

**STUDIES ON THE DEVELOPMENTAL
AND HISTOCHEMICAL ANALYSIS OF DIGESTIVE AND
SECRETORY GLANDS OF SOME INSECTIVOROUS
PLANTS OF MEGHALAYA**



BY

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*THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE
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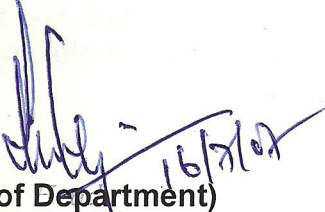
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DECLARATION

I, Ksh. Raseshowri Devi, hereby declare that the subject matter of this thesis entitled "*Studies on the developmental and histochemical analysis of digestive and secretory glands of some insectivorous plants of Meghalaya*" is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University / Institute.

This is being submitted to the North-Eastern Hill University, Shillong for the award of the degree of Doctor of Philosophy in Botany.


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CHAPTER – 1

Introduction

Carnivorous plants are angiosperms which possess special morphological, anatomical and physiological properties. They attract their victims by means of scent, colouration and nectar (Lloyd, 1942), and can trap and digest arthropods as well as some other small animals. After digestion, they take up minor quantity of the digested prey (Lloyd, 1942; Juniper et al., 1989). This whole process is carried out in modified plant parts or traps to capture the preys, such as, pitchers in *Nepenthes*, modified leaves in *Drosera* and bladders in *Utricularia* spp. Therefore, different traps of insectivorous plants play key role in benefiting the supplements of essential nutrients.

Plant carnivory is one of the many possible adaptational strategies to overcome the unfavorable condition of micro habitats, such as, soil condition in which moisture content is very high, acidic and deficient in essential nutrients mainly nitrogen and phosphorous. Besides, carnivorous plants obtain water and minerals from the soil; they also extract nutrients from captured animals. This phenomenon of carnivory has fascinated the scientific community ever since Darwin (1875), who drew attention to it in his remarkable book "Insectivorous Plants". The general features of carnivorous plants have been reviewed in detail by Juniper et al. (1989).

On the basis of their trapping mechanism, Lloyd (1942) divided

the carnivorous plants into two different categories, such as, carnivorous plants bearing *active traps* and carnivorous plants bearing *passive traps*. Later on, Heslop-Harrison (1976) grouped the genera of angiospermic carnivorous plants into four classes, such as, i) pitcher plants (e.g. *Nepenthes*), in which glandular surfaces bearing the secretory glands are immersed in the pitcher fluid which contain digestive enzymes. The fluid is secreted by the glands during the early growth phase of the leaves, and the products of the digestion are taken up continuously by the gland tissues which supplement nutrient requirements for several months; ii) plants with small traps in which microscopic preys are drawn together with water by active suction process (e.g. *Utricularia*), or passively by water currents (e.g. *Genlisea*) where, the digestive glands release their enzymes after such type of stimulation of the traps; iii) plants in which the secretion accumulates on the surface of the individual gland head forming globules (e.g. *Drosera*), where digestion of the prey begins when the prey comes in contact with the globules, and the digested products are absorbed through the glands and iv) plants in which the digestive glands remain dry until stimulated by the preys which are being captured (e.g. *Dionaea*).

Approximately 645 species of insectivorous plants have been reported so far from all over the world, and their distribution is mainly restricted to the tropical and sub-tropical belts (Venugopal et al., 2007). The Eastern Himalayan region of India has been identified as one among the 25 biodiversity "hotspots" of the world (Swaminathan, 1991;

Mohan Ram et al., 2001). Out of the six families of insectivorous plants available in the world, India has contributed three families namely: Droseraceae, Lentibulariaceae and Nepentheceae.

The Lentibulariaceae of insectivores has 4 genera, of which *Utricularia* and *Pinguicula* occur in India. Lentibulariaceae accounts for ca. 280 species (Janarthanam and Henry, 1992). The 'Bladderworts' with nearly 210 species is the largest and widely distributed genus among the insectivorous plants. They are widely distributed in tropical, subtropical and a few species in temperate zones. Taylor (1989) included 33 species of insectivorous plants from India under the genus *Utricularia* in his taxonomic monograph, and later on, Janarthanam and Henry (1992) reported a total of 35 species of *Utricularia* from India. Out of the 35 species of insectivorous plants available in India, 18 species are endemic to particular localities.

North-Eastern Himalayan region of India is rich in insectivorous plants with maximum number, where, Joseph and Joseph (1986) reported eleven species of *Utricularia*, two species of *Drosera* and the unigeneric species *Nepenthes khasiana* Hk. f. *Nepenthes khasiana* Hk. f. of the family Nepentheceae is predominantly distributed only in Meghalaya state. Janarthanam and Henry (1992) also reported thirteen endemic species of *Utricularia* from Peninsular India and five species from the Eastern Himalaya particularly from Meghalaya state. The species reported from Meghalaya state include *U. brachiata* Oliver, *U. furcellata* Oliver, *U. kumaonensis* Oliver, *U. multicaulis* Oliver and *U. recta* Taylor.

