3: REVIEW OF LITERATURE

i. Ferns and associated entomofauna:

Diversity and distribution:

The foothill region of Eastern Himalaya that chiefly includes the Terai region of Darjeeling has no specific report on fern flora. However, some literature on the diversity and distribution of the fern species of this area can be figured out from the existing literature on Indian ferns. Besides the comprehensive "Handbook of the ferns of British India, Ceylone and Malaya Penunsulia " by Beddome (1892), some more reviews on fern flora of Northern India including those of Nepal , Darjeeling and Sikkim Himalayas are available (Clarke,1880; Mehra and Bir,1964; Sinha and Gurung,1985). Tagawa (1966), Panigrahi and Patnaik (1968) and Dhir and Saiki (1984) have furnished an account of fern flora of Himalaya including that of Eastern region. Distribution of the extant forms of Darjeeling hills with their climatic limitations has been reported by D'Costa and Mukherjee (1985). Distribution of some homosporous ferns that include *Diplazium esculentum* and the reasons behind their sporadic, distinct and patchy occurence has been explained with reasons by Singh and Roy (1989). Dixit (1984) published a census on Indian pteridophytes. Some aspects of ecology, distribution and phytogeography of Himalayan ferns is also

available from the publications of Bir et al. (1982), Bir (1987), and Punetha (1989), and Dixit and Tripathi (1986).

The relative paucity of insects that eat ferns when compared to the angiosperms was noted about a century back by Schneider (1892) and subsequently by Brues (1920) and Weiczorek (1973). The evidences to support the claim that ferns are underutilized as a food source is scant (Balick et al. 1978; Rees, 1971; Huffaker, 1974). A general account of insect fauna of ferns are few and scattered. For over a hundred years discrete information on occurrence of different insect species on some particular ferns like the bracken, (Pteridium aquilinum (L.) Kuhn are available (Meikle, 1937; Weiczorek, 1973; Lawton, 1976; Rigby and Lawton, 1981; Lawton et al, 1985). Lawton and Gaston (1989) published an article on temporal patterns in the herbivorous insects of bracken - a test of community predictibility. Posada et al. (1987) indicated Callopistria floridensis as a serious pest of several ornamental ferns. Some of the more comprehensive studies include those of Swezey (1922), Cooper-Driver (1978), Gerson (1979), Aurbach and Hendix (1980) and Hendrix (1980). In an article on 'Number, seasonality and feeding habits of insects attacking ferns in Britain', Ottosson and Anderson (1983b) have given a review of the fern feeding insects. Herbivore damage to three tropical ferns has been assessed by Hendrix and Marquis (1983).

Hendrix (1980) in his comprehensive list of insects utilizing ferns as a food source has based his data from various sources and surveys. He has catagorically listed the different taxa of the British fern feeding insects along with information on their occurrence.

Some of the relatively recent literatures on Taxonomic groups of insects attacking ferns are mentioned hereby :

Orthopterans are reported to utilize ferns of forest floor (Rowell et al. 1983). A new genus and species of Thysanoptera is described from South Indian altitudes (Mohan Daniel, 1985). Report on occurrence of a new species infesting ferns in Western Himalaya (Chakraborty and Banerjee, 1989); and two species of aphids and a jassid infesting ferns has been reported by Mohan Daniel and Chandrasekar (1986 a, b) from South India. An annotated account of the fern associated insects from the Terai region of Eastern Himalaya is under publication (Mukhopadhyay and Thapa, 1991).

ii. Bioecology of fern attacking insects:

a. Host-plant preference :

Hendrix and Marquis (1983) in their study on herbivore damage to three tropical ferns have given the techniques of assessing the host plant damage. They have also emphasised and compared the nature of preference and damage on ferns and tropical angiosperms by insects. In a study of palatibility of ferns and the ecology of two tropical grasshoppers, Rowell et al. (1983) has considered thirteen species of ferns. They have tried to correlate the biochemical parameters of the fern hosts with

their palatibility. The biochemical basis of preference of fern hosts have been worked out for aphids and a jassid by Mohan Daniel and Chandrasekar (1986 a, b) and for a thysanopteran species by Mohan Daniel (1985). Kaplanis et al. (1967) and Jones and Firn (1978) have emphasized the role of phytoecdysteroids in bracken as a defence against phytophagous insect attack. Soo Hoo and Fraenkel (1964) have shown how ferns are resistant to a polyphagous southern army worm.

Literature on food selection and feeding in Acridoids is vast. A recent contribution by Gangwere et al. (1989) gives a review on " Food selection and feeding in acridoids". In the same article a chapter on ' The phylogeny of host selection ' gives information on plant association of acridoids. Further it reports both monocotyledons and dicotyledons as food plants of Atractomorpha crenulata . The species selects its hosts by using a number of sensilla (Ananthakrishnan et al. 1985) and particularly those on its antenna (Shafi,1987). Muralirangan and Muralirangan (1985) has stressed upon the role of physicochemical factors in acridid food selection and feeding behaviour. Sanjayan and Ananthakrishnan (1987) have shown how host preference of some acridid are related to the biochemical parametres. Ram and Gupta (1989) in their study on integrated pest management in fodder cowpea found A. crenulata to be damaging to the crop.

