CHAPTER I

OCCURANCE AND DISTRIBUTION OF DROSOPHILA SPECIES IN NAGALAND, A SUB-HIMALAYAN HILLY STATE OF NORTH-EAST INDIA
INTRODUCTION:
The fruit fly *Drosophila* is one of the most intensively studied organisms in biology that serves as a model system for investigations of many developmental, cellular processes, disease, adaptation, diversity and evolution; whose underlying fundamental principles are comparable to higher eukