DISCUSSION AND CONCLUSIONS

The salient features emerged from the present investigation on “Biosystematics and bioassay in food plants of eri silkworm, Philosamia ricini Hutt.” are discussed here in the light of the existing literature / knowledge in this area.

In the present investigation, the attention has been drawn towards the distribution pattern, characterization of exo-morphic and micro-morphological features, palynological data, biochemical analysis and bioassay studies (rearing trials using independent and combination of host plants) in order to identify the elite species for commercial rearing of eri silkworm. Observed results were discussed in the proceeding paragraphs.

NOMENCLATURE

There has been confusion regarding the taxonomic status of the genus Samia Hubner especially on its nomenclature. Packard (1914) treated Samia and Philosamia Grote as a separate genus. Seitz (1928) considered Samia as a valid genus and treated Philosamia and Drepanoptera Rotchild as its counter parts representing India and African fauna of Samia, respectively. However, Schiissler (1933) revalidated both Samia and Philosamia as separate genera, representing African, American and oriental fauna. Arora and Gupta (1979) stated Samia is represented by a single species cynthia Drury with several subs species, including ricini Boisduval. However, Hampson (1892) treated cynthia and ricini as separate species. Further, there is some confusion and uncertainty regarding the correct authorship of the name ricini. Several authors have attributed the name ricini to either Jones, Anderson or Donovan, in addition to Boisduval. But, Peigler and
Naumann (2003) have cited the authorship as ‘Anonymous’ since they have not been able to determine the earliest author to have validated the name. Of late, researchers have adopted different nomenclature in their valid publications such as *Philosamia ricini* (Joshi and Mishra, 1982; Kaleemurrahman and Gowri 1982; Singh and Singh, 1984; Dutta and Kalita, 1997; Dinesh and Sundaramoorthy 2003; Priti Pragyan Ray *et al.*, 2010; Rajesh Kumar and Elangovan 2010; Priti Pragyan Ray and Rao 2010), *Samia cynthia ricini* (Devaiah *et al.*, 1985; Reddy *et al.*, 1989; Rajaram and Samson 1991; Mane and Patil, 2000; Hazarika *et al.*, 2003; Govindan *et al.*, 2005; Rajashekargouda R. Patil *et al.*, 2009; Chandrashekhara and Govindan 2010; Mukul Deka *et al.*, 2011), *Samia ricini* (Kar *et al.*, 2004; Dutta and Khanikor 2005; Kar 2010; Sarmah *et al.*, 2012; Mainu Devi, 2012), *Samia cynthia* (Hao Zheng *et al.*, 2006), *Philosamia cynthia ricini* (Wang and Xu, 1982; Ye Geongyin and Hu Cui, 1996). This clearly indicates the ambiguity in adopting nomenclature of eri silkworm and warranting critical revision considering the rules/guidelines laid for the purpose by International Code of Zoological Nomenclature (ICZN). Under this back drop the previous/old nomenclature viz., *Philosamia ricini* Hutt has been followed in the present work.

**SOCIO-ECONOMIC PERSPECTIVE**

India has unique distinction of producing all varieties of silk i.e., mulberry, eri, tasar and muga. Non mulberry sericulture in India is an age old tradition which is being practiced and preserved by the tribal folk. The ericulture has been considered as an agro based industry of rural poor with potential of generating additional employment. Eri culture hold great promise in the non-mulberry sector compared to tasar and muga and it is being practiced in...
many parts of India. Assam is the highest eri silk producing among the states in India followed by Meghalaya, Nagaland, Manipur, Uttar Pradesh, Arunachal Pradesh, West Bengal, Mizoram, Andhra Pradesh, Bihar, Orissa, Madhya Pradesh, Punjab, Sikim and Chhattisgarh (Utpal Kumar and Manjit Das, 2010).

Eri silkworm is a multivoltine, polyphagous insect and exhibits selective approach towards a particular host plant. The host plants which are selected instinctively by the insect as its choice are called ‘primary’ food plants. When eri worms reared on these taxa, healthy and robust growth of the silkworms can be expected resulting in the production of good cocoon crop. On the other hand, the host plants which are consumed by silkworm under the constraints are known as ‘secondary’ or ‘tertiary’ depending on the preference of the silkworm (Seth, 1995).

Eri worm feeds on the leaves of varieties of plant species belonging to different families. The important taxa are *Ricinus communis* (Castor), *Manihot esculenta* (Tapioca), *Jatropha curcas* (Wild castor), *Plumeria rubra* (Temple tree), *Ailanthus excelsa* (Tree of Heaven) and *Carica papaya* (Papaya). These taxa exhibit diversity in their habit, morphological features and adaptability. They are under cultivation for their economic importance. Castor plant is cultivated for its oil yielding seeds. Similarly, tapioca is cultivated as an economically important plant for its starch yielding tuberous roots. The seeds of wild castor (*Jatropha curcas*) are a source of Biodiesel. Further, latex of this plant known to contain jatrophine which is an anticancerous agent. The tender twigs of the plant are used for cleaning teeth. The juice is reported to relieve toothache and strengthen gums (Reddy Prasad *et al.*, 2012).
Plumeria is a highly valued tree for ornamental and religious purpose and often planted near temples. Flowers are used in wreath making and offered to deities in temples. The latex acts as a purgative, applied externally for itches (Devprakash et al., 2012). Ailanthus plants are rich source of a variety of organic compounds of varying structural patterns. Ailanthus wood is used in manufacturing of plywood, match sticks, toy and packing materials. Mature leaves are best fodder for sheep’s. Leaf extract is used for washing wounds. The pulp is obtained from debarked wood and used in paper industry (Pijush Kunda and Subrata Laskar, 2010). Papaya is popular as a delicious table fruit. Ripened fruit is rich in vitamins and calcium. White milky latex is used as a cosmetic and to heal toothache and tooth decay. Raw papaya fruit, as well as all other parts of the plant, contain a milky juice in which an active principle known as papain is present. Papain is used as an ingredient in the manufacture of chewing gum and for enzymatic degumming of silk (Paramar Namit and Rawat Mukesh, 2012; Aravind et al., 2013). Besides these, some host plants of Eri are used in pharmaceutical industry for the production of life saving drugs (Ayoola and Adeyeye, 2010; Kalimuthu et al., 2010; Nisar Ahmad et al., 2011; Mohd Iqbal Mir, 2013). The propagation and cultivation of these plant species is relatively easy and inexpensive. However, these plant species have not been hither to exploited for Ericulture in Southern India. Considerable potentiality is prevailing around these plants for the improvement of socio-economic status of rural folk. Further, these taxa are found in abundance in Southern States of India. Hence, there is ample scope for the introduction of Ericulture in Southern part of our country to uplift the socio-economic status.
DISTRIBUTION OF HOST PLANTS

The host plants of eri silkworm are not only form an important component of the living and dynamic ecosystem on the earth but also the human beings in various ways. They give us shelter, food and medicine. In order to improve the promising genotypes of plant species their distribution pattern, palynological data, nutrition requirement, bio assay studies, climatic conditions and morphological details needs to be critically studied. In this context, present investigations unravel the interspecific variations found among the selected host plants of eri silkworm.