Information on host choice, biology and food utilization and growth indices of the arctiid moths is vivid but scattered.

Various aspects of larval biology and development of Spilarctia obliqua (=Diacrisia obliqua) are available from works of Singh and Gangrade (1974), Sinha et al. (1975), Katiyar (1975 a, b), Katiyar et al. (1976), Yadav & Singh (1979), Deshmukh et al. (1979) Gupta (1982), Gupta et al (1979), Prasad and Premchand (1980), Poonia et al. (1981), Kabir et al. (1985), Goel et al. (1986), Kabir and Miah (1987), Dhale et al. (1988), Srivastava and Pandey (1988) and Sharma and Tara (1989). Development behaviour of the species on sugarbeet has also been studied by Singh and Sachan (1987), and on some common weeds by Rathore and Sachan (1978).

Literature on Spilarctia casigneta (=Diacrisia casignetum) is relatively poor. Most of the work available on biology and influence of the host plant on development, fecundity and egg hatchability has been done by Banerjee and Haque (1983 a,b ; 1985). The pest status of the species as a defoliator of sunflower has been highlighted by Banerjee and Haque (1984). Recently Chatterjee and Choudhury (1989) have further investigated some aspects of nutritional ecology and biology of the species on host plants like castor, groundnut, beans, jute, sesame and sunflower.

b. Energy budget and nutritional ecology.

Some idea on ecology and bioenergetics of A. crenulata can be obtained from works of Senthamizhselvan and Murugan (1988). Information on energy metabolism and ecological efficiencies of S. obliqua is scant. Kumar (1983) has published on the consumption and utilization of host by this arctiid on live

weight basis. Subsequently Goel and Kumar (1985) documented a relationship among food consumption , respiration and body weight of the species. Dry matter budget of S. casigneta on sunflower leaf have been investigated by Banerjee and Haque (1984). Slansky (1990) has emphasised the study of insect nutritional ecology as a basis for studying host-plant resistance (HPR). In a similar work, Krishna (1987) has documented pronounced disparities in the reproductive performance of adult moths as a result of larval food quality.

c. Insect-weed-crop interaction :

The role of grasses and other weeds as an original or alternate source of insect pests can not be ignored (Uvarov, 1964). Van Embden (1965) cited a number of weeds or wild plants as a host of crop pest or disease. Similar findings for weeds as alternate or alternative hosts have been reported for acridids (Meera, 1982; Ananthakrishnan, 1992). Some comprehensive reports with regard to insect-weed-crop interaction are from Ananthakrishnan et al. (1986) and Ananthakrishnan (1992). Halfhill et al. (1984) have documented how a species of aphid over winters using asparagus fern as host. Strong and Levein (1979) studied that the total number of insect species associated with any plant is more a function of ecological factor. In light of this, Hendrix (1980) proposed that host plant switching rather than slow evolutions of fern feeders account for the present insect fauna on ferns.

Interpatch migration of insect is demonstrated by Solbreck and Tullberg (1990). A comprehensive account of the importance of migration in 'Insect Life Cycles ' is also available from Solbreck et al (1990). That certain weeds also serve as reservoirs of alternate hosts and prey for natural enemies, have been highlighted by works of Hemenway and Whitcomb (1967), Flaherty (1969) Perrin (1975) and Doutt & Nakata (1973). In recent years Somchoudhury and Dutt (1989) reported infestation of Diacrisia eggs by Trichogramma

iii. Additional references, books and manuals :

Besides the above specific literatures, some of the more generalised publications that were found useful in connection with the study of the species (two arctiid and one acridid) are as follows :-

Muthukrishnan and Pandian (1987) in a comprehensive approach published the article on insect energetics in the book "Animal Energetics ". Another useful book on "Productivity of terrestrial animals, principals and methods " is by Petrusewicz and Macfadyen (1970). Scriber and Slansky (1981) published a review article on nutritional ecology of immature insects followed by the article on "food consumption and utilization" in the "Comprehensive insect physiology, biochemistry and pharmacology " (Slansky and Scriber, 1985). Some articles of general importance on nutritional ecology of insects are from Slansky (1982) on "Insect nutrition : An adaptationists

perspective ", Slansky and Scriber (1982) on " A sleected bibilography and summary of quantitative food utilization by immature insects ". A well discussed articles on quantifying and comparing food consumption and growth in insects is available from Farrar et al. (1989). Slansky (1985) published a useful article on food utilization by insects interpretations observed between dry weight and energy efficiencies. The book "Nutritional ecology of insects, mites, spiders and related invertebrates " edited by Slansky and Rodriguez (1987) is highly informative. Some related literatures on compensatory feeding and growth response of caterpillars are from Slansky & Wheeler (1992 a,b). An article by Slansky (1993) in the book "Caterpillars Ecological and Evolutionary Constraints on foraging " provides a detailed discussion on the fundamental quest for nutrients. The over views on allelochemic-nutrient interactions in herbivore nutritional ecology (Slansky, 1992) and a response of generalist and specialist insects to quantitative allelochemical variation (Bowers and Puttick, 1988) deal at length with the role of allelochemicals on insect performance. Barbosa et al. (1990) indicates the defensive role of foliage allelochemicals.

