REVIEW OF LITERATURE

The Literature pertaining to distribution, morphological features, pollen studies, phytochemical constituents, rearing performance and marketing related issues of eri silkworm, *Philosamia ricini* have been critically reviewed and presented here briefly.

GENERAL ASPECTS


Ye Geongyin and Hu Cui, (1996) recorded the distribution and biological characteristics of *Philosamia cynthia ricini*. In the world, there are about 400-500 species of silk producing moths. Most of the wild silkmoths belong to the families Saturniidae, Notodontidae, Lasiocampidae and Pieridae. *Philosamia cynthia ricini* is mainly distributed in India, China, Japan, Cuba, Egypt, France
and Italy. The number of generation varies from region to region. The larvae feed on the leaves of *Ricinus communis*, *Manihot utilissima*, *Heteropanax fragrans*, *Carica papaya*, *Evodia flaxinifolia*, *Ailanthus excelsa*. The total larval duration is 23-30 days under 15-20°C, 18-23 days under 20-25°C, 14-18 days under 25-30°C. A female moth lays about 500 eggs during the whole adult period. The cocoon is spindle-shaped and its colour is white, grey yellow, cream-coloured or red brown. Length and width of cocoon are 3.5-4.5 cm and 1.5-1.8 cm respectively. The cocoon weight, shell weight, filament length and filament size are 2.3g-3.2g, 0.35-0.45g, 300-567 m and 2.35-2.36 denier respectively. The silk is used for producing spun-silk fabrics.

Monalisa Dutta *et al.*, (2000) recorded the morphological characteristics of eight eri eco-races (Borduar, Titabar, Khanapara, Dhanubhanga, Mendipathar, Sille, Nongpoh and Kokrajhar) and their host plants found in different zones of Northeastern India. According to these authors, eri larvae possess yellowish green head, light blue integument and usually covered with white powdery secretions. Cocoons are oval in shape. Moth colour found variable, but always solidly white on the dorsal surface of the abdomen. Ground colour was usually gray or grayish brown, rarely reddish, but occasionally olive gray. Wing pattern was heavily marked by white in antemedian and postmedian lines.

Reddy (2000) stated that there has been confusion regarding the taxonomic status on the genus *Samia* Hubner, especially on its nomenclature. *Samia cynthia* is one of the most economically important non-mulberry silk moths, popularly called “Ailanthus or Eri silkmoth” is represented by a single species *cynthia* Drury with several sub species, including *ricini* Boisduval which is a
domesticated race. These two (cynthia and ricini) were treated as separate species by Hampson (1892), who differentiated ricini from cynthia on the basis of abdomen having segmented band of white hairs instead of tufts. Its fore wing with an antemedial line is more angled and generally joining the postmedial band. He opined that the current valid name of the domesticated Eri silkworm is “Samia cynthia ricini.” It is distributed in India, Bhutan, Bangladesh, Sri Lanka, Myanmar, Indonesia, and China.

Reddy et al., (2000) recorded the morphology and embryonic development of eri silkworm egg. They stated that the eri eggs are oval, flat, broader at anterior end and narrower at posterior end. Egg shell or chorion is the outer most cover, enclosing the nucleus at the anterior micropylar end. Below the chorion, a thin vitelline membrane covers the protoplasm and the yolk. Egg is whitish and appears yellowish due to gum coat on the surface. The development of embryo from oviposition till hatching is mainly dependent on the temperature during incubation. The embryo requires 10 days (240 hrs) to complete development at a constant temperature of 23.50 ± 5°C and relative humidity of 75.00 ± 1.00 per cent.

Sannappa et al., (2002) listed the Castor hybrids and varieties recommended for cultivation under different agroclimatic conditions of India. They have recommended the Castor hybrids like GAUCH-1, GCH-2. GCH-4, DCH-32, GCH-5, DCH-177, GCH-6, TMVCH-1 and varieties such as Aruna, Bhagya, Sowbhagya, RC-8, VI-9, Jwala, SA-2, TMV-5, TMV-6, Co-1, T3. T4, Jyoti (DCS-9), GC-2 (SKI-73), Kranti (PCS-4) and AKC-1 for rearing eri silkworm since they encourage good growth and development resulting in higher eri silk production.
Chowdhury (2004) recorded the origin, evolution and distribution of silkworm species found in the Eastern region of India. He stated that the actual rearing of silk worms began about 45 centuries ago along the bank of river Huang Ho – known as the ‘Nucleus area of North China’. He opined that the genus *Samia* has 12 species which found to occur in the Oriental region, out of 12 species only the *ricini* is reared for production of silk.

Kar *et al.*, (2005) studied the environmental regulation of emergence, fecundity and hatching of eri silkworm in different seasons reared on the leaves of castor. Winter season was found to be best season followed by autumn, spring, rainy and summer seasons in order to conduct commercial crops. They stated that environmental conditions during summer are less suitable for grainage and commercial rearing of eri silk moth.

Singh (2005) worked on the utilization of ericulture by-products. The eri silkworm guts are used in medical industry as suture material. Eri pupae provide by-products in the form of supplementary protein. One hundred grams of dried eri silkworm provide 75% of the average individual’s daily protein requirement of vitamins and minerals. He opined “the protein, fat, vitamins and calories of eri silkworms are comparable to meat and fish”. He called eri pupae as “Poor man’s meat”. Further, silkworm litter forms a valuable material in the preparation of organic manure. He concluded that extensive and sustainable exploitation of the wastes of the ericulture and castor culture can help to improve the economies of both ericulturists and castor farmers. These by-products are so easily available and offer excellent business potential.
Manohar and Suryanarayana (2008) have stated that the natural plant and animal products are serving as human food in many parts of the World. The silkworms too exploited as potential diet. Further, they stated that the ericulture, an subsidiary occupation of rural hilly tribal populace, and the waste by-products of eri culture is of immense potential in generating the sources of human food, chocolates, animal food, fertilizers, medicines, cosmetics, etc. The advantage of taking out the live pupae without damaging the quality of eri silk, made the tribal communities to use the pupae as rich food source. The richness of the pupae in protein (60%), fats (25%), amino acids (8%), vitamins and minerals, made their use as food as the daily requirement of balanced diet. In terms of food value it is scoring on par with meat and fish. The eri pupae smoked in ash and hot coal, boiled in salt water followed by semi drying, looks like blackened peanuts or cashew nuts and can be used as ready to eat dishes. The prospect of utility of eri pupae as an alluring dish in addition to its several uses will ensure additional income for the eri rearers and in the upliftment of the socio-economic condition of the poor tribal people.

Sivilai Sirimungkararat et al., (2008) reared eri silkworms on Manihot varieties, viz, Manihot glaziovii and Manihot esculenta var. variegata. They stated that the eri worms are rich in protein content (66 percent) compared to mulberry silkworm (53-54 percent). Various eri food recipes were developed by them using late fifth instar larvae, prepupae and pupae as the principal raw materials, combined with herbs, vegetables and spices. They opined that the eri silkworms are safe ‘green’ edible insects. Further, eri food has excellent potential as a protein source and security food for school children, rural dwellers and local communities.
Teotia et al., (2008) reported the utilization of eri pupae. The eri pupae have a high calorific value of 460 kcals/100g on dry basis and 133 kcals/100 g on fresh weight basis, which is higher to cow’s milk (69 kcals/100 ml), eggs (163 kcals/10 g), chicken (120 kcals/100 g), white sugar (385 kcals/100 g) and raw carrot (42 kcals/100 g). Further, eri pupae are rich in protein (53.3%), fats (25.6%), and carbohydrates (4.4%). Pupal protein contains all essential amino acids including high concentration of leucine, which is important human nutrition. The pupa also has sufficient quantities of calcium, iron and other minerals required for growth and development, all together making it comparable to meat and fish. They opined that the ericulture industry is mainly promoted for the production of Eri Spun Silk for textile purpose, however many waste like eri pupae, stems, rearing waste, silk waste, etc can be harnessed for a variety of purposes.

Ratha and Paramatha (2009) recorded the important morphological characters and the desirable traits available in 12 Jatropha species (J. curcas, J. gossypifolia, J. glandulifera, J. multifida, J. tanjorensis, J. podagrica, J. integerrima, J. pandurifolia, J. villosa, J. nana, J. heynei, J. maheswari). They stated that “among the available Jatropha species, the physic nut (J. curcas) is found to be promising to feed the future green energy demands”. 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.

Verma and Gaur (2009) considered Jatropha curcas as a potential source of non-edible fuel producing plant. They also reported its medicinal properties. They stated that it grows well in the tropical and subtropical climate in India. The seed contains 40-

*Biosystematics and Bioassay in food plants of Eri Silkworm, Philosamia ricini Hutt*
50% viscous oil known as ‘curcas oil’. They opined “this potential biodiesel crop can be exploited for major economic activity to provide income and employment opportunities to the rural communities”.