These host plants exhibit diversity in their habit, morphological features and adaptability. They are under cultivation for their economic importance. *Ricinus communis* commonly called castor belongs to family Euphorbiaceae. Castor plant grown worldwide in tropical and temperate climates. It is being cultivated throughout India for its oil yielding seeds. Often it is grown as an ornamental plant in private garden because of its massive palmate leaves and rapid growth. The nutritive reserves of *Manihot esculenta* commonly called cassava / tapioca also belongs to the family Euphorbiaceae. It is cultivated mainly for its starchy roots. It is one of the most important food staples in the tropics. It is distributed throughout India. *Jatropha curcas* commonly called wild castor, belongs to the family Euphorbiaceae. It is a multipurpose tree of significant economic importance because of its several industrial and medicinal uses. It grows throughout the tropical and subtropical regions around the world. It survives on poor stony soils and is resistant to drought. *Jatropha* is the most primitive form and has the potential to be cultivated for biodiesel. *Plumeria rubra* commonly called temple tree belongs to the family Apocynaceae. It
is distributed throughout India and it has wide spread in tropical landscapes. It is highly valued tree for ornamental and religious purpose and often planted near temples. *Ailanthus excelsa* commonly called ‘Tree of Heaven’ belongs to the family Simaroubaceae. It is a large, deciduous fast growing tree extensively cultivated in many parts of India in the vicinity of villages. The tree is indigenous to Southern and Central India and distributed in Rajasthan, Bihar and in dry deciduous forest of Maharashtra. It is grown as shade and avenue tree throughout most of the hotter parts of India. The tree serves as shelter belts along borders of fields. *Carica papaya* commonly called papaya belongs to the family Caricaceae. Papaya is a popular and economically important fruit tree of tropical and subtropical zones and found throughout India. The fruit is consumed world-wide as fresh fruit and as a vegetable or used as processed products.

Karnataka, one of the agriculturally important states of Southern India, is blessed with flourishing green forests and suitable climatic conditions harbouring varied flora required for rearing eri silkworm. In southern and central plateau of this state castor, tapioca and papaya are being extensively cultivated during rainy season for oil yielding seeds (castor), starch containing tuberous roots (tapioca) and delicious edible fruit (papaya). These three plant species are grown as monocrops or as an intercrop in coconut plantation or mango orchards. Often, *Ricinus communis* grows almost as a weed in desolate places by the side of streams, irrigation canals or as a backyard crop or as an escape in waste land. Castor stem is used in paper industry. Tapioca is one of the most efficient photosynthesizing plants known. The tuberous roots accumulates starch in large quantities. The high photosynthetic efficiency and presence of large quantity fermentable sugar in
hydrolyzed starch make the tuber an attractive source of renewable energy. For preparation of alcohol, it is an excellent source of carbohydrates other than molasses. Fresh tubers are used for production of ethanol. The malnad region (Hassan, Chickmagalur, Shimoga, Kodagu districts) of Karnataka and other hilly traits (ex. Biligiri Rangana hill of Chamarajanagar district) has ample scope for expansion of tapioca cultivation not only as a source for supplementary diet for the people but also to introduce ericulture. *Carica papaya* not only produces edible, proteinacious, mineral rich fruit but also the latex obtained from the raw fruit contains papain. The enzyme papain is very useful for degumming silk and also widely employed in breweries. *Jatropha curcas*, one of the outstanding ‘biodiesel’ plant, has been cultivated for raising fence (edge plant) in order to protect other economically beneficial agricultural/horticultural/sericultural crops from stray cattle. In recent decades, this taxon has been grown extensively in arid and semi-arid agricultural zones of Tumkur and Chamarajanagar districts for its oil yielding seeds. *Plumeria rubra* (temple tree) and *Ailanthus excelsa* (tree of heaven) have also been grown in large scale. *Plumeria* is usually grown near the temple and other religious places. Its fragrant flowers are used for worshiping god and saints. Evolved genotypes of this taxon with attractive petals (Figs. 38 – 43) and lust green leathery leaves are planted in public parks and near the prominent buildings for ornamental purpose. *Ailanthus excelsa* is found in wild state in scrubby and deciduous forests of Karnataka. This plant species has been grown extensively under farm forestry programme for its useful timber and pinnate leaves. *Ailanthus* bark is used for extraction of tannins. Its soft-wood, being light is used for carts, match splints and box, box planking and plywood making (Jat *et al.*, 2011). Agro-tech for propagation and
cultivation of these taxa have been very well defined (Gupta, 1980; Jat et al., 2010; Sarmah and Gogoi, 2011; Ahmed and Sarmah, 2011). These are eco-friendly plant species, easy to propagate and inexpensive to cultivate.

**EXOMORPHIC CRITERIA**

Host plants of eri silkworm characterised in the present work fall under different plant families. Three of them viz., *Ricinus communis*, *Manihot esculenta*, and *Jatropha curcas* belong to one and the same family Euphorbiaceae of the order Euphorbiales. Other three taxa studied come under totally different families and taxonomically very distinct. Their family status is Apocynaceae (*Plumeria rubra*), Simaroubaceae (*Ailanthus excelsa*) and Caricaceae (*Carica papaya*).

Castor, tapioca and wild castor share common gross morphological characteristic features. All are shrubs, terrestrial and found under cultivation. However, *Jatropha curcas* also exist in wild condition found particularly in the scrubby jungles. Stem of these taxa is herbaceous or semi-woody and contain milky latex. Unisexuality is a rule in these taxa. Flowers small, regular, trimerous, hypogynous with tricarpellary syncarpous, tri locular ovary, single ovule in each locule, axile placentation. Style ends with trifid stigma which is further forked. Fruit in all these plant species is a capsule and seeds are carunculate, which is a most important salient taxonomic feature of the family Euphorbiaceae. Though these taxa resemble in several gross morphological characters yet, they differs in many morphological criteria and they are specific to each taxon and could be used as diagnostic characters for the identification/genotype tagging. Stem of castor
plant is hallow, soft, pink in colour and often coated with white powdery substance. Leaves are simple, alternate, with long petiole which is also hallow, palmately lobed lamina, margin serrate with acute tip, multicostate venation (Fig. 16). Flowers are unisexual, monoecious, small, trimerous, regular, hypogynous and found on terminal or axillary raceme (Figs. 17 & 18). Fruit is a warty capsule called regma (Fig. 19) and seeds with brownish testa, white streaks are found, carunculate (Fig. 20). In comparison, tapioca possess semi-solid stem, more or less yellowish green in colour. Leaves are palmately lobed, often highly dissected (Fig. 22). Flowers small, trimerous, unisexual, monoecious, hypogynous, found in cymose inflorescence found in leaf axils (Fig. 23). Fruit is oblong, smooth walled capsule (Fig. 25). In contrast, wild castor (Jatropha curcas) exhibit seemingly xeric habit. Leaves simple, petiolate, often crowded at the stem tip, palmately lobed, multicostate (Fig. 28). Inflorescence is a corymbose cyme found in leaf axils (Fig. 29). Fruit is a smooth walled, ovoid capsule. Seeds carunculate (Figs. 30 & 32).

Plumeria, Ailanthus and Carica are taxonomically distinct. Plumeria plants ooze milky latex when the leaves are detached. Leaves are leathery, dark green with emarginate veins and obtuse or acute tip (Fig. 34). Flower showy, actinomorphic, pentamerous, with twisted petals (Fig. 35). Ovary superior, bicarpellary which is free at the ovary region and conjoint at style and stigma. It stands between apocarpous and syncarpous plant families (transitional stage). Fruit is very unique which is a pair of follicle (Fig. 36). Seeds with silky hairs (pappus) which help in dispersal (Fig. 37). In contrast to this taxon, Ailanthus is a medium to large sized tree found growing/cultivated in dry lands (Fig. 44). Bark of this plant yield tannin. Leaves are pinnately compound (Fig. 45) and serves as
fodder for milchi cattle (sheep and goats). Inflorescence is cymose panicle (Fig. 46 & 47) and fruit is very characteristic i.e., single seeded ‘Samara’ (Fig. 49). In contrast, *Papaya* is a tree; stem is very herbaceous and clothed with prominent leaf scars (Fig. 50). Such leaf base scars present on the stem of papaya are totally absent in the other taxa studied. Flower is regular, polygamous i.e., trioeicous flowers are often found (occurrence of male, female and bisexual flowers on the same plant), pentamerous, hypogynous. Fruit is a berry, oblong, indehiscent, many ovules on parietal placentation (Fig. 54). Systematic Botanists worked previously on the phenotypic characters of these taxa have also recorded the distinct morphological features and family status (Hooker, 1878; Bentham and Hooker, 1883; Gamble, 1967; Saldhana and Nicolson, 1979; Divakar, 2009; Idu *et al.*, 2009; Dinesh Kumar, 2010; Thi Thi Htun, 2011). However, certain minute differences are found depending upon the genotypic variability and environmental conditions in which the plant species found growing.

The earlier workers have also recorded morphological variation among the members of the family Euphorbiaceae. Lancaster and Brooks (1983) recorded the morphological characters of cassava plant and stated that its leaves offer a good source of supplementary protein and vitamins A and C and minerals. Shaheen (2002) recorded the morphological variations present within and among *R. communis* grown in Egypt and stated that the leaf is decorated with fine crystals and has a roughened surface due to irregular pattern wax. Hao Zheng *et al.*, (2006), Ingo Kowarik and Ina Saumel (2007) stated that the genus *Ailanthus* is a medium sized tree. Further, they have indicated that bark and fruit have medicinal uses and tree is a source of timber. Jaime A. Teixeira da Silva *et al.*, (2007) recorded the biology of *Carica papaya* and stated
that it is a fast-growing, semi-woody, tropical plant and contains many biologically active compounds i.e., chymopapin and papin. Radha et al., (2008) recorded the macro and microscopic characters of *P. rubra* leaves. Ratha and Paramathma, (2009) also recorded morphological characters and the desirable traits available in 12 *Jatropha* species. *J. curcas* is a wild hardy plant well adapted to arid and semi arid conditions and can grow well in low fertile, moisture and even calcareous soil. Ram Prasad and Bandopadhyay (2010) stated that origin of the castor plant is found to be in Ethiopia and India. Thi Thi Htun (2011) recorded the taxonomic description of Euphorbiaceae family. He stated that it is a large, diverse family with unisexual flowers, superior syncarpous ovaries, one ovule per locule and fruit is a capsule. Xiu-Rong and Gui-Jie, (2012) recorded the reproductive biological characteristics of *Jatropha curcas*. Devprakash et al., (2012) recorded the morphological characters of *Plumeria* species found in India commonly known as frangipani.

**MICROMORPHOLOGICAL FEATURES**

Stomata are small pores, found typically on the undersides of leaves that are opened or closed under the control of a pair of bean-shaped cells called guard cells. Stomata are the important anatomical characteristics of a leaf which control the rate of CO$_2$ movement from air to the chlorophyllous tissue within the leaf and thereby influence the rate of CO$_2$ exchange in vascular plants (Wallace et al., 1972). Stomatal size, index and frequency are important parameters in selecting a disease and drought resistant genotypes and believed to regulate the leaf yield. An attempt has been made to study the stomatal size, index and frequency of the taxa used in the present investigation. Stomatal size was low in
Jatropha curcas (179.50 µm²) when compared to other host plants. Higher stomatal size was recorded in Carica papaya (377.50 µm²) followed by Plumeria rubra (272.50 µm²), Manihot esculenta (253.50 µm²), Ailanthus excelsa (215.00 µm²) and Ricinus communis (211.00 µm²). Stomatal index was lower in Carica papaya (19.21) when compared to other host plants. Higher stomatal index was recorded in Plumeria rubra (26.79) followed by Manihot esculenta (26.21), Ailanthus excelsa (26.14), Jatropha curcas (22.26) and Ricinus communis (22.10) respectively. Stomatal frequency was low in Jatropha curcas (315.00 mm²) when compared to other host plants. Higher stomatal frequency was recorded in Carica papaya (572.75mm²) followed by Plumeria rubra (515.00mm²), Manihot esculenta (404.25mm²), Ricinus communis (358.50mm²) and Ailanthus excelsa (324.50mm²) respectively (Table – 3; Figs. 56-61; 104-106).

Inamdar and Gangadhara (1978) observed the structure and ontogeny of stomata in Euphorbiaceae species. Highest stomatal frequency was recorded in M. esculenta (432) followed by J. curcas (176) and R. communis (136). Highest stomatal index observed in R. communis (25) followed by M. esculenta (24) and J. curcas (14). Highest epidermal cells were observed in M. esculenta (1296) followed by J. curcas (976) and lowest was recorded in R. communis (413). Kranti Rai and Ela Tiwari (2012) stated that the stomata of J. curcas are anomocytic and anomotetracytic. Its density was 0.29 and index was found to be 4.48. Saadu et al., (2009) stated that the M. esculenta have paracytic stomatal complex type with a frequency of 100%. Stomatal size is 52.30µm, density is 16.45mm² and index of 3.03%. Abdulrahaman et al., (2009) stated that the J. curcas have paracytic stomatal complex type with a frequency of 100%. The size of stomata was found to be 60.05µm and the density
recorded 15.33mm$^2$. Radha et al., (2008) recorded the $P. \text{rubra}$ stomata are paracytic type. There are two subsidiary cells; these cells are equal or slightly unequal in size. Dinesh kumar et al., (2010) opined that the stomata of $A. \text{excelsa}$ are anomocytic.

**PALYNOLGY**

Palynology is the study of pollen grains produced by seed plants (angiosperms and gymnosperms) and spores produced by pteridophytes, bryophytes, algae and fungi. Palynological data serves as a tool for reconstruction of past vegetation and environment. It can also be applied to taxonomy, genetics, evolutionary studies, forensic sciences, allergy studies and study of past human impact on vegetation. Pollen is one plant material best resistant to various kinds of treatment. It remains unchanged in structure and sculpture for millions of year, when fossilized in the soil. Pollen mother cells (microsporocytes) are differentiated from sporogenous cells in the young male organ. These cells are poorly attached to each other by plasma connections. The study of pollen morphology is important, particularly for plant identification and taxonomic studies, allowing inferences to be made regarding the potential crosses between species (Livia de Jesus Vieira et al., 2012). Pollen biology has direct relevance in agriculture, horticulture, forestry, plant breeding and biotechnology. Pollen morphological characters like size, shape, wall, exine structure, ornamentation, apertures, etc., are often employed for the delimitation of taxa. The exine and apertures are most wanted characters useful in authentic identification of the genotype. Pollen grains of plants of diverse origin are quite different in their basic architecture and wall pattern. Each plant species bears a specific wall surface pattern, which helps immensely in the identification
and classification. Each taxon having its own characteristic features such as type varied from inaperturate, dicolpate, tricolpate, tetracolpate, etc., (Erdtman, 1952; Miller and Webster, 1962; Punt, 1962; Erdtman, 1966; Bahadur et al., 1998; Thi Thi Htun 2011).

In the present investigation palynological details in 6 host plants of eri silkworm were described using Light microscopes. The pollen grains of *R. communis* are prolate, sub-spheroidal, tricolporate, reticulate. Average size of the pollen grain is 82µm (Fig. 62). The pollen grains of *M. esculenta* are polyporate, spheroidal with richly ornamented reticulated crotonoid pattern of exine. Average size of the pollen grain is found to be 148.2 µm (Fig. 63). The pollen grains of *J. curcas* are oblate, spherical, omniaperturate, which aligned reticulately to form a crotonoid pattern. Exine is usually covered with globular structures. Average size of pollen grain is found to be 94µm (Fig. 64). *P. rubra* pollen grains are prolate, tricolporate with pseudocolpi with thick exine and thin intine. Average size of pollen grain is found to be 52.2µm (Fig. 65). The pollen grains of *A. excelsa* are tricolporate, reticulate exine, lumina open and elongated towards the colpus, striate. Average size of the pollen grain is found to be 84µm in diameter (Fig. 66). The pollen grains of *C. papaya* are sub spheroidal, tricolporate, reticulate, with thick exine. Average size of the pollen grain is 48µm in diameter (Fig. 67).

Anjum and Qaiser (2005) stated that pollen grains of Euphorbiaceae usually radially symmetrical, isopolar, prolate-spheroidal to subprolate or prolate, colporate (tri, rarely 6-7), colpi generally with costa, colpal membrane psilate densely granulated, sexine as thick as nexine or slightly thicker than nexine. Thi Thi Htun (2011) stated *R. communis* pollen grain is tricolporate.
M. esculenta pollen grains are polyporate and pantoporate. J. curcas is inaperturate. The shapes of the pollens are spheroidal in M. esculenta and J. curcas. Whereas pollen grains of R. communis are suboblate. The ornamentation of exine is croton pattern in M. esculenta and J. curcas, reticulate in R. communis. Wang et al., (2010) observed the richly ornamented “crotonoid” pattern of M. esculenta under scanning electron microscope and the average diameter of pollen grain is about 160 µm and pollen type is monad. Livia de Jesus Vieira et al., (2012) reported that the M. esculenta pollen grains varied from 132 to 163 µm in the wild accession, and 129 to 146 µm in the cultivated accessions. The pollen grains of all accessions were very large, apolar, spherical, inaperturate, with an exine ornamented with pila organized in the croton pattern. Erdtman (1952) first studied the pollen of Jatropha and proposed the “Crotonoid pattern”. Later, several workers investigated various Indian Jatropha and brought to light the significance of various components of sporoderm ornamentation in relation to taxonomy of the genus (Rao and Raju, 1994; Miller and Webster, 1962; Punt, 1962; Bir Bahadur et al., 1997). Rukhshinda Aftab and Anjum Perveen (2006) stated that the Plumeria acutifolia pollens are prolate, tricolporate with 2 pseudocolpi and one normal colpi. Sexine as thick as nexine. Devarkar (2011) stated that the A. excelsa pollens are hexagonal in polar view, elliptical in equatorial view. Apertures are tricolpate with long, narrow colpi, reticulate exine, lumina open and elongated towards the colpus.

CHEMO ASSAY

Plants and their parts vary considerably in their nutritional value. Though the reproductive parts are generally rich in nutrition in terms of calories contributed by proteins, a major constraint in
the use of these organs is a limiting factor due to their limited life span. The foliage usually provides the greatest bio-mass of the plant and the best food (McNeill and Prestige, 1982). Host plant selection involves not only choosing the right species of plant, but also selecting an individual plant with omnipotent factors suitable for feeding and development. Furthermore, the ecology of the host plant, its abundance, distribution of individual plants, is of particular importance. At this juncture, the main question to be answered is what actually causes the preferential feeding behaviour of silkworm. Probably the innate behaviour or genetic makeup of silkworm and biochemical constituents of the host foliage may be responsible for the selective feeding behaviour of the silkworm. In this context the present findings throw light on the quantitative biochemical constituents of host plants of eri silkworm, *Philosamia ricini* Hutt.

**Moisture content**

Leaf moisture plays a vital role in improving nutrition levels of leaves which in turn improve the palatability of leaves for silkworm. Hence, the moisture content in the leaves may serves as one of the criteria in estimating their quality. Moisture in the required quantities is very much essential for silkworm as it facilitates protein, carbohydrate and lipid metabolism. If moisture content is lesser in the host plant foliage, the silkworm larvae may not cherish such leaves, though it is rich in all other biochemical constituents. Further, leaf moisture content serve as an important criterion in judging the leaf quality. The silkworm mainly depends on foliage to meet their water requirement. Many have reported favourable effect of high moisture content of leaves on their palatability and
digestibility by silkworms (Friend, 1958; Waldbauer, 1968; Bongale et al., 1997, Talebi Esfandarani et al., 2002).

In the present investigation host plants recorded variation in moisture content. *M. esculenta* recorded highest moisture content (74.50%) followed by *C. papaya* (73.50%). *R. communis* (72.75%) and *J. curcas* (72.75%) recorded equal amount of moisture content which did not differ significantly between themselves. *P. rubra* (70.50%) and *A. excelsa* (70.25%) revealed more or less same amount of moisture content. However, these two plants differed significantly with rest of the food plants at 0.05% level of significance (Table - 4, Fig. 68).

The earlier workers who considered different host plants of *Philosamia ricini* for foliar analysis have also registered variation in moisture content. Sannappa and Jayaramaiah (2002), Chandrappa (2005) and Sengupta et al., (2008) have observed variations in moisture content of leaves among the castor genotypes. Kaleemurrahman and Gowri (1982) have reported maximum moisture content in the tender leaves of host plants studied. Radha et al., (2008) observed 11.41% of moisture content in *Plumeria alba* leaf. Jat et al., (2008) reported 67.39% of moisture in *A. excelsa*. Godson et al., (2012) recorded variation in moisture content of *Carica papaya* morphotypes (oblong red 83.09%, Pear orange 81.27%, Round orange 83.99% and Round yellow 85.17%). Chandrashekar et al., (2013) reported the highest moisture content in DCS-85 (71.15%) castor genotype and lowest moisture content was observed in 48-1 genotype (63.45%).

Hence, from the foregoing, discussion it is quite evident that moisture content tend to vary in host plants. Further, moisture
content will differ within the same taxon if leaves of different maturity are taken into consideration. The present study also demonstrates this concept. The variation in moisture content can be attributed to variation in leaf size, thickness, number of stomata and their size, presence or absence of hairs on the leaves. On the other hand, the role of ecological conditions in which plants found to occur and the genetic makeup of the taxa cannot be ignored.

**Amino acid**

Amino acid in the leaves have great importance for healthy development of silkworm and quality of the cocoon produced by them (Ito, 1967). Eri larvae derive amino acids in the free form as well as in protein form from the leaves of the host plants. Amino acid obtained from the host foliage are utilised by the larvae for their growth and cocoon spinning (Jolly et al., 1972; Mane and Patil, 2000; Mainu Devi, 2012; Bose et al., 1989). Further, importance of amino acids has been intensively investigated as a specific requirement of *B. mori* and other phytophagous insects with particular reference of host plants (Vasuki and Basavanna, 1968; Slansky and Scriber, 1984). Amino acids are very important for many phytophagous insects and help them in food selection (Horie, 1980). Considerable amount of amino acids are utilised for the formation of haemolymph, development of silk glands and cocoon production.

In the present investigation the food plants showed variation with respect of amino acid content in the foliage. *R. communis* topped the list with highest content of amino acids (47.25 µmoles/g) followed by *M. esculenta* (45.75 µmoles/g) and *J. curcas* (43.50 µmoles/g). On the other hand, *C. papaya* (42.75 µmoles/g) differed
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significantly with respect to amino acid content. However, *P. rubra* (41.75 µmoles/g) and *A. excelsa* (41.50 µmoles/g) revealed more or less same amount of amino acid content. However, these two host plants differed significantly with rest of the food plants at 0.05% level of significance (Table – 4, Fig. 69).

Sannappa (1997) recorded the amino acid content in castor genotypes (Aruna 0.089% and PCS-121 0.044%). Suresh *et al.*, (2008) observed the presence of amino acid content of 0.94 mg/g in *C. papaya* leaves. Kamalesh Khokhani *et al.*, 2012 reported that 223mg of amino acid found in 100gm of sample leaves of *A. excelsa*. The present investigation is in conformity with the earlier reports. The probable reason for these variations may be attributed to genetic makeup of taxa, the fertility of the soil and also ambient climatic conditions. Apart from this lot of interconversion of foliar constituents may also be responsible.

**Total Proteins**

Leaf protein is a major determinant of nutrient quality for majority of Lepidopteran larvae (Salnsky and Feeny, 1977, Mattson, 1980). Proteins have a direct bearing on the growth and development of silkworm larvae. The presence or absence of required amount of protein content in the foliage ultimately decides the suitability or otherwise of the leaves for feeding silkworm. Proteins form the major requirement in all the phytophagous insects and are most commonly the limiting nutrient for optimal growth of insects (Qader, 1991).

In the present investigation, the host plants revealed significant variation with respect to protein content. *R. communis*
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registered highest protein content (34.75 mg/g) followed by *M. esculenta* (33.50 mg/g). *A. excelsa* (26.25 mg/g) and *J. curcas* (25.25 mg/g) recorded significant variation in this constituent. However, protein content was found to be more or less same in *C. papaya* (24.75 mg/g) and *P. rubra* (24.50 mg/g). These two plants differed significantly with rest of the food plants at 0.05% level of significance (Table – 4, Fig. 70).

Kaleemurahman and Gowri (1982) stated that the protein content varies according to the age of the leaves with highest of 28.72 % in middle, 10.77% in mature and 10.33% of protein in tender leaves of castor. Basaiah (1988) recorded the crude protein content of 19.119, 17.002 and 16.398 mg/g of leaf in Local, RC-8, and Aruna castor varieties respectively. Ayodeji .O Fasuyi (2005) recorded the crude protein in manihot varieties TMS 30555 (33.2gkg⁻¹) and Local variety (36.3gkg⁻¹). Gulriz Baycu *et al.*, (2008) stated that the protein content in *A. excelsa* was 1.896 mg.g⁻¹. Sengupta *et al.*, (2008) reported the variation in protein content of castor genotypes, highest in NBR-1 (26.89mg/g⁻¹) and lowest in RG-553 (24.87mg/g⁻¹). Mohd Iqbal Mir *et al.*, (2013) reported 24.8g of protein in *R. communis*. Jat *et al.*, (2011) reported the crude protein of 19.87% in *A. excelsa*. Godson *et al.*, (2012) recorded the protein content of *C. papaya* morphotypes (oblong red 5.84%, Pear orange 9.16%, Round orange 7.24% and Round yellow 10.80%). Chandrashekar *et al.*, (2013) also reported variation in crude protein content in castor genotypes, highest was registered in Local genotype (34.56%) and GCH-4 (31.48%) recorded the lowest content of protein. Present findings are in agreement with these reports. In the present investigation also quantitative changes in protein content in the host plant has been recorded. The probable reasons
for variation may be attributed to fertility of soil, age of the plant and genetic makeup of the plant.

**Starch**

In the present investigation, the host plants considered exhibited variation with respect to starch content in their foliage. Highest starch content was recorded in *R. communis* (5.50 mg/g) followed by *J. curcas* (4.50 mg/g), *M. esculenta* (4.25 mg/g) and *C. papaya* (3.73 mg/g). However, significant variation was not recorded with respect of starch content of *P. rubra* (3.57 mg/g) and *A. excelsa* (3.50 mg/g) (Table – 4; Fig. 71). Several workers reported the variation in starch content in food plants of muga and tasar silkworms. They have stated that the starch content increases at the maturity of leaf advances (Anonymous, 1966-67; Kohli *et al*., 1969; Sinha *et al*., 1986; Anilkumar P. Grampurohit, 1997). However, Jolly *et al*., (1974) have observed a declining trend of starch in *Shorea robusta*, *T. Arjuna* and *T. tomentosa* as the leaf maturity advances. The amount of starch present in the foliage of different host plants tend to vary in their concentration (Agarwal *et al*., 1980).

Starch is a primary product of photosynthesis in the chloroplasts of plants. It plays an important role in the day-to-day carbohydrate metabolism of the leaf, and its biosynthesis and degradation represent major fluxes in plant metabolism. Starch serves as a transient reserve of carbohydrate which is used to support respiration, metabolism, and growth at night when there is no production of energy and reducing power through photosynthesis, and no net assimilation of carbon. It is an
important ingredient for phytophagous insects. It acts as a phagostimulant (Carmen Hostettler et al., 2011).

**Total soluble and reducing sugars**

Soluble and reducing sugars play a very important role in silkworm nutrition. These metabolic compounds help in the healthy growth and development of silkworm larvae. Sugar concentrations vary considerably in relation to levels of light and typically increase during the day and decline at night when there is a conversion of sugar to starch. These sugars induce the feeding in phytophagous insects. It is also known that for many insects feeding on different plants, phagostimulatory effects are likely to be dominated by sugars. It has also been established that the amount of feeding on leaves is correlated with their sugar content in the foliage. However, such examples do not prove that sugar is the only factor affecting feeding, but they indicate that the sugar content of leaves is likely to be very important in food selection (Boppre, 1984, Nishida and Fukami, 1990; Bongale and Chaluvachari, 1993).

**Total soluble sugars**

With respect to total sugar content, *R. communis* registered highest soluble sugar content (66.25 mg/g) followed by *M. esculenta* (64.50 mg/g), *J. curcas* (62.25 mg/g) and *A. excelsa* (61.75 mg/g). Significant variations were not registered with respect of total soluble sugar content of *C. Papaya* (58.50 mg/g) and *P. rubra* (58.25 mg/g) (Table – 4, Fig. 72).
Reducing sugars

The host plant considered for the present investigation revealed differences with respect of quantity of reducing sugar content in the foliage. Highest reducing sugar was observed in *R. communis* (69.75 mg/g) followed by *C. papaya* (69.50 mg/g). Significant variations were not observed in these host plants. *M. esculenta* recorded 67.75 mg/g. *P. rubra* observed 66.50 mg/g. Lowest reducing sugar was recorded in *J. curcas* (64.75 mg/g) and *A. excelsa* (64.75 mg/g) (Table – 4, Fig. 73).

Sengupta et al., (2008) reported soluble sugar in castor genotypes, NBR-1 exhibits maximum sugar content (36.45 mg/g⁻¹) and minimum sugar content was registered in RG-3056 (34.04 mg/g⁻¹). Alok sahay and Kapila (1993) recorded variation in reducing and total soluble sugar content in three primary host plants of tropical tasar silkworm *viz.*, *T. Arjuna*, *T. Tomentosa* and *S. robosta*. Banarjee et al., (1993) also confirm the variations in the total sugar and reducing sugar contents in host plants of the temperate tasar silkworm. Working on seven host plants they recorded significant variations in the levels of total soluble and reducing sugars. Kohli et al., (1969) opined that total soluble and reducing sugar contents of different host plants of tasar silkworm differ considerably from one another. In the present investigation also the similar results in reducing and total soluble sugar content were recorded. Variation in the sugar content may be due to reduction in the leaf lamina and malformation of leaves.
Total Phenol content

Plants contain many bioactive molecules which are responsible for various benefits offered by plants. Major antioxidant compounds present in the plants are phenols. Phenols contain one or more aromatic rings with phenolic hydroxyl groups. Phenolic compounds are in general considered as responsible for disease resistance in plants and they function as hydrogen donors or acceptors in oxidation reaction and they play a decisive role in lignifications. Earlier workers have reported that the resistant varieties possess higher content of total phenols than the susceptible ones (Lily and Ramadasan, 1979; Sharma et al., 1983). Some phenolics show anti auxin activities and act as plant growth inhibitors. The role of phenolic substances has been extensively studied in many crops. Phenolics in general comprise anthocyanins, leuco-anthocyanins, anthoxanthins, hydroxyl cinnamic acids and coumarin derivatives. These are called polyphenols (Goodman et al., 1967).

With respect to phenolic content, R. communis (6.75 mg/g) recorded highest phenol content. There was no significant differences in phenol contents of M. esculenta (5.75 mg/g) and P. rubra (5.75 mg/g). However, A. excelsa recorded 5.12 mg/g of phenol content. The host plants C. papaya (4.64 mg/g) and J. curcas (4.25 mg/g) differed significantly in phenolic content (Table – 4, Fig. 74).

Suresh et al., (2008) observed 0.24 mg/g of phenol content in C. papaya leaves. Tahir Mughal et al., (2010) recorded the presence of phenol content in R. communis leaves. Shashank Bhatt and Suresh Dhyani (2012) reported the presence of phenol content in
A. excelsa leaves. Nirmala et al., (2010) observed 21.10% of phenolic content in P. rubra leaves. Krishnaveni et al., (2013) reported the phenol content of R. communis (2.4 mg/g) and C. papaya (4.0 mg/g). Present results on the phenolic content in different host plants of eri silkworm are in agreement with these reports.