In case of angiosperms, all the endemic species are considered neoendemics as they have taxonomically interrelated species complements and occur in the same or adjacent areas (Nayar, 1980). The genus *Drosera* (Droseraceae) commonly called 'Sundew' consists of approximately 170 species. In India three species of the genus *Drosera* namely, *D. indica* L., *D. burmanii* Vahl. and *D. peltata* Sm. var. *lunata* Cl. have been reported from different regions (Jayaram and Prasad, 2006). *D. peltata* Sm. var. *lunata* and *D. burmanii* Vahl. grow throughout the plains as well as on the hills up to an elevation of 3000 m asl. Mathew (1999) reported that in Western Ghats of India, *D. indica* flourished in open habitats during the rainy season. According to Kanjilal and Bor (1940) and Raseshowri and Venugopal (2006), *D. peltata* is commonly distributed in Assam, Meghalaya and Mizoram states of North-east India, which grows in similar habitats to *D. indica*. The distribution of *D. burmanii* Vahl and *D. peltata* var *lunata* are also being reported from Jowai, Jarain, Pynursla, Shillong and Raliang area of Meghalaya (Joseph and Joseph, 1986).

The unigeneric family Nepentheceae comprises of approximately 74 species (Willis, 1966; Kaul, 1982) of which *Nepenthes khasiana* Hk. has been reported from Khasi, Jaintia and Garo hills of Meghalaya state (Jain and Sastri, 1980; Joseph and Mani, 1982; Hooker, 1886). Few population of this species was rediscovered from certain other parts of Meghalaya such as Jarain, Sutnga, Magheshkola and Lawbah (Haridasan and Rao, 1985; Rogers and Gupta, 1989; Choudhury, 2000).

Rathore and Tandon (1995) conducted shoot bud culture of *N. khasiana*. While studying the vegetation dynamics in coal mines of Jaintia hills in Meghalaya, Lyngdoh et al. (1992) reported that *N. khasiana* could not regenerate even after ten years in those areas due to the unscientific coal mining activities. This mining led to the degradation and destruction of the natural vegetation of the hills including the suitable micro habitats of *N. khasiana*. Studies on the reproductive biology of the family Nepentheceae is very meager, however, the development of anther and microsporogenesis was studied by Venugopal and Rashi Devi (2003).

Venugopal (1999) observed two types of glands in the pitcher - one for secretion of digestive enzymes and another for the absorption of digested products. Pant and Bhatnagar (1977) studied the detail anatomy and morphology of *Nepenthes khasiana*, *N. gracilis*, *N. raffleisana* and *N. ampullaria*. However, studies on the developmental aspects of glands in *Nepenthes khasiana* Hk. f., *Drosera peltata* Sm., *Utricularia bifida* Sm. and *U. pubescens* Sm. have not been carried out so far. Numerous studies have been published on foliar structure and development (Hooker, 1859; Fenner, 1904; Macfarlane, 1908; Kuhl, 1933; Roth, 1953; Schmid-Hollinger, 1970, 1979), glandular structure and function in the pitchers (Llyod, 1942; Luttge, 1971; Amagase, 1972a; Amagase et al., 1972b; Toekes et al., 1974; Heslop-Harrison, 1976; Adams and Smith, 1977; Fahn, 1979), and on the animal inhabitants (nepenthebionts) and prey in the pitchers (Beaver, 1979; Wirth and Beaver, 1979; Erber, 1979).

The potential medicinal uses of the insectivorous plants found in North-East India still remain unknown. Many ethnic groups of Meghalaya have been using the liquid of unopened pitcher as remedy for stomach pain and cough. The herbal practitioners of Khasi and Jaintia hills prescribe the fluid of the pitcher for diabetic patients as well as to cure patients suffering from urinary tract diseases. Cystitis patients and patients with vaginal tumors or menopause are also treated with this fluid. For the external use, the fluid of both open and unopened pitchers is applied on infected parts of the body.

The local people of Garo hills grind the pitcher into powder along with the shells of molluscs and are used for the treatment of leprosy. However, application of parts of such insectivorous plant for the treatment of diseases mentioned is not scientifically proved. This needs detail scientific study which may throw some light on the pharmaceutical potentiality of the plant. Many of the secondary products of secretory glands may have varied types of biological activities including insecticidal and pesticidal property which lead to better understanding of plant protection mechanisms to crops.

Studies on all the aforesaid aspects, particularly digestive enzymes secreted by the glands of insectivorous plants are important. There are only a few studies and reports on the developmental aspects of digestive glands and histochemical localization in the gland tissues (Heslop-Harrison and Knox, 1971; Fahn, 1979; Heslop-Harrison and Heslop-Harrison, 1980, 1981). Therefore, this study aims to investigate the development of secretory and digestive glands, and histochemical

localization in the gland tissues of the four representative species of the three families viz. Nepentheceae, Droseraceae and Lentibulariaceae.

The thesis embodied particular emphasis on the following objectives:

- to study the development of digestive and secretory glands in *Nepenthes khasiana* Hk. f., *Drosera peltata* Sm. Var. *lunata* Cl., *Utricularia bifida* Sm. and *U. pubescens* Sm.,
- to study the histochemical localization in the different types of traps of the above mentioned plants.