Chutia et al., (2010) documented the vanya silk varieties found in Nagaland. According to these authors, majority of the non-mulberry silk moths belong to the family Saturniiidae which constitute one of the largest groups of Lepidoptera comprising about 1200-1500 species distributed all over the world and out of which only 80 species are known to produce silk of economic value. Non-mulberry silk moth’s *viz.*, eri, muga and temperate tasar are commercially exploited in Nagaland. Nagaland harbours 15 species of wild silkmoths including the cultivated three species *Samia ricini*, *Antheraea assamensis* and *Antheraea proylei*. The usage of silk of *Samia* species is embedded with the cultural heritage of people of North-eastern India. The genus *Samia* contains 19 species, out of which wild eri, *S. canningi* and its domesticated variety, *S. ricini* are found abundantly in different areas of Nagaland. While *Samia ricini* (domesticated eri silkworm) is exploited traditionally for production of eri pupae and spun yarn.

Meena Misra and Amarendra Misra (2010) reported that the *Jatropha* plants can prevent soil erosion, grown as live fence and used as an alternate commercial crop. Its seed oil can be used as a feed stock for biodiesel, making soaps, glue or dye industry. The seed cake is rich in nitrogen and phosphorus, and can be used as manure. They also reported that all parts of the plant including seeds have medicinal properties.

Jat et al., (2011) recorded the occurrence of *Ailanthus* (Ardu) species in abundance in the arid regions of Rajasthan. Ardu is a

*Biosystematics and Bioassay in food plants of Eri Silkworm, Philosamia ricini* Hutt
multipurpose tree used for many purpose including timber, fuel, fodder, ethnomedicine, etc. The wood is white and lustrous, with a yellowish colour. Wood is straight grained, fairly even and very coarse textured, and it is extensively used in cottage industries for making wooden toys and cheap quality bats and packing cases/boxes. The timber of ardu is valued Grade III and Grade IV category by the forest department and it is considered good for manufacturing plywood. The stem and branches of ardu are used for fuel wood. The leaves are used for the preparation of lotion for scabies and the root bark is used for epilepsy and asthma. This taxon is found to be very much compatible and adapted to harsh arid ecosystem. It is one of the main species which act as an integrated component in farming systems of farmers, and especially during the drought. They stated that ardu could be one of the important tree species for the drought period and in arid ecosystem to sustain the productivity of sheep, goats and other animals, and secure livelihoods for pastoralists and farmers.

Ahmed et al., (2012) reported eri silkworm feeding on Syonaka (Oroxylum indicum. L) for the first time in India. They observed the average larval period of 23 days and effective rate of rearing 45 percent. They reported the morphological features of O. indicum. It is a medium sized deciduous tree growing 8 – 12 meters in height. The bark is grayish brown in color with corky lenticels. Leaves are very large, 2-3 pinnate, leaflets 12 cm long and 8 cm broad. The flowers are reddish-purple outside and pale pinkish-yellow within, numerous, in large erect racemes. The fruits are flat capsules, 0.33-1 meter long and 5-10 cm broad, sword shaped. The plant grows all over India in deciduous forest and in moist areas. They stated that this taxon can be used as food plant of eri silkworm, Samia ricini.
Mech and Ahmed, (2012) registered the role of women in eri culture. They reported that the eri silkworm is fully domesticated and reared in indoor condition and hence the women play a major role in decision making for most of the activities of eri culture. Women participate in almost all activities like leaf harvesting, silkworm rearing, cleaning, collection of dry leaves for spinning cocoons, harvesting of cocoons, spinning of spun yarn and also marketing of pupae, cocoons, spun yarn and fabric production. Eriiculture provides self-employment to the rural women through which they can supplement their family income. Therefore, the rural women can contribute a lot in socio-economic development of rural sector through eri-culture.

Reddy Prasad et al., (2012) recorded the medicinal benefits of *Jatropha curcas*. This plant is a rich source of many natural products most of which have been extensively used for human welfare, and treatment of various diseases. *Jatropha curcas*, a multipurpose, drought resistant, perennial plant gaining a lot of economic importance because of its several potentials in industrial application and medicinal values. *J. curcas* has been used as traditional medicine to cure various infections. The medicinal uses of the leaves, fruit, seed, stem bark, branches, twigs, latex and root have been recorded. This plant typically contains mixture of different chemical compounds that may act individually, additively or in synergy to improve health.

Sarmah et al., (2012) listed the ecoraces of eri silkworm, *Samia ricini* found in different region. They reported that commercially exploited *S.ricini* is a multivoltine and has several eco-races namely Borduar, Titabar, Khanapara, Nongpoh, Mendipathar, Dhanubhanga, Chuchuyimlang, Lahing, Barpathar, Diphu,
Adokgri, Lakhmipur, Dhemaji, Kokrajhar, Imphal, Cachar, Dhakuakhana, Genung, Jonai, Dhansiripar, Sadiya, Tura, Jona Kachari, Barpeta, Ambagaon and Rongpipi. According to these authors the eco-races are named based on the place of origin.

Singh et al., (2012) recorded the bio-resources of eri silkworm and its host plants utilization and need for their conservation. The rich bioresources of eri silkworm and the forest/waste land based food plants are the source of income for rural mass as host plant leaves are extensively utilized by farmers for silkworm rearing, thereby playing a pivotal role in rural economy of the region. Studies on the rearing performance of eri silkworm ecorace revealed highest ERR in Borduar followed by Titabar, highest shell ratio in Kokrajhar red followed by Borduar local, highest ERR was recorded in G.B. Spotted followed by G.B. Zebra. The highest shell ratio was recorded in yellow plain followed by G.B. Zebra. Evaluation on rearing performance of eri silkworm on various food plants during different seasons revealed superiority of castor in all the yield parameters irrespective of seasons with significantly higher ERR and shell ratio. Similarly the overall rearing parameters on kesseru (Heteropanax fragrans) and payam (Evodia flaxinifolia) during different seasons were also encouraging. However, the overall performance on tapioca was significantly low as compared to other food plants.
BIOSYSTEMATICS

Nagib Nassar (1977) recorded the chromosome number and pollen viability of wild *Manihot* species. This study revealed that seven species had a regular meiosis with haploid number of \( n = 18 \). Multi-associations, laggards or irregular distribution of chromosomes were not observed. Pollen viability was found to be 90.6% in *M. tripartite*, 92.4% in *M. anomala*, 91.3% in *M. zehntneri*, 90.1% in *M. oligantha*, 94.7% in *M. gracilis*, 92.8% in *M. nana* and 90.4% in *M. tomentosa*.

Kaleemurrahman and Gowri (1982) have recorded the foliar constituents of four food plants *viz.* castor, tapioca, papaya, and maharukh of eri silkworm, *Philosamia ricini*. Significant variations were observed between these food plants in their moisture, ash, total carbohydrate, total protein, calcium and magnesium contents. Phosphorus, calcium and magnesium content of castor leaves varied with the age of the leaves. Phosphorus content was higher in matured leaves (0.11%) followed by middle order (0.09%) and tender leaves (0.07%). Calcium was higher in tender (1.32%) followed by mature (1.22%) and middle order (0.88%) castor leaves. While magnesium content was higher in middle order (0.83%), followed by tender (0.74%) and matured leaves (0.53%).

Lancaster and Brooks (1983) stated that the Cassava leaves are rich in vitamin C, vitamin A and contain appreciable quantities of riboflavin. Values of 231 and 482 mg of vitamin C per 100 g fresh leaf have been found in light and dark coloured leaves. Values of riboflavin reported in light and dark coloured leaves are 0.33 and 0.51 mg per 100 g fresh leaf respectively. Cassava leaves offer a good source of supplementary protein, vitamin A, C and also minerals. They stated that “there are number of ways of preparing

*Biosystematics and Bioassay in food plants of Eri Silkworm, Philosamia ricini* Hutt*"
Review of Literature

dishes from cassava leaves adding variety to the diet as well as nutrients”. Incorporation of other vegetables and meat into these dishes adds further to their nutritive value and organoleptic interest.

Rupali Gogoi and Yadav (1995) studied the biochemical parameters (body weight, water content and cocoon weight) of Philosamia ricini reared on two host plants viz., Castor (Ricinus communis) and Kesseru (Heteropanax fragrans). This study revealed that the specific activity of alanine aminotransferase, aspartate aminotransferase and glutamine synthetase were found to be higher in larvae fed on kesseru. While the amount of protein, DNA, RNA, free amino acids and body wet weight were recorded higher in castor fed larvae as compared to those fed on kesseru. The water content was also found higher in kesseru fed larvae.

Shaheen (2002) recorded the morphological variation present within and among Ricinus communis grown in Egypt. The flowers, leaves, seeds and pollen grains of R.communis collected from different phytogeographical regions were studied with both scanning electron and light microscopy. He studied two morphological patterns based mainly on capsule, seed, leaf and pollen characters. The first pattern represented by a small capsules with very sparse prickles and crested ridge with fine crystals wax, seeds were gray with a smooth surface, leaf is decorated with fine crystals and has a roughened surface due to irregular pattern wax, stomata were present at the same level with the other epidermal cells, some of them paracytic and the others surrounded by indistinguishable cells, pollen composition was monad, diad, tetrad and T shaped; globes pollen shape, trilet aperture, perforate exine sculpture. The second pattern represented by bigger capsules with

*Biosystematics and Bioassay in food plants of Eri Silkworm, Philosamia ricini Hutt*
dense prickles and prominent broad ridges with roughened wax and without stomata. Seeds are grayish with brown spots, and perforated surface, leaf has roughened surface of irregular pattern wax, stomata raised above the other epidermal cells and all of them are paracytic, pollen composition was monad, diad, tetrad, and necklace shape, oblate, dicolporate aperture and granulated exine sculpture.

Puangpaka Soontornchainaksaeng and Thaya Jenjittikul, (2003) recorded the Karyology of five species of *Jatropha* viz., *J. curcas*, *J. gossypifolia*, *J. integerrima* 'Red flower’ and ‘Pink flower’, *J. multifida* and *J. podagrica*. Chromosomes were found to be very small in size. Bivalent length ranges from 1 µm to 3.67 µm. Most of the species have chromosome numbers of 2n = 22 and a base number of x = 11. *J. curcas* is chromosomally similar to *J. multifida*. Both the taxa have a meiotic configuration of 7 ringII + 4 rodII. *J. integerrima* ‘Red flower’ and ‘Pink flower’ have the same meiotic configuration of 6 ringII + 5 rodII. *J. podagrica* has a meiotic configuration of 8 ringII + 3 rodII. *J. curcas* was found to be both diploid and tetraploid.

Anjum and Qaiser (2005) studied the pollen morphology of forty species representing six genera of the family Euphorbiaceae which are found to occur in Pakistan. They stated that the family Euphorbiaceae is of considerable economic importance for rubber plant (*Hevea*), castor oil (*Ricinus communis*), cassava (*Manihot esculenta*) and tung oil (*Aleurites fordii*). This family is also known for its ornamental plants like Croton. Euphorbiaceae is a europicalynous family. Pollen grains usually radially symmetrical, isopolar, prolate-spheroidal to subprolate or prolate often oblate-spheroidal, colporate (tri, rarely 6-7), colpi generally with costae,
colpal membrane psilate to sparsely or densely granulated, ora lar- langate, sexine as thick as nexine or slightly thicker or thinner than nexine. Tectal surface commonly reticulate or regulate – reticulate rarely striate or verrucate. On the basis of exine pattern 5 distinct pollen types viz., Andrachne-aspera - type, Chrozophora oblongifolia - type, Euphorbia hirta – type, and Mallotus philippensis – type and Phyllanthus urinaria – type are recognized by them.

Hao Zheng et al., (2006) stated that the genus Ailanthus consists of approximately ten species, which have a wide distribution ranging from Asia to North Oceania. Ailanthus altissima is a deciduous woody tree that can reach a height of 20 m. The bark is smooth with vertical streaks. The leaves are odd-pinnate, 40-60 cm in length, consisting of 13-27 opposite or nearly opposite leaflets, which are papery, ovate, or lanceolate, 7-13 cm long and 2.5-4 cm wide, acuminate in apex and suborbicular or cuneate at the base, with one or two glandular tips. The inflorescence is a panicle with greenish flowers. The flowers are about 6 mm long with 5 imbricate sepals and five petals. The staminate flowers have an unpleasant odor. The fruit is an oblong samara with single flat seed in the middle of the wings. The tree is a source of timber. The leaves serve as forage for Samia cynthia. The bark and fruit have medicinal uses.

Ingo Kowarik and Ina Saumel (2007) recorded the biological characteristic features of Ailanthus altissima (Mill.) Swingle found in Central Europe. They stated that the Ailanthus is a medium-sized tree which attains maximum heights of 27-30m in the temperate zone. Leaves are large, pinnately compound, pubescent or nearly glabrous, with terete petioles, enlarged at the base and often tinged above. Male inflorescences are larger and produce more flowers.
than those on a female plant. Male flower has ten spreading functional stamens, each with a globular fertile anther and a glandular green disc. Female flower has less than ten sterile stamens with abortive anthers, a green glandular disc, a pistil with 5-6 free carpels, styles joined toward the base. Male flowers emit a unpleasant odor. They reported that the occurrence of elliptic tricolporate pollen belongs to the Rhus-type and average size is 31.5 µm. Fruit is a samara. The samaras are spirally twisted with one centrally placed seed. Their color varies from greenish yellow to reddish brown. Ailanthus is a tetraploid species with 2n = 80 chromosomes.

Ravichandran et al., (2007) evaluated the effect of hydroalcoholic extract of stem bark of Ailanthus excelsa Roxb (Simaroubaceae) on rats to explore its antifertility activity. A strong antiimplantation (72%) and abortifacient activity (56%) was observed at the tested dose levels (200 and 400 mg/kg, p.o.). Administration of extract with ethinyl estradiol cause significant antiestrogonic activity. They opined that hydro alcoholic extract of Ailanthus excelsa has antifertility effect.

Jaime A. Teixeira da Silva et al., (2007) recorded the Biology and Biotechnology of Carica papaya (Caricaceae). They stated that Papaya is a fast-growing, semi-woody, tropical herb. The stem is single, straight, hollow and contains prominent leaf scars. Leaves are palmately lobed, usually large, arranged spirally and clustered at the crown. The 5-petalled flowers of papaya are fleshy, waxy, cream to yellow in colour, and slightly fragrant. Flowers are borne singly or on cymose inflorescences in the leaf axils. Staminate tree produce long pendulous male inflorescences bearing 10 stamens in each flower. The fruit is melon like, oval or nearly round, somewhat
pyriform, or elongated club shaped. The chromosome number is 2n=18. Carica papaya contains many biologically active compounds. Two important compounds are chymopapain and papin which are widely used to cure digestive disorders and disturbances of the gasterointestinal tract.

Gulriz et al., (2008) investigated the similarities and differences in the chemical constituents and protein patterns of two different Ailanthus species viz., Ailanthus altissima (Miller) Swingle and Ailanthus excelsa Roxb. Carbohydrates and/or glycosides, condensed tannins, sterols and/or triterpenes, coumarins, alkaloids and flavonoids were present in both of the ailanthus extracts. Protein content of the leaves was found higher than the stem bark protein content in both species. They reported that their findings may be used as an additional tool for chemotaxonomic studies and molecular discriminations.

Krishna et al., (2008) recorded the nutritional value of the fruit and medicinal properties of various parts of Carica papaya. They stated that the Papaya is commonly known for its food and nutritional values throughout the world. The medicinal properties of papaya fruit and other parts of the plant are also well known in traditional system of medicine. Each part of the papaya tree possesses economic value and it is grown on commercial scale. Papaya fruit is low in calories and rich in natural vitamins and minerals. It places first among the fruits for vitamin C, vitamin A, riboflavin, folate, calcium, thiamine, iron, niacin, potassium and fibre. Papaya has more carotene compared to other fruits such as apples, guavas, sitaphal and plantains, which help to prevent damage by free radicals. The fruit is a rich source for different types of enzymes. Papain may help in the digestion of protein. Latex
containing proteolytic enzymes, papin and chemopapin are used in curing diarrhea, pain of burns and whooping coughs. Leaves contain alkaloids carpain, vitamin C and vitamin E and used for curing jaundice, urinary complaints, dressing wounds, antibacterial activity and fever.

Lidia et al., (2008) described the pollen grain development in hermaphrodite papaya tree. It was described from meiocyte to the mature pollen grain. In the microsporogenesis, the microspore mother cells or the meiocytes underwent meiosis giving rise to the tetrads that were enclosed by the calose. The tetrads were released by the dissolution of the calose by calase activity and microspores underwent mitosis. Micro-gametogenesis was characterized by asymmetrical mitotic division of each microspore giving rise to binucleate pollen grains. The structures similar to the plastids were found in the cytoplasm and close to the nucleus of the generative cell. Mature pollen grain of papaya is round in shape with three germination pores or the apertures. During the pollen grain development, the tapetum cells showed signs of the degeneration, with altered cytoplasmic contents and cell morphology.

Radha et al., (2008) recorded the macro and microscopic characters of leaf, petiole and physiochemical evaluations of Plumeria alba leaves. Leaf obavate, elliptic, length 22cm, width 7.5cm and with 32-35 pairs of lateral vein. Fruit a pair of follicle, green, woody, cylindrical. Leaves have very thick midrib and thin lamina arising from the adaxial – lateral portion of the midrib. The midrib is 1.8mm vertically and 2.5mm horizontally. The ground tissue is differentiated into outer zone of smaller collenchymas cells and remaining portion being parenchymatous. The lamina is trichomatous on the abaxial side and smooth and glabrous on the

*“Biosystematics and Bioassay in food plants of Eri Silkworm, Philosamia ricini Hutt”*
adaxial side. The stomata are paracytic type. There are two subsidiary cells, lying on the lateral sides of the guard cells. The subsidiary cells are equal or slightly unequal in size.

Sengupta et al., (2008) reported the physiochemical parameters viz., moisture percentage, relative water content (RWC), total chlorophyll, total soluble protein and sugar content in nine superior castor genotypes viz., RG3056, RG2713, RG (CSRS)-1, RG2717, NBR-1, Damalgiri red, RG 553, Talap green, RG 2824. Moisture content which is one of the most important character for eri silkworm rearing, found maximum and at par in the varieties RG-CSRS-1, NBR-1, and RG2717 but RWC content was found highest in NBR-1 (83.16%). Total chlorophyll content was significantly high in variety NBR-1 (2.16mg g⁻¹f w). Soluble protein content of leaves found significantly high in NBR-1 (36.45mg g⁻¹f w) and at par with Damalgiri Red (36.24mg g⁻¹f w). They reported that the genotype NBR-1 and Damalgiri red are qualitatively superior genotypes suited for eri silkworm rearing.

Stephen H Brown (2008) identified four different forms of Plumeria rubra. He stated that this species is the parent stock for many color variations. Flower colors of Plumeria rubra were considered distinct in each species but are now regarded as different forms of the same species. All forms have twisted over lapping corollas, much like the blades of a propeller. Forma acutifolia has white flowers and yellow centers. Forma lutea has yellow flowers. Forma rubra has pink flowers with a tangerine yellow center and forma tricolor has pale yellow white flowers with yellow centers and a red or pink rim.

Sujatha et al., (2008) highlighted the role of biotechnological tools in the genetic improvement of Castor and Jatropha. They
assessed the genetic diversity using protein based markers. Further, in-vitro studies were carried out by them successfully in castor using meristematic explants. They initiated genetic transformation experiments for development of insect resistant and ricin-free transgenics with very low transformation frequency. These authors considered *Jatropha* as a potential biofuel crop. They opined “great scope exists for genetic improvement of *Castor* and *Jatropha* through conventional methods, induced mutations, interspecific hybridization and genetic transformation”.

Suresh *et al.*, (2008) investigated the antimicrobial and phytochemical activities of the leaves of *Carica papaya*. They stated that the leaves contain a number of medicinally important compounds. The result revealed that aqueous and chloroform leaf extracts possesses antibacterial activity against tested gram positive (*Bacillus subtilis, Pseudomonas aeruginosa* and *Staphylococcus aureus*) and gram negative (*Escherichia coli* and *Klebsiella pneumonia*) bacteria. The extracts of *C. papaya* in aqueous and solvent (concentration of 75 µl/ml) exhibit relatively higher zone of inhibition compare to concentration 25 and 50 µl/ml. The *Bacillus subtilis, Escherichia coli, Klebsiella pneumonia, Pseudomonas aeruginosa* and *Staphylococcus aureus* were resistant to aqueous leaf extracts and chloroform leaf extract of *Carica papaya*. This study revealed that aqueous extract of *Carica papaya* exhibit higher zone of inhibition compared to chloroform extract.

Divakar *et al.*, (2009) have reported the biology and genetic improvement of *Jatropha curcas* L. The genus *Jatropha* contains approximately 175 known species. They stated that the objectives for genetic upgradation of the crop should aim at more number of female flowers or pistillate plants, high seed yield with high oil
Review of Literature

content, early maturity, resistance to pests and diseases, drought tolerance/resistance, reduced plant height and high natural ramification of branches. Chromosomes are very small in size (bivalent length 1 µm to 3.67µm) with most species having $2n=22$ and base number of $x=11$.

Ayoola and Adeyeye (2010) reported the phytochemical and nutrient evaluation of *Carica papaya* leaves. They have collected three samples of *C. papaya* leaves (Green, Yellow, and Brown) for the analysis of phytochemical composition. The phytochemical analysis of the leaves showed the presence of saponins, cardiac glycosides, and alkaloids. Tannin was absent in the leaves. The presence of saponins supports the cytotoxic effects of papaya leaf such as permealization of the intestine. The leaves also contain vitamins and thiamine. Further, mineral analysis showed highest values (mg/kg) of Ca, 8612.50; Mg, 67.75; Na, 1782.00; K, 2889.00; Mn, 9.50 in the green leaves, and Fe, 147.50 in yellow leaves. This study revealed that papaya leaves can be used in the herbal treatment of various diseases and as a potential source of useful elements for drugs formulation.

Damasceno Junior *et al.*, (2010) evaluated the meiosis and the pollen viability in *Carica papaya* and *Vasconcellea monoica*. The meiotic analyses confirmed that both species are diploids, with $2n = 2x = 18$ chromosomes and 9 bivalents at diakinesis. Abnormalities were observed in different meiotic stages, in both species although they were higher in *V. monoica*. The meiotic index and pollen viability were higher in *C. papaya* than in *V. monoica*.

Dinesh Kumar *et al.*, (2010) recorded the pharmacognostical, phytochemical, pharmacological and future aspects of *Ailanthus excelsa* Roxb. It is a fast growing tree and is extensively cultivated

*Biosystematics and Bioassay in food plants of Eri Silkworm, *Philosamia ricini* Hutt*
in many parts of India in the vicinity of villages. It is cultivated as an avenue tree for its deep shade and can be used for ant-erosion purposes. The bark has been used in medicine to counteract worms, excessive vaginal discharge, malaria and asthma. Traditionally the mattress made of leaves is used as bed for children suffering from fever. In Kanakpura taluk of Karnataka, the pests of stem bark along with goat milk and neem oil is used for curing the nose rope wound in Ox. The purified fractions of A. excelsa were found to be strong plant growth inhibitors and therefore could be considered as potent, effective and environmentally safe agricultural pesticides. They opined that “this plant is really a plant of heaven which has a wide scope in the treatment of serious and chronic diseases”.

Kalimuthu et al., (2010) recorded the antimicrobial activity of Jatropha curcas L. Methanol extract obtained from both in vivo leaf and leaf derived callus were subjected to antimicrobial activity against six microorganisms. The in-vitro leaf callus extracts at high concentrations (1.0 and 1.2%) inhibited the growth of Staphylococcus aureus and Pseudomonas sp. They suggested that the extract of J. curcas can be used as antimicrobial agents in new drugs for the therapy of infectious diseases caused by pathogens.

Ngozi Awa Imaga et al., (2010) screened the leaf extracts of Carica papaya for possible antioxidant, phytochemicals, proximate nutrient constituents, amino acid composition and mineral content. Phytochemical screening confirmed the presence of folic acid, vitamin B₁₂, alkaloids, Saponins, Glycosides, Tanins and anthraquinones. Further, they recorded the presence of flavonoids, antioxidants, vitamin A and C. They stated that the presence of

*“Biosystematics and Bioassay in food plants of Eri Silkworm, Philosamia ricini Hutt”*
Folic acid and vitamin $B_{12}$ are very useful in the synthesis of red blood cells.

Nirmala et al., (2010) recorded the phytochemical constituents of *Plumeria rubra* and their Antioxidant activities. The study clearly indicates that the plant *Plumeria rubra* contains flavonoids, phenols, tannins, terpenoids, protein, carbohydrate, amino acids and cardiac glycosides.

Pijush Kundu and Subrata Laskar (2010) recorded the chemical and pharmacological aspects of *Ailanthus* sp. Alkaloids, quassinoids, triterpenoids, steroids and flavonoids are present in the different parts of the genus. *Ailanthus excelsa* would be treated as highly palatable and nutritious fodder for cattle, sheep and goats. Its cytoplasmic leaf protein and seed protein can be used for human consumption. The study revealed that the ailanthus plants are rich sources of a variety of organic compounds of varying structural patterns, and highly relevant not only for medicinal but also for chemotaxonomic studies.

Ramprasad and Bandopadhyay (2010) stated that origin of the castor plant is found to be in Ethiopia (Africa) and India. It is commonly cultivated in many tropical and subtropical areas of the world but not in the cold regions. The leaves are usually 30-60 cm in diameter, membranous, broad, serrate and palmate with seven to many lobes. The flowers usually large, erect, monoecious, apetalous and in terminal sub-panicled racemes. The female flowers are found above the male flowers and cross-pollination occurs by wind. Castor seeds are oval in shape and light to deep chocolate in colour with different molting on the seed coat.
Sasikala and Paramathma (2010) recorded the chromosomes numbers in *Jatropha* species *viz.*, *Jatropha villosa var.villosa, Jatropha villosa var.ramnadensis, Jatropha multifida, Jatropha podagrica, Jatropha maheswarii, Jatropha glandulifera, Jatropha gossypifolia, Jatropha tanjorensis* and *Jatropha curcas*. Seven species exhibited 11 bivalents and $2n = 22$ and $x = 11$. But the two other species, *J.villosa var. villosa* and *J.villosa var. ramnadensis* showed only 10 bivalents and $2n$ number of 20 chromosomes and $x = 10$. This study recorded $n = 10$ and $n = 11$ haploid chromosome numbers. Except *J. tanjorensis*, cytological investigation in all other species exhibited normal and complete pairing and bivalent formation in metaphase I and equal separation of chromosome in anaphase and indicated that the course of meiosis was normal.