**Chlorophyll content**

Chlorophyll is an essential and important constituent in the foliage. Greenness is an indication of the presence of rich chlorophyll in the foliage. Chlorophyll acts as a connecting link between the organic and inorganic components of the ecosystem. There is a strong correlation between chlorophyll content with the quality of the foliage. There are two types of chlorophyll found in plant. Chlorophyll ‘a’ and chlorophyll ‘b’. Chlorophyll ‘a’ is a specific form of chlorophyll used in oxygenic photosynthesis. In the presence of light, the silkworm synthesizes the red fluorescent protein from chlorophyll ‘a’ which has anti-viral property, thus reducing the incidence of viral disease in eri silkworm (Chandrashekar et al., 2013). It absorbs most energy from wavelength of violet blue and orange red light. Chlorophyll ‘b’ is a form of chlorophyll helps in photosynthesis by absorbing light energy (Levent Inanc, 2011).

**Chlorophyll ‘a’**

The host plants studied showed variation with respect of chlorophyll ‘a’ content in the leaves. R. communis recorded maximum chlorophyll ‘a’ content (2.91 mg/g) than any other host plants considered for the present investigation. M. esculenta registered 2.75 mg/g of chlorophyll followed by J. curcas (2.25
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mg/g). *C. papaya* (1.94 mg/g) and *A. excelsa* (1.86 mg/g) revealed more or less same amount of chlorophyll ‘a’ content. However, these two plants differed significantly with rest of the food plants at 0.05% level of significance. *P. rubra* recorded lowest content of chlorophyll ‘a’ (1.66 mg/g) among the host plants studied (Table – 4, Fig. 75).

**Chlorophyll ‘b’**

The host plants considered for present investigation did not show much variation in chlorophyll ‘b’ content. Highest was recorded in *P. rubra* (0.93 mg/g) followed by *A. excelsa* (0.91 mg/g). Variations were not registered in *R. communis* (0.80 mg/g), *M. esculenta* (0.80 mg/g) and *C. papaya* (0.80 mg/g). Chlorophyll ‘b’ content was slightly low in *J. curcas* (0.75 mg/g) (Table – 4, Fig. 76).

**Total chlorophyll content**

The host plants studied showed variation with respect to total chlorophyll content in the leaves. *R. communis* recorded maximum chlorophyll content (3.70 mg/g) followed by *M. esculenta* (3.50 mg/g) and *J. curcas* (3.00 mg/g). *A. excelsa* (2.77 mg/g) and *C. papaya* (2.75 mg/g) revealed more or less same amount of total chlorophyll content. However, these two plants differed significantly with rest of the food plants at 0.05% level of significance. The host plant *P. rubra* (2.60 mg/g) observed less amount of total chlorophyll content compared to other host plants (Table – 4, Fig. 77).

total chlorophyll contents to be 1.226, 1.353 and 2.579 mg/g respectively with local castor genotypes. Similarly, Chandrappa et al., (2005) recorded higher chlorophyll ‘a’ (2.948), ‘b’ (1.251) and total chlorophyll (4.234) mg/g contents in 48-1 castor genotype. However, the same were lower with JI-226 genotype (2.387, 0.607 and 2.993 mg/g). Chandrashekar et al., (2013) also reported the marked differences among the leaves of castor genotypes in respect of chlorophyll ‘a’, ‘b’, and total chlorophyll contents. Significantly higher chlorophyll contents were recorded in 48-1 genotype (2.965, 1.156. 4.115 mg/g) and same were less with DCS-9 (2.425, 0.692 and 3.115 mg/g). Sengupta et al., (2008) reported the total chlorophyll content in NBR-1 castor genotype to be 2.16 mg/g⁻¹. In the presence of light, the silkworm synthesizes the red fluorescent protein from chlorophyll ‘a’ which has anti-viral property, thus reducing the incidence of viral disease in eri silkworms. Other host plants viz., M. esculenta, J. curcas, P. rubra, A. excelsa and C. papaya have not received much attention by the earlier researchers related to chlorophyll analysis.

REARING TRIALS

The performance of the host plants based on growth and yield parameters will lead to partial conclusion about the fitness of a particular host plant for commercial exploitation. The growth and development of eri silkworm, Philosamia ricini is known to vary depending on the quality leaf used as food source, which inturn indicated by commercial characteristics of cocoon crop. It is quite evident that tender, succulent and nutritious leaves are known to favour the good growth and development of young age silkworms. Whereas, progressively mature leaves are required for the lateage silkworms (Krishnaswami et al., 1978; Devaiah et al., 1978).
**Larval duration (Days)**

Eri worms were reared from hatching to spinning on the leaves of *R. communis, M. esculenta, J. curcas, P. rubra, A. excelsa* and *C. papaya* independently. The total larval duration was significantly shorter (19.75 days) when eri worms fed on *R. communis*. The total larval duration was longer in case of *C. papaya* fed eri silkworms (25.50 days). *M. esculenta* recorded 21.25 days larval duration. Significant variations were not observed in *J. curcas* (23.00 days) and *A. excelsa* (23.50 days). However, *P. rubra* recorded 24.75 days of larval duration (Table – 5; Figs. 78 – 89 & 90).

Devaiah *et al.*, (1978) reported 21-28 days larval duration of eri worms when reared on castor leaves. Thangavelu and Phukhon (1983) have recorded larval duration of 15-17 days on castor leaves, 18-19 days on kesseru leaves, 18-20 days on tapioca leaves and 18-26 days on barkesseru leaves during different seasons. Reddy *et al.*, (1989) observed minimum larval duration of 22.36 days when reared on castor and it was maximum (37.33 days) on *A. excelsa*, 31.58 days on tapioca, and 31.27 days on *P. rubra* leaves. Rajaram and Saratchandra (1998) recorded minimum larval duration of 20 days on castor followed by 24 days on kesseru and it was maximum (29 days) on Phutkoul. Hazarika *et al.*, (2003) observed shortest larval duration on castor (18-34 days) and slightly higher values on tapioca leaves (19-40 days) during different seasons. These reports slightly differ from the present investigation. Difference in larval duration might be due to the host leaf or selective preference and conversion efficiency exerted by the insect itself.
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With respect to combinations of host plants eri larvae which were fed with *R. communis* leaves during 1st instar to 3rd instar and feeding with *M. esculenta*, *A. excelsa* and *J. curcas* from 4th instar to spinning separately recorded mean larval duration of 20.67 days, 23.33 days and 24.67 days respectively (Table – 6; Fig. 97). Mukul Deka *et al.*, (2011) reported 22.33 days to 27.33 days of larval duration in the combination of castor (1st to 3rd instar) and kesseru leaves (4th instar to spinning); 21.33 days to 27.76 days of larval duration in the combination of castor (1st to 3rd instar) and tapioca leaves (4th instar to spinning). These earlier reports differ significantly from the present observed results.

**Larval weight (g)**

Host plants directly influence growth and development of larvae. The quality and quantity of silk produced by a ripe larva directly depend on the quality and quantity of the silk contents in the silk gland (Mitalee Baruah, 2012). Healthy growth of the larva ensures luxuriant growth of the silk gland in turn results in the maximum production of silk. Eri larvae which were fed on *R. communis* recorded the highest larval weight of 8.45 g followed by *M. esculenta* (7.61 g). Lowest larval weight was recorded in *J. curcas* (5.84g). Significant variations were not observed in *A. excelsa* (6.23 g), *P. rubra* (6.02 g) and *C. papaya* (5.92 g) (Table – 5; Figs. 78 – 89 & 91). The present results are in line with the earlier reports of Rajesh kumar and Elangovan (2010) who recorded the maximum larval weight in castor (7.38g) followed by tapioca (6.45g), papaya (6.18g) and minimum larval weight was observed in *Jatropha* (5.55g). However, several researchers have reported different values, related to larval weight when the eri worms were fed with the leaves of different plant species. Rajaram and Saratchandra (1998)
observed highest larval weight of 5.80g on castor followed by 5.30g on kesseru and it was lowest (4.90g) on phutkoul. Neelu Nangia et al., (2000) reported that the mature larval weight was 5.60g on castor followed by 5.05g on barkesseru, 4.90g on gulancha, 4.80g on tapioca and minimum was observed on papaya (4.50g). Devaiah et al., (1985) recorded the maximum larval weight in castor (4.648g) followed by white plumeria (4.512g), red plumeria (3.349g) and lowest was observed in tapioca (1.861g). Reddy et al., (1989) reported that the weight of mature larvae were maximum in castor (4.79g) followed by tapioca (4.60g) and A. excelsa (4.39g) and lowest larval weight was observed in P. rubra (3.63g).

