). Domestication of muga silkworm : a major break through in muga culture. *Sericologia.*, **23**(2-3) : 153-158.

Thangavelu, K. and Sahu, A.K. (1986). Further studies on the indoor rearing of muga silkworm, *Antheraea assama* Westwood (Saturniidae : Lepidoptera). *Sericologia.*, **26**(8) : 215-224.

Trivedi, K. and Nair, K.S. (1998). Dietary efficiency and silk productivity. *Indian Silk*, **36**(9) : 5-7.

Trivedi, K. and Nair, K.S. (1999). Feed conversion efficiency of improved multi x bivoltine hybrids of silk worm *Bombyx mori* L. *Indian J. Seric.* **38**(1) : 30-34.

Tzenov, P. (1993). Study on the food utilization in genetic sex limited breeds for egg and larval traits of the silkworm, *Bombyx mori* L., at moderate, reduced and excess feeding amount. *Sericologia.*, **33**(2) : 247-256.

Ueda, S. (1963). Studies on the effects of rearing temperature upon the health of silkworm larvae and upon the amount of cocoon silk production – III on the effect of lower rearing temperature. *J. Seri. Sci. Japan.*, **33**(1) : 34-42.

Ueda, S. and Harizuka, H. (1962). Studies on the effects of rearing temperature affecting the health of silkworm larvae and upon the quality of cocoons, Effects of temperature in each instar. *Acta. Sericologia. Jpn.*, **41** : 6-21.

Ueda, S.; Kimura, R. and Suzuki, C. (1969). Studies on the growth of silkworm *Bombyx mori* – II. The influence rearing upon the larval growth, productivity of silk substance and egg, boiled off loss in the cocoon shell. *Tech. Bull. Sericult, Exp. Sta.* **23(3)** : 255-293.

Uvarov, B.P. (1931). Insect and climate. *Trans. Ent. Soc. Lond.* **79** : 1-247.

Vats, L.K. and Kaushal, B.R. (1982). A quantitative study of food consumption, assimilation and growth of *Pieris brassicae* (Lepidoptera : Pieridae) on two host plants. *Indian J. Ecol.*, **9** : 292-297.

Verma, A.N. and Atwal, A.S. (1967). Effect of constant and variable temperature on the development and silk production of *Bombyx mori* L. (Lepidoptera : Bombycidae). *J. Res. Punjab Agri. Uni*., **4** : 233-239.

Waldbauer, G.P. (1964). The consumption, digestion and utilization of solanaceous land non-solanaceous plants by larvae of tobacco hornworm, *Protoparce sexta* (Johan) (Lep : Sphn.) *Ent. Ext. Appl*., **7** : 253-269.

Waldbauer, G.P. (1968). Consumption and Utilization of food by insect. *Adv. Insect Physiology.*, **5** : 229-288.

Yadav, G.S. and Goswami, B.C. (1999). Correlation and regression studies between different quantitative characters of muga silkworm, *Antheraea assamensis* Helfer during two commercial crops . Bull. Ind. Acad. Seri. **3**(2) : 12-20.

Yamamoto, T and Fuzimaki, T. (1982). Inter strain differences in food efficiency of silkworm, *Bombyx mori* reared on artificial diet. *J. Sci. Jpn*., **51** : 312-315.

Yamamoto, T. and Fujimata, T. (1960). Inter strain differences in food efficiency of silkworm *Bombyx mori* L. reared on artificial diet. *J. Seric. Sci. Jpn*., **51**(4) 24 : 312-315.

Yamamoto, T. and Gamo, T. (1976). Studies on the breeding in relation to the improvement of the food utilization in the silkworm *Bombyx mori* L., mutual relation among the amount of food ingested, the amount of food digested and several quantitative characters in the silkworm reared on the artificial diet. *J. Seric. Sci. Jpn*., **45**(1) : 81-86.

Yokoyama, T. (1962). Synthesized science of sericulture (translated and published by Central Silk Board). Chapter 14. Silkworm rearing, : **Pp**. 246-321.

Yokoyama, T. (1963). Sericulture. *Ann. Rev. Entomol*., **8** : 287-366.