Syakira and Brenda (2010) have recorded the antibacterial capacity of *Plumeria alba* petals. This study revealed that *Plumeria alba* has got significant antimicrobial capacity resembling a broad spectrum antibiotic against the common uro-gastro pathogenic *Escherichia coli*, which is one of the common bacteria with pathogenic strains and are relatively resistant towards synthetic drugs.

Tahir Mughal *et al.*, (2010) explored the phytochemical and pharmacognostical properties of *Ricinus communis* and *Jatropha integerrima*. These two plants were extensively used as remedies against several diseases and complaints such as cancer, diabetes, rheumatism and scabies. The dried leaves and dried whole plant were extracted with methanol. The phytochemical screening was done to identify the presence of carbohydrates, proteins, alkaloids, phytosterol, phenol, flavonoids, tannins, saponins and
phlobatannins which are helpful in the confirmation of the authenticity of the plants.

Wang et al., (2010) recorded the microsporogenesis and pollen formation in cassava. Microsporogenesis occurs at the end of the sporophytic phase and undergoes a clearly defined cell division program resulting in a gametophyte (pollen grain) comprising the generative and vegetative cells. Cassava is a monoecious species producing both female and male flowers on the same plant. Inflorescences are generally terminal and formed at the insertion point of the reproductive branching. Typically, two female flowers are located at each basal branch of the inflorescence. The average diameter of cassava pollen grain is about 160 µm and pollen type is monad. The richly ornamented reticulated “crotonoid” pattern of the exine is observed under scanning electron microscope.

Abhishek Mathur et al., (2011) reported the antimicrobial activity of various extracts of roots (200mg/ml) of Ricinus communis. They screened the root extract against pathogenic microorganisms such as Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa, Salmonella typhimurium, Proteus vulgaris, Bacillus subtilis, Candida albicans and Aspergillus niger using well diffusing method. The hexane and methanol extracts showed good activity against pathogenic bacterial and fungal strains. Hexane showed prominent antimicrobial activity against Candida albicans and Aspergillus niger fungal strains. Methanol extracts were found to be prominent against E.coli and Aspergillus niger.

Chaitanya and Sarvani (2011) evaluated the antibacterial activity of Ricinus communis leaf extract by using five bacteria; two Gram-positive bacteria (Bacillus subtilis and Staphylococcus aureus) and three Gram-negative bacteria (Escherichia coli, Proteus
Review of Literature

*Biosystematics and Bioassay in food plants of Eri Silkworm, Philosamia ricini* Hutt

... vulgaris and Pseudomonas aeruginosa). The concentration of ethanolic extract of 5gm/ml was tested for antibacterial activity. Gentamycin is used as standard. They reported that “ethanolic extract of R. communis leaves has significant antibacterial activity”.

Mary Kensa and Syhed Yasmin (2011) reported the phytochemical screening and antibacterial activity of Ricinus communis. It showed good activity against the bacterial strains Pseudomonas aeruginosa, Escherichia coli and Staphylococcus aureus. The antibacterial assay revealed that the acetone and hexane extracts possess good zone of inhibition where as ethanolic extract having antibacterial activity was found only on higher concentration.

Megha Kasarwala et al., (2011) recorded the ethanolic extract of leaves and stem bark of Ailanthus excelsa for its anthelmintic activity against Pheretima posthuma (Indian earthworm). Phytochemical screening has shown the presence of flavonoids, alkaloids, carbohydrates and proteins in both ethanolic extracts of the plant. The study revealed that the stem bark ethanolic extract has taken less time for paralysis and death of worms than leaf ethanolic.

Nisar Ahmad et al., (2011) investigated the potential of Carica papaya leaves extracts against Dengue fever in 45 year old patient bitten by carrier mosquitoes. The symptoms of dengue fever include high fever, rash, and a severe headache, severe joint and muscular pain, nausea, vomiting and eye pain. The extract was prepared in water. 25 ml of aqueous extract of C. papaya leaves was administered to patient infected with dengue fever twice daily for five consecutive days. Before the extract administration the blood samples from patient were analyzed. Plate count (PLT), White Blood
Review of Literature

Cells (WBC), and Neutrophils (NEUT) decreased from $176 \times 10^3 / \mu L$, $8.10 \times 10^3 / \mu L$, 84% to $55 \times 10^3 / \mu L$, $3.7 \times 10^3 / \mu L$ and 46%. Subsequently, the blood samples were rechecked after the administration of leaves extract. It was observed that the PLT count increased from $55 \times 10^3 / \mu L$ to $168 \times 10^3 / \mu L$, WBC from $3.7 \times 10^3 / \mu L$ to $7.7 \times 10^3 / \mu L$ and NEUT from 46% to 78.3%. The study showed that aqueous extract of *Carica papaya* leaves is a potential drug against Dengue fever.

Obumseulu *et al.*, (2011) evaluated the phytochemical constituents of the ethyl acetate, ethanol and aqueous leaf extracts of *Ricinus communis*. Alkaloids (1.5%), saponins (0.46%), flavonoids (8.78%) and tannins (1.08mg/ml) were observed. A thin layer chromatographic study showed two spots each for the ethanol and ethyl acetate extracts. Antibacterial activity gave values of 24.25 mm and 22.50 mm for *Staphylococcus aureus* and *Escherichia coli* respectively. The present investigation indicates that the aqueous leaf extracts of *Ricinus communis* might be exploited as natural drug for the treatment of several infectious disease caused by *S. aureus* and *E. coli*.

Rahman *et al.*, (2011) investigated the antibacterial activity of ethanolic extracts of leaves and stem of *Carica papaya*. Gram negative (*Escherichia coli*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Salmonella paratyphi A*, *Shigella flexneri*) and Gram positive bacteria (*Staphylococcus aureus*, *Staphylococcus epidermidis*, *Bacillus subtilis*, *Micrococcus luteus*) were used for the screening of antibacterial activities of the extracts of leaves and stem. They opined that the antibacterial action was dose dependent. Significant difference was reported in bacterial sensitivity of leaves and stem extracts. The leaves extracts were

*Biosystematics and Bioassay in food plants of Eri Silkworm, Philosamia ricini* Hutt*
found more active than the stem. *C. papaya* leaves and stem contains some valuable antibacterial compounds that inhibit the growth of wide variety of Gram positive and Gram negative organisms. The leaves and stem of *C. papaya* has antibacterial effects that could be useful in treating variety of bacterial infections. Pawpaw leaves showed the presence of alkaloid, flavonoid, Saponin, Tanin and Glycosides. They concluded that “the *C. papaya* can be seen as a potential source of useful food and drug items”.

Devprakash *et al.*, (2012) recorded the morphological characters and antimicrobial activity of *Plumeria* species. They have reported that *Plumeria*, the most celebrated of all tropical flowers, in India commonly known as frangipani. The three main species, commonly found are *Plumeria obtusa*, *Plumeria rubra*, *Plumeria acuminate* (*P. acutifolia*). *Plumeria obtuse* has white flowers with small brilliant yellow centre up to 9 cm in diameter. The leaves are dark green, glossy obovate and obuste at both ends. This tree can grow to about 6-9 m tall and partly deciduous at different times of the year. *Plumeria rubra* flowers are in various shades of red, pink, orange and yellow. The leaves also have many different sizes, shapes and colors. This species is a deciduous tree which can exceed 10 m tall. *Plumeria acuminate* is an evergreen or partly deciduous tree grows up to 6 m high. Leaves are light green in colour, elliptic in shape with acuminate tips and the colour of the flower can vary from white to yellow. Methanolic extract of *Plumeria* species were investigated for their invitro antimicrobial properties by agar disc diffusion method. The crude methanolic extracts MEPA inhibited the growth of both gram positive bacteria (*Bacillus subtilis, Stephyltococcus aureuspers* and *Micrococcus luteus*) and gram negative bacteria (*Escherithia coli, Pseudomonas aeruginosa* and *Salmonella typhimurium*). The Gram positive bacteria appeared to be

*Biosystematics and Bioassay in food plants of Eri Silkworm, Philosamia ricini* Hutt
more susceptible to the extracts than the gram negative bacteria (Rasool et al., 2008). The ethanol extract showed the strong in-vitro antimicrobial activity against *Enterococcus faecalis*, *Bacillus subtilis*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Salmonella typhimurium*, *Aspergillus niger* and *Candida albicans*.

Godson E. Nwofia et al., (2012) recorded the chemical composition of leaves, fruit pulp and seeds of *Carica papaya* L. The result showed the significant difference (P<0.01) for proximate, chemical and vitamin composition of these morphotypes. The leaves had more crude fibre, Ca, Mg, Fe and K than the fruit pulps and seeds. The most abundant vitamin in these morphotypes was found to be beta-carotene (54.36 - 72.82mg/100g in seeds, 644.10 - 666.67mg/100g in leaves, and 5173.33-6207.18mg/100gm in fruit pulp). Vitamin C was more in the fruit pulp and lowest in the seeds. Carotenoids are responsible for fruit color.

Livia de Jesus Vieira et al., (2012) reported viability, production and morphology of pollen grains in genus *Manihot*. Floral buds in pre-anthesis were extracted from fifteen different available accessions of *Manihot*; five of them were cultivated and ten of them were from wild species. The size of the pollen grains varied from 132 to 163 µm in the wild accessions, and 129 to 146µm in the cultivated accessions. The pollen grains are very large (>100µm), apolar, spherical, inaperturate, with an exine ornamented with pila organized in the *Croton* pattern. The wild accessions, in general, produced more and larger pollen grains compared to cultivated accessions.

Jitendra Jena and Ashish Kumar Gupta (2012) reported that the castor plant has got high medicinal value to maintain the disease free healthy life. The plant is used as laxative, purgative,
fertilizer and fungicide. The plant possess beneficial effects such as anti-oxidant, antihistamic, antinoceptive, antiasthamic, antiulcer, immunemodulatory, antidiabetic, hepatoprotective, antifertility, antinflammatory, antimicrobial and many other medicinal properties. This activity of the plant is due to the important phytochemical constituents like flavonoids, saponins, glycosides, alkaloids and steroids.

Kamlesh Khokhani et al., (2012) recorded the spectrophotometric chromatographic analysis of Amino acid in leaves of Ailanthus excelsa. Amino acids have been identified by their characteristic colors, reported Rf values by chromatography. The study revealed that the amino acid present in alcoholic extract of Ailanthus excelsa are Leucine, Glycine and Tyrosine.

Manpreet Rana et al., (2012) reported Ricinus communis as a very important indigenous medicinal plant. It is a native plant of India. It has various pharmacological actions. It contain chemical constituents’ like Ricin A, B and C which have antitumor action. It also has alkaloid (ricinine) and glycoside which may be useful for various herbal formulations as anti-inflammatory, analgesic, antipyretic, carid tonic and antiasthamic.

Parmar Namita and Rawat Mukesh (2012) recorded the medicinal properties of Ricinus communis (Euphorbiaceae) and Carica papaya (Caricaceae). They stated that the Castor is soft wooded small tree, wide spread throughout tropics and warm temperature regions of the world. The leaf, root and seed oil of this plant have been used for the treatment of the inflammation, liver disorders, hypoglycemic and laxative. Methanolic extracts of the leaves of Ricinus communis showed antimicrobial properties. The parts of Carica papaya that are usually used include the leaves,
Review of Literature

Shashank Bhatt and Suresh Dhyani (2012) recorded phytochemical constituents of *Ailanthus excelsa*. The secondary metabolites such as glycosides, phenol, lignin, saponins and tannins were reported. These compounds are known to have curative activity against several pathogens and therefore can be used for the treatment of different diseases. They suggested this plant for a good source of drug for human health.

Sujatha *et al.*, (2012) reported bioactivity and biochemical characterization of *Manihot esculenta*. They stated that the cassava leaf is rich in protein (14-40%), potassium, iron, calcium, sodium, vitamin B1, B2, B6, C and carotenes. Cassava leaf protein is similar to milk, cheese, soybean, fish, and egg. Maximum amount of crude and fiber protein are present in seed followed by leaf and flower. In addition, minerals such as K, Na, P and Mn are present in seed, leaf and flower. The antibacterial activity exhibited by extracts of leaf, flower and seed of *M. esculenta* is used in traditional Indian medicine for the treatment of various ailments.

Surendra Sharma and Naresh Kumar (2012) stated that *Plumeria* is a medicinal as well as ornamental plant widely used in perfumery. The root bark is bitter, pungent, carminative, laxative and useful in treating ulcers and leprosy. The preliminary phytochemical screening carried out by them reveal the presence of fruit, seed, latex and root. Papaya contains many biochemically active compounds. Two important compounds are chymopapin and papin, which are supposed to aid in digestion. Papin is used in the treatment of arthritis. The leaves are used as soap substitute which are supposed to remove stains. Papin is also used for degumming natural silk.

*Biosystematics and Bioassay in food plants of Eri Silkworm, Philosamia ricini* Hutt
carbohydrate, alkaloids, glycosides, tannins iridoids and saponins in various bark extract of Plumeria plant.

Xiu-Rong and Gui-Jie, (2012) recorded the reproductive biological characteristics of Jatropha curcas. The result revealed the existence of J. curcas in both unisexual and monoecious forms. Both male and female flowers have five petals in contorted arrangement and five sepals in imbricate arrangement. Female flower originated from bisexual flower finally formed unisexual flowers as the stamen fail to grow in different period. The pistil posses 3-5 styles, connected at base and separated into 3-5 stigmas on the top. Each stigma had 2-4 lobes.

Aravind et al., (2013) recorded the medicinal properties of Carica papaya. Its fruit, root, bark, peel, seeds and pulp are known to have medicinal properties. Many benefits of papaya are due to high content of Vitamins A, B and C, proteolytic enzymes like papain and chymopapain which have antiviral, antifungal and antibacterial properties. Papain is present in the bark, leaves and fruit. The milky juice is extracted, dried and used as a chewing gum for digestive problems, toothpaste and meat tenderizers. They opined that “Carica papaya is a neutraceutical plant having a wide range of pharmacological activities”. The whole plant has its own medicinal value.

Bahekar and Kale (2013) recorded the phytopharmacological properties of Manihot esculenta. According to these authors the plant is rich in various macro and micronutrients. It contains various antioxidants like α-carotene, vitamin C, vitamin A, anthocyanins (flavonoids), saponins, steroids and glycosides. Leaves contain toxic substances, which are associated with the high concentration of cyanogenic glycosides. The roots and leaves are

“Biosystematics and Bioassay in food plants of Eri Silkworm, Philosamia ricini Hutt”
commonly utilized for the treatment of ringworm, tumor, conjunctivitis, sores and abscesses. Leaves have also been used against many disorders such as rheumatism, fever, headache, diarrhea and loss of appetite. The flour cooked in grease, the leaf stewed and pulped, and the root decocted as a wash are said to be folk remedies for tumors.

Mohd Iqbal Mir (2013) recorded the pharmacological value of *Ricinus communis* L. The castor plant has high traditional and medicinal value to maintain the disease free healthy life. Traditionally the plant is used as laxative, purgative, fertilizer and fungicide. The plant possess beneficial effects such as antioxidant, antihistamic, antinociceptive, antiasthmatic, antulcer, immunemodulatory, antidiabetic, hepatoprotective, antifertility, anti-inflammatory, antimicrobial, central nervous system stimulant, lipolytic, wound healing, insecticidal, larvicidal and many other medicinal properties. The review confirms that the therapeutic value of *Ricinus communis* is much more. The presence of phytochemical constituents and pharmacological activities proved that the plant has a leading capacity for the development of new good efficacy drugs in future.

Swati Patil *et al.*, (2013) reported that *Carica papaya* leaves have been used traditionally to treat indigestion, as a vermifuge, anti-tumor and immunomodulatory effects. Aqueous extract of the leaf is beneficial in increasing the platelet count in thrombocytopenic rat model. Aqueous extract of *C. papaya* leaves at concentration of 400mg/kg and 800mg/kg were given to cyclophosphamide induced thrombocytopenic rats for a period of fifteen days. Blood was withdrawn at various time intervals to determine the platelet count. They opined that the *C. papaya* leaf
extract was found to increase the platelet count and also to
decrease the clotting time in rats.

**BIOASSAY**

Joshi and Mishra, (1982) recorded the silk percentage and
effective rate of rearing of eri silkmoth, *Philosamia ricini* Hutt
rearing on two host plants and their combinations. The experiment
was conducted in four different combinations *viz.*, TT (1<sup>st</sup> to 5<sup>th</sup>
instar larvae reared on the leaves of tapioca), TC (1<sup>st</sup> to 3<sup>rd</sup> instar
larvae reared on tapioca leaves while 4<sup>th</sup> and 5<sup>th</sup> on castor leaves),
CT (1<sup>st</sup> to 3<sup>rd</sup> instar larvae reared on castor leaves while 4<sup>th</sup> and 5<sup>th</sup>
on tapioca leaves and CC (1<sup>st</sup> to 5<sup>th</sup> instar larvae reared on castor
leaves alone). They concluded that the silk ratio is maximum in
dietary regimen CC and minimum in dietary regimen TT, where as
in TC it is higher than dietary regimen CT. The effective rate of
rearing is almost similar in dietary regimen TT and CT, while it is
slightly lower in dietary regimen CC than TC.

Thangavelu and Phukon (1983) evaluated four different host
plants of eri silkworm to assess their suitability for rearing. The
order of preference reported by them is Castor (*Ricinus communis*
Linn.), Kesseru (*Heteropanax fragrans* Seem), Tapioca (*Manihot
utilissima* Phol.) and Barkesseru (*Ailanthus excelsa* Roxb.). Number
of eggs per laying varied from 395 in castor and 331 in barkesseru.
The hatching percentage is highest on castor (90%) and lowest on
barkesseru (74%). Larval period is shorter (16 days) and larval
mortality lower (32.6%) on castor and the corresponding values are
22.75 days and 81.4% respectively on barkesseru. Effective rearing
rate is higher in castor (67.4%) and kesseru (64.9%) and lower on
tapioca (36.6%) and barkesseru (18.6%). The study recommended
the suitability of the food plants in the following order *viz.*, castor, kesseru, tapioca and barkesseru for eri silkworm rearing.