Some of the valuable articles on plant-animal relationship are available from edited books by Harborne (1978), Visser and Minks (1982), Brattsten and Ahmad (1986)

Ananthakrishnan and Raman (1988) , Abrahamson (1989) and Ananthakrishnan (1992).

Literature consulted in other areas like biochemistry, statistics, software etc. have been mentioned under the section "Materials and Methods ".

In scanning the vast literature manually from available abstracts, reprints, and books, some inadvertant lapses and slips are possible, but most of the literature hunting has been done keeping in mind their utility in the present work.

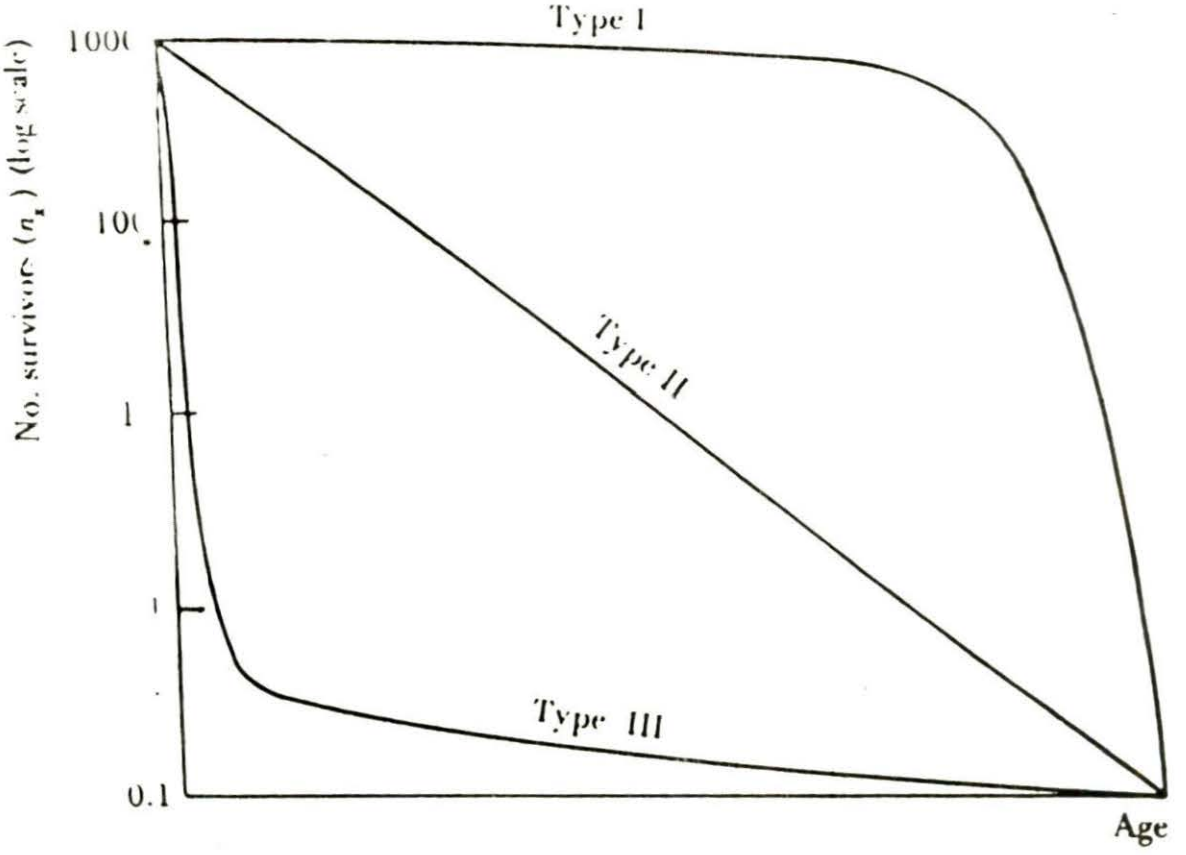

Fig.6. Hypothetical survivorship curves.
(After Pearl 1928)

Fig.7a. Natural appearance of fern species (*Diplazium esculentum*.

Fig.7b. Natural occurrence of fern species *Christella crinipes*.

Fig. 7a.

Fig. 7b.

Fig.8a. Natural occurrence of *Microlepia spelunceae*.

Fig.8b. Natural occurrence of fern species *Lindsea ensifolia*.

Fig. 9. Natural occurrence of fern species *Dicranopteris linearis*

Fig.8a.

Fig.8b.

Fig.9.