The eri larvae which were reared on R. communis leaves from 1\textsuperscript{st} instar to 3\textsuperscript{rd} instar and M. esculenta, A. excelsa and J. curcas during 4\textsuperscript{th} instar and 5\textsuperscript{th} instar separately recorded mean larval weight of 6.48 g, 6.00 g and 5.78 g respectively (Table -6, Fig. 98).

Mukul Deka et al., (2011) conducted eri rearing during four different seasons and recorded 5.47g to 6.07g of larval weight in the combination of castor (1\textsuperscript{st} to 3\textsuperscript{rd} instar) and kesseru leaves (4\textsuperscript{th} instar to spinning), 5.20g to 7.23g of larval weight in the combination of castor (1\textsuperscript{st} to 3\textsuperscript{rd} instar) and tapioca leaves (4\textsuperscript{th} instar to spinning).

**Effective rate of rearing (%)**

Source of food is the key factor in improving effective rate of rearing in insects. Therefore, commercially viable insects have to be managed through proper balanced diet. In the present study, ERR of 92.14% was recorded when the eri worms were reared on the leaves of R. communis followed by M. esculenta (89.60 %). Much
difference was noticed when the eri worms were reared on other host plants from brushing to spinning. *J. curcas*, *P. rubra*, *A. excelsa* and *C. papaya* leaves recorded a mean ERR of 85.47%, 83.70%, 81.65% and 80.27% respectively (Table – 5; Figs. 78 – 89 & 92).

Present findings are in agreement with that of Rajesh kumar and Elangovan (2010). They have recorded the highest ERR % in castor (91.05) followed by tapioca (88.00%) and *Jatropha* (86.50%) and lowest ERR % was observed in papaya (85.60%). Thangavelu and Phukon (1983) have reported considerably less ERR of 77.50%, 79.50%, 74.50% and 65.00% on castor, kesseru, tapioca and barkesseru leaves respectively. Neelu Nangia *et al*., (2000) recorded the highest ERR on castor (94.65%) followed by tapioca (77.25%), barkesseru (77.20%), gulan change (64.80%) and minimum ERR was observed on papaya (61.49%). Hazarika *et al*., (2003) recorded the best ERR on castor (90.60%) followed by kesseru (87.10%) and tapioca (69.10%). According to Debaraj *et al*., (2003) the ERR on payam (*Evodia flaxifolia*) was 58 percent during May–June and 93.33 percent in November.

Eri silkworms were fed with the leaves of *R. communis* during 1st instar to 3rd instar periods and then fed with leaves of *M. esculenta*, *A. excelsa* and *J. curcas* from 4th instar to spinning independently. The mean ERR of 80.00%, 76.00% and 71.33% respectively (Table – 6, Fig. 99). Earlier workers have also reported variation in ERR %. Mukul Deka *et al*., (2011) recorded 79.67% to 90.53% of ERR in the combination of castor (1st to 3rd instar) and kesseru leaves (4th instar to spinning), 78.80% to 89.46% of ERR in the combination of castor (1st to 3rd instar) and tapioca leaves (4th instar to spinning).
## Cocoon weight (g)

Nutrition plays an important role in improving the growth and development of silkworm. It is stated that silk production is dependent on the larval nutrition and nutritive value of host plants plays a very effective role in producing good quality cocoons (Chandrashekar et al., 2012).

Notable differences were recorded with cocoon weight as influenced by the different host plants. Significantly higher cocoon weight was recorded on *R. communis* leaves (3.85 g). Cocoons procured by rearing the larvae on the leaves of *A. excelsa* from brushing to spinning weighed less (3.20 g) when compared to cocoons obtained by feeding the larvae with *R. communis* leaves. Likewise, cocoons were small in size and weighed less when the larvae fed with *M. esculenta* (3.17 g) leaves. *P. rubra* (3.03 g) and *C. papaya* (3.00 g) revealed more or less same amount of cocoon weight when compared to the other host plants. *J. curcas* recorded the lowest weight of cocoons (2.88 g) (Table – 5; Figs. 78 – 89 & 93).

Devaiah and Dayashankar (1982) reported highest cocoon weight (2.421 g) when eri worms were reared on castor and lowest on red plumeria (1.529 g). Further, in another research article Devaiah et al., (1985) reported that the cocoon weight was maximum in case of castor (2.116 g) compared to tapioca (1.884 g), white plumeria (1.336 g) and red plumeria (1.700 g). Reddy et al., (1989) observed the highest cocoon weight in castor (4.79 g) followed by tapioca (4.60 g), *A. excelsa* (4.39 g) and *P. rubra* (3.63 g). Neelu Nangia et al., (2000) recorded highest cocoon weight in castor (2.11 g) followed by barkesseru (1.99 g), tapioca (1.88 g), gulancha (1.87 g) and papaya (1.77 g). Results are in broad agreement with the
observation of Rajesh Kumar and Elangovan (2010) who reported the highest cocoon weight in castor (3.59g) followed by tapioca (3.20g), Jatropha (2.70g) and papaya (2.65g). The variation may be due to an impact of nutrition as influenced by these host plants.

Eri silkworms were reared on the leaves of R. communis during 1st instar to 3rd instar periods and then fed with leaves of M. esculenta, A. excelsa and J. curcas separately from 4th instar to spinning recorded. The mean cocoon weight of 3.31g, 3.16 and 2.67g respectively (Table – 6, Fig. 100).

Mukul Deka et al., (2011) recorded highest cocoon weight (3.90g) during spring season in the combination of castor (1st to 3rd instar) and kesseru leaves (4th instar to spinning); 3.51g of cocoon weight in the combination of castor (1st to 3rd instar) and tapioca leaves (4th instar to spinning).

**Pupal weight (g)**

Healthier larvae show greater pupation rates. Eri worms fed on the leaves of R. communis showed highest pupal weight (3.03g) than other host plants studied. A. excelsa and M. esculenta recorded the mean pupal weight of 2.74g and 2.67g respectively. There was no significant difference in the pupal weight of J. curcas (2.57g) and C. papaya (2.56g). Lowest pupal weight was registered in P. rubra (2.44g) (Table – 5; Figs. 78 – 89 & 94). Devaiah and Dayashankar (1982) stated that the pupal weight depends on the type of hosts provided for the worms. The highest pupal weight (2.153g) was recorded on castor and lowest (1.403g) was recorded in red plumeria. Likewise, Devaiah et al., (1985) recorded maximum pupal weight (1.824g) in castor, followed by tapioca
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(1.634g), white plumeria (1.255g) and red plumeria (1.488g). The results are slightly comparable with the earlier report of Reddy *et al.*, (1989). The highest pupal weight (2.74g) was recorded on *R. communis* and tapioca (2.73g) followed by *A. excelsa* (2.66g) and lowest was recorded in *P. rubra* (1.94g). Neelu Nangia *et al.*, (2000) reported the pupal weight of 1.79, 1.76, 1.68, 1.63 and 1.68g on castor, barkesseru, tapioca, gulanch and papaya respectively. Debaraj *et al.*, (2003) observed the maximum pupal weight (2.94g) on castor followed by tapioca (2.61g), payam (2.50g) and kesseru (2.43g) when reared during November month.