Devaiah *et al.*, (1985) studied the growth and silk production in *Samia cynthia ricini* Boisduval fed on four different host plants, *viz.*, castor, tapioca, red *Plumeria* and white *Plumeria*. The necessity of alternating host plants is felt during scarcity of castor leaves, especially during the fifth instar when the larvae consume more quantity of leaves. They opined that the use of various host plants will have a direct influence on the silk production. Significant difference was not observed in the larval weights when eri larvae were reared on castor, white *Plumeria* and red *Plumeria*. On the other hand significant difference was noticed in the larval weight when reared on tapioca leaves compared to other hosts plants. Significant difference was noticed between the cocoon weight and shell weight in the case of larvae fed on castor leaves. They have concluded that *Ricinus communis* is the best host plant affecting the larval weight, cocoon weight and the shell weight considerably followed by red *Plumeria*, white *Plumeria* and tapioca.

Ataur Rahman Khan and Musaddarul Hoque (1987) recorded the effect of various combinations of castor-papaya leaf on the oviposition and fertility of the eri silkworm, *Philosamia ricini* Hutt. The study revealed that the general tendency of papaya leaves was to reduce the oviposition and fertility of the eri worm. They concluded that farmers can fruitfully utilize a mixture of castor and papaya leaves or can feed the worms on papaya leaves for the first 15 days and castor leaves during the rest of the feeding period during the shortages of castor leaves.

Reddy *et al.*, (1989) observed the rate of development, survival, cocoon yield and reproduction of *Samia cynthia ricini*
Boisduval reared on four different host plants (castor, tapioca, *Plumeria* and *Ailanthus excelsa*). The rearing was conducted at temperature ranging 25 to 29°C and relative humidity of 51 to 84%. The worms had shorter developmental period (46.49 ± 1.32), high survival rate (95.67 ± 2.02), maximum growth index (2.06), higher shell percentage (12.20 ± 0.71) and higher net reproductive rate (503.52) when reared on castor. They stated that the castor is the most suitable plant followed by tapioca and *Plumeria*. *Ailanthus excelsa* is the least suitable food plant for ericulture.

Rajaram and Samson (1991) studied rearing performance of eri silkworm, *Samia cyynthia ricini* Boisduval, on different host plants like castor, kesseru and ganasarai (*Cinnamomum glanduliferum* Meissn). They have not noticed any significant variation in larval weight. However, there was a variation in larval duration between the new host plant ganasari (708 hr) and the other host plants castor (516 hr) and kesseru (579 hr). The qualitative characters like cocoon weight, shell weight did not vary significantly between the plants. But a significant increase in shell weight was noticed in ganasari (0.344g) when compared to primary host plants (castor 0.343g and kesseru 0.326g). This study confirms that castor is the most suitable for eri rearing and ganasarai considered as a secondary host plant of eri silkworm.

Dutta and Kalita (1997) conducted consumption and utilization studies on four food plants viz., castor, kesseru, tapioca and borpat by the larvae of eri silkworm, *Philosamia ricini* Hutt. The study revealed that with lower rate of food consumption (CI), higher percentage of approximate digestibility (AD) and higher efficiency of conversion of ingested (ECI) and digested (ECD) food to body

“Biosystematics and Bioassay in food plants of Eri Silkworm, *Philosamia ricini* Hutt”
biomass, Castor was utilized best for better growth (GR) of larvae, kesseru was next after castor followed by tapioca and borpat.

Reddy and Narayana Swamy (1999) studied the consumption of food, leaf-cocoon and leaf-egg ratios of eri silkworm reared on different host plants (Bangalore local, Aruna and RC-8 varieties of castor and tapioca). The study revealed that leaf-cocoon ratio was higher in tapioca (19.79:1) and lower in Bangalore local variety of castor (12.17:1) but greater leaf-egg ratios were obtained in local castor (5.08:1) and lower in tapioca (3.40:1) leaves. It is inferred that the Bangalore local variety of castor is a suitable host for rearing eri silkworm. Aruna and RC-8 varieties of castor and tapioca stood in serial sequence.

Govindan et al., (2005) evaluated the feeding efficiency in eri silkworm, Samia cynthia ricini reared on eight different varieties of castor (local pinky powdery, local pink non-powdery, local green powdery, local green non-powdery, DCH-32, DCH-177, DCH-9, 48-1). The nutritional efficiency of eri silkworm differed significantly among the castor varieties. Total food consumption and food digestion were recorded more in the DCH-177 variety, whereas eri worms fed with leaves of local green powdery variety recorded lower total food consumption and food digestion.

Dinesh and Sundaramoorthy (2003) recorded the life cycle duration of philosamia ricini reared on thirteen released castor varieties viz., Aruna, Bhagya, DCS-9, SKI-73, 48-1, GCH-4, RHC-1, SH-41, TVC-31, TVC-15, TMV-5, NES-6, CO-1. This experiment was conducted in order to tag the best castor genotype for eri rearing. The study revealed that RHC-1 to be the best as the eri silkworm complete its life cycle very early about 35.2 ± 6.1 days, followed by the variety TMV-5(35.3 ± 4.8 days) and Aruna (36.0 ± 4.8 days).
eri worm takes long time to complete its life cycle when reared on variety SKI-73 (41.7 ± 9.6 days) and longest on variety CO-1 (44.7 ± 12.5 days).

Hazarika *et al.*, (2003) studied the effect of three different food plants (castor, kesseru and tapioca) during four different seasons (spring, summer, autumn and winter) on the larval development and cocoon characters of silkworm, *Samia cynthia ricini* Boisduval. Castor was found to be the best in terms of different parameters *viz.*, nutritive value of leaves, larval weight, effective rate of rearing, cocoon weight and shell weight, pupal weight, fecundity and hatching. Larval duration was found to be shorter on castor than kesseru and tapioca. Further, when multiple trait evaluation index and scores were employed to rank the food plants and seasons, castor plant and autumn (October – November) season were found best among three different food plants and four different seasons.

Kar *et al.*, (2004) recorded the reproductive and commercial productivity of the cultivated eri silkmoth, *Samia ricini* Donovan during different seasons in Orissa. The result found that the reproductive and commercial productivity were varied in accordance with variation in seasonal environmental parameters of the rearing. The winter season was found to be the best season, followed by autumn, spring, rainy and summer seasons to produce both qualitative and quantitative eri silk in Orissa.

Ravikumar and Sarangi (2004) recorded the variation in the content of soluble protein and total sugar in the haemolymph, midgut and silkgland during the fifth instar development in different varieties of eri silkworm, *viz.*, plain and light blue coloured and zebra marked larvae. They reported that the fluctuation in the quantity of biomolecules are due to the degree of assimilation in the
midgut, transport by the haemolymph and utilization by the silkgland during fifth instar development. They opined that the zebra marked larvae are better for silk production compared to other two varieties.

Dutta and Khanikor (2005) studied the rearing performance of eri silkworm, *Samia ricini* with interchange of food plants (castor, kesseru, barkessuru and borpat) in different seasons (spring, summer, autumn and winter). They have concluded that castor is the best food plant for eri rearing during all the seasons as it recorded the highest larval weight, larval duration, effective rate of rearing, cocoon weight and shell weight. Further, it was evident that the combination of castor and barkessuru recorded better results in effective rate of rearing and silk ratio. They opined that “the productivity of eri silk can be increased by rearing the silkworm in combination of leaves of different food plants more particularly castor (1\textsuperscript{st} to 2\textsuperscript{nd} instar) interchanging with Barkessuru (3\textsuperscript{rd} to 5\textsuperscript{th} instar)”.

Urmimala Hazarika et al., (2007) recorded the fecundity in different ten eco races like Nongpoh, Impal, Kokrajhar Red, Bordhur Local, Titabar Local, Sille, Dhanubhanga, Mendipathar, Khanapara, Jonai, Lahing, Cachar, Adokgiri, Diphu, Chuchuyimlang, Lakhimpur of eri silkworm, *Samia ricini* Donovan in three different seasons. They observed that the pupal weight and fecundity were maximum in Bordur ecorace and minimum in Cachar ecorace. Larval weight was found maximum in Diphu and minimum in Adokgiri ecorace. They stated that the October-November was found to be the best season in respect of getting maximum pupal weight, fecundity and larval weight.
Rajashekargouda R. Patil et al., (2009) studied the rearing performance of eri silkworm, *Samia cynthia ricini* Boisd on few food plants *viz.*, castor (Aruna variety) and three varieties of tapioca (Co-2, ME-1, ME-120). Significant results were observed in larval duration. Lowest larval duration was recorded in castor. Among the different tapioca varieties ME-1 registered lowest larval duration followed by Co-2 and ME-120. Castor was significantly superior to all the three tapioca varieties for 5th instar larval, silk gland and cocoon weights followed by Co-2, ME-1 and ME-120. However, tapioca varieties failed to show any significant difference among themselves for 5th instar larval and cocoon weights. Variety Co-2 registered maximum larval and cocoon weights.

Priti Pragyan Ray et al., (2010a) studied the performance of different ecoraces (Borduar, Titabar, and Mendipathar) of eri silkworm, *Philosamia ricini* in agroclimatic conditions of Western Odisha. It was observed that morpho-developmental parameters, cocoon characteristics, fecundity, mortality and silk production were found to be better in Borduar variety compared to Mendipathar and Titabar ecoraces.

Priti Pragyan Ray et al., (2010b) evaluated the comparative rearing performance of three different ecoraces of eri silkworm in five different seasons (summer, rainy, autumn, winter and spring). The result showed the significant differences in the productivity parameters of the ecoraces and different seasons of rearing. Borduar ecorace was found to be the highest when compared to others ecorace (Titabar and Mendipathar). The study records that the ecoraces of eri silkworm perform better in the winter season compare to other seasons.
Priti Pragyan Ray and Rao (2010) recorded the rearing performance of different ecoraces of eri silkworm, *Philosamia ricini* Hutt, during winter season. Ecoraces of *P. ricini* viz., Borduar, Titabar and Mendipathar was analyzed for their hatching percentage, larval duration, larval weight, cocoon weight, shell weight, pupal weight, shell ratio percentage and effective rate of rearing. Borduar ecoraces performed best and showed better adaptability than other ecoraces in winter season and found suitable for Odisha climatic conditions for commercial rearing.

Rajesh Kumar and Elangovan (2010a) evaluated the volumetric attributes of eri silkworm, *Philosamia ricini* reared on various host plants like castor, tapioca *Jatropha* and papaya. Maximum silk yield was observed when larvae were fed on castor leaf and highest shell weight of 0.53g was also recorded. They stated that the highest larval volume, silk gland volume and silk gland ratio was recorded in castor followed by tapioca, *Jatropha* and papaya.

Rajesh Kumar and Elangovan (2010b) recorded the rearing performance of different eco races of eri (Borduar, Titabar, Dhanubhanga and Mendipathar). They analysed hatching percentage, larval duration (days), weight of grown larvae (g), yield (by number and weight), cocoon weight (g), shell weight (g), shell ratio (%), cocoon shape variability, pupal period (days), pupation rate (%), and leaf silk conversion rate (%). They have concluded that the Mendipathar eco-race has better adoptability than Titabar, Borduar and Dhanubhang eco-races.

Rajesh Kumar and Gangwar (2010) recorded the effect of different food plants in relation to the seasons on the larval growth and its economic characters. They have reported that the castor

*Biosystematics and Bioassay in food plants of Eri Silkworm, *Philosamia ricini* Hutt*
food plant has shown significant increase in the larval weight, silk gland weight, cocoon weight and the shell weight considerably followed by other host plants *i.e.*, tapioca, *Jatropha* and papaya in spring season.

Chandrashekhar and Govindan (2010) studied the performance of eight castor genotypes on rearing of eri silkworm, *Samia cynthia ricini* Boisduval. They have reported that DCS-85 genotype favoured higher ERR, cocoon weight, shell weight, shell yield and these traits were lower with GCH-4. Eri pupae formed by the worms nourished with leaves of DCS-9 registered higher pupal weight of 25.90g/10 and the same was lower with GCH-4 (21.776g/10). However, fecundity was more with DCS-85 genotype (340 eggs/laying) and it was least with GCH-4 (275 eggs/laying).

Kar (2010) reported that the silk is a fine, proteinacious animal fibre produced by the ripe larva of the silkmoth. The quality and quantity of silk produced by ripe larvae depend on the quality and quantity of the silk contents in the silk gland. The silk glands (left and right) of cultivated eri silk moth, *Samia ricini* are elongated, tabular, folded and occupy conspicuous part of larval anatomy. Typologically these are ‘Z’ type having zigzag middle and posterior part. The average length of the silk gland is about 40.50 ± 7.49 cm with a weight of about 1.29 ± 0.14 g when reared on castor plant.

Manjunath Naik *et al.*, (2010) recorded the growth, development and economic cocoon parameters of eri silkworm on new hosts *viz.*, Jack fruit (*Artocarpus heterophyllus* Lam), Fountain tree (*Spathodea comanulata* Pal.) Banayan tree (*Ficus bengalansis* L.), Indian almond (*Terminalia catappa* Linn.) and Carrot (*Daucus carota* Linn.). Among new host plants fountain tree considered to be the superior host plant. They stated that the *Spathodea*
companulata leaves are dark green, compound and evergreen. Leaves are available throughout the year. Further, they reported that for chawki rearing the carrot leaves are more suited than the leaves of other new host plants. They have recommended the use of carrot leaves in place of castor leaves, for rearing chawki worms.

Mukul Deka et al., (2011) recorded the impact of feeding of Samia cynthia ricini in respect to larval growth and spinning in different seasons on different host plants. The evaluation of the data revealed that castor (red variety) has established supremacy over the other food plants i.e., kesseru and tapioca. The data showed that the minimum larval duration, fecundity, effective rate of rearing percentage and better spinning characters in spring season followed by autumn, winter and summer season.

Singh et al., (2011) recorded the rearing performance and economic traits of eri silkworm, Samia ricini on host plants viz., castor and kesseru. The study revealed that the eri silkworm reared on castor produced best quality cocoons with higher fecundity, effective rate of rearing and shell ratio. While eri silkworms reared on kesseru produced small but compact cocoons with strong fibre. Although, castor is the best food plant of eri silkworm, growing castor involves recurring expenditure because of its annual nature. Kesseru being a perennial and forest based tree, only a minimal cost is involved for maintenance and hence the farmers of northeastern states mainly depend on kesseru leaves for large scale commercial rearing of eri silkworm. They reported that the eri silkworm pupae have high nutritional values with 53.3% protein, 25.6% fat, 4.4% carbohydrates and vitamins on dry weight basis. Eri silkworm litters, excreta, unused leaves/stalk/petioles of castor,
kesseru and tapioca are recyclable waste, which are used as manure and as substrate in biogas production.

Chandrashekar et al., (2012) evaluated different castor genotypes for their suitability in eri silkworm rearing. Eight castor genotypes were evaluated by providing leaves of these genotypes throughout the larval stage. Eri worms nourished with leaves of DCS-85 genotype registered significantly higher ERR of 92.00 percent, while it was lower with GCH-4 (83.33%). Similarly, DCS-85 genotype recorded higher cocoon weight (27.78g/10), cocoon yield (250.50g/100 worms and 75.14 kg.100 DFLs), shell weight (3.415 g/10) and shell yield (9.237 kg/100DFLs) and these traits were lower with GCH-4 (200.1 g, 24.50g, 60.02kg, 2.715g and 6.651 kg respectively). The eri worms fed on leaves of DCS-85 were found superior in respect of shell ratio (12.29%), silk productivity (4.879 cg/day) and fibroin (78.25%) and sericin (21.55%), while these were inferior with GCH-4 (11.08%, 3.620 cg, 72.10% and 27.65 %, respectively). Eri pupae formed by the worms nourished with leaves of DCS-9 registered higher pupal weight of 25.90 g/10 and the same was lower with GCH-4 (21.76 g/10). Similarly, fecundity was more with DCS-85 genotype (340 eggs/laying) and it was least with GCH-4 (275 eggs).

Mitalee Baruh Hazarika (2012) stated that the quality of leaves directly influence healthy growth and survival of eri silkworm. They reported that highly nutritious and nutrient balanced food are the prime factors responsible for healthy growth and development of any insect, as it provides the ultimate source of energy to the insects. In order to improve the food value of the kesseru (*Heteropanax fragrans*) they recommended the use of foliar spray (Tricovit) on leaves while rearing eri silkworm. The result

*Biosystematics and Bioassay in food plants of Eri Silkworm, *Philosamia ricini* Hutt*
showed that between the treated and untreated kesseru the shell ratio was recorded highest on the kesseru treated (14.40%) and lower on the kesseru untreated (14.16%). Among the season, the results revealed that highest shell ratio was recorded in autumn (14.80%) followed by summer (14.67%), late summer (14.58%) and lowest in spring (13.98%). The interaction effect of food plant variety with season on shell ratio was recorded to be non-significant. The study suggest that foliar spray can be used to increase the nutrition value of eri silkworm for better rearing performance.

Sarmah et al., (2012) recorded the seasonal variation in the commercial and economic characters of eri silkworm, Samia ricini Donovan. Eri silkworm is reared in indoor conditions for production of cocoons, by utilizing the leaves of castor. A non bloomy red variety (NBR-1) of castor was used as food plant. They opined that the commercial rearing of the eri silkworm is possible during August-November season to get better crop harvest. They concluded that Borduar eco-race of eri silkworm is useful for commercial seed as well as cocoon production to make the eri silk industry more economically vibrant and sustainable.