Eri larvae fed with *R. communis* leaves up to 3rd instar and from 4th instar onwards feeding with *M. esculenta*, *A. excelsa* and *J. curcas* leaves separately till spinning recorded the mean pupal weight of 2.86g, 2.69g and 2.25g respectively (Table – 6, Fig. 101). Mangammal (2008) reported the pupal weight of 1.79g of eri silkworms fed on artificial diet up to 3rd instar and castor leaves from 4th instar to fifth instar indicating these value differ depending upon the food source and nutritional content of the host plant.

**Shell weight (g)**

Significantly highest shell weight was recorded on *R. communis* (0.54g) followed by *M. esculenta* (0.49g). However, same amount of shell weight was recorded in *J. curcas* (0.46g) and *A. excelsa* (0.46g). Shell weight is comparatively low in *C. papaya* (0.44g) and *P. rubra* (0.43g) (Table – 5; Figs. 78 – 89 & 95). These results are comparable with the report of Rajesh kumar and Elangovan (2010) who recorded the highest mean shell weight of 0.53g on castor, followed by tapioca (0.45g), *Jatropha* (0.37g) and lowest mean shell weight was observed in Papaya (0.28g). Devaiah
et al., (1985) reported highest shell weight on castor (0.292g), followed by tapioca (0.250g), red plumeria (0.212g) and white plumeria (0.149g). Reddy et al., (1989) reported the highest shell weight of 0.38g on castor followed by 0.33g on tapioca, 0.32g on A. excelsa and 0.26g on P. rubra leaves. Neelu Nangia (2000) reported the shell weight of 0.340g, 0.266g, 0.23g, 0.116g and 0.15g on castor, gulancha, tapioca, barkesseru and papaya respectively.

Eri larvae which were fed with R. communis leaves during 1st to 3rd instar and feeding with M. esculenta, A. excelsa and J. curcas leaves separately from 4th instar to spinning recorded the mean shell weight of 0.48g, 0.46g and 0.41g respectively (Table – 6, Fig. 102). Mukul Deka et al., (2011) recorded highest shell weight (0.590g) during spring season in the combination of castor (1st to 3rd instar) and kesseru leaves (4th instar to spinning), 0.556g of shell weight in the combination of castor (1st to 3rd instar) and tapioca leaves (4th instar to spinning).

Shell ratio (%)

Higher shell ratio determines the quantity of raw silk that can be reeled from a cocoon. In general, if shell ratio is higher, more the silk can be obtained. Eri worms which were fed on R. communis, M. esculenta, J. curcas, P. rubra, A. excelsa and C. papaya recorded the mean shell ratio of 14.19%, 15.69%, 15.24%, 15.15%, 14.14% and 14.67% respectively (Table – 5; Figs. 78 – 89 & 96). Devaiah et al., (1985) recorded the shell ratio of 13.83% in castor followed by 13.09% in white plumeria, 12.41% in tapioca and 11.37% in red plumeria. Reddy et al., (1989) reported the highest shell ratio percentage in castor (12.20%) followed by P. rubra (11.85%),
A. excelsa (11.05%) and lowest shell percentage was recorded in tapioca (10.78g). Deebraj *et al.*, (2003) reported the maximum shell ratio of 11.44% when eri worms were reared on castor followed by 11.34% on payam, 11.31% on kesseru and 10.61% on tapioca. Rajesh Kumar and Elangovan (2010) recorded the highest shell ratio of 14.74% in castor followed by tapioca (14.05%), Jatropha (13.65%) and Papaya (12.10%). The present findings are in conformity with the above cited research data.

The eri worms were reared on *R. communis* leaves up to 3 rd instar and then fed with *M. esculenta*, *A. excelsa* and *J. curcas* leaves separately in 4 th and 5 th instar. The mean shell ratio of 14.50%, 14.55% and 15.35% respectively were recorded (Table – 6, Fig. 103). Mukul Deka *et al.*, (2011) recorded highest shell ratio (16.07%) during Autumn season in the combination of castor (1 st to 3 rd instar) and kesseru leaves (4 th instar to spinning), 15.88% of shell ratio in the combination of castor (1 st to 3 rd instar) and tapioca leaves (4 th instar to spinning).

**Marketing of eri cocoons**

Ericulture is ideally suited for improving the rural economy of the country since, it is practiced as a subsidiary industry to agriculture. However, this industry is hindered by various constraints like -

- Absence of systematic plantation of eri food plants for a steady supply of leaves for rearing.
- Lack of well planned extension programs to introduce ericulture to the states where the host plants are found in abundance
Discussion and Conclusions

- Vanya silk sector in general, eri segment in particular has not been fortunate enough like mulberry sector to enjoy a well regulated and competitive market facility (Bhatia et al., 2010).

Currently, ericulturists are largely rely upon the state run co-operative societies that purchase the cocoons as per the rates fixed by the concerned department of sericulture. Often, cocoons are disposed in the weekly markets available locally and ericulturists are subjected to exploitation by the middleman.

Tazima (1958) stated “the sericulture in India particularly needs to develop based on prevailing ambient, aptitude and attitude of the population. Suitable silkworm races have to be evolved and introduced, utilizing appropriate technology for reeling, stressing post harvest programme for treatment of cocoons and grade silk as well as organising efficient marketing mechanism”. Hence, it is suggested that the Central Silk Board, Ministry of Textiles, Government of India may asses the situation of marketing and its backward and forward linkages to fill up the lacunae, so that the poor and disadvantaged are compensated suitably and their suffering are alleviated. Since ericulturists essentially belong to the weaker section of the society and most of them are BPL tribal families such an obvious support seems reasonable.

The foregoing observations plus discussion on ‘Biosystematics and Bioassay in food plants of eri silkworm, Philosamia Ricini Hutt clearly demonstrated the distinctness in several aspects like distribution, morphological account, biochemical constituents and also in rearing performance of the six host plants studied. In the rural region, sericulture has to be developed as a pleasant enterprise benefiting the poor villagers.
need. Keeping these views, present study concludes/recommends the following:

- Since the binomial nomenclature of the eri silkworm is treated differently by earlier workers, a thorough revision strictly in accordance with the rule/guidelines of International code of Zoological Nomenclature (ICZN) is suggested.

- The taxonomic status of the plant species studied were found distinct. Exomorphic characteristic features are specific to each taxon. Hence, phenotypic characters of these taxa recorded in the present work could be considered for genotypic tagging.

- In overall biochemical and rearing results, *Ricinus communis* (castor plant) demonstrated its superiority proving it to be unquestionably the most ideal host plant for rearing eri silkworm, *Philosamia ricini*.

- *Manihot esculenta* (tapioca/cassava) has also proved as the host plant of next choice with respect of biochemical parameters and rearing performance.

- Other host plants studied (*Jatropha curcas*, *Plumeria rubra*, *Ailanthus excelsa* and *Carica papaya*) though supported the growth and development of eri larvae they proved to be less productive for commercial purpose. However, the leaves of these host plants could be utilized during scarcity for rearing purpose and their economic produce could be made use in order to uplift the rural economy.

- All the taxa studied are multipurpose plants required for sericulture, horticulture, Animal husbandry (fodder purpose) and Agro-forestry programmes. Further, many parts of these plants also provide medicine to cure several deadly diseases.
Discussion and Conclusions

Therefore, cultivation of these plants is recommended in barren/waste land, forest region, on the bunds of irrigation channel, community land, along the borders of the cultivated field, so that their produce could be exploited to generate subsidiary income and it will go a long way in poverty alleviation.

- Sequential rearing schedule clearly proved that the combination of host plants *viz.*, castor and tapioca is beneficial for commercial rearing of eri silkworms. Hence, feeding castor leaves from brushing to 3rd instar and interchanging with juvenile leaves of tapioca during 4th and 5th instar periods is recommended.

- Due to the lack of well designed extension programmes; absence of systematic plantation of eri host plants; paucity in providing assured market facility for disposal of eri cocoons and other end products, it is recommended that the Central Silk Board, Ministry of Textiles, Government of India to launch action plan to bridge the existing gap so that the poor eri rearers mostly weaker section of the society coming under BPL tribal families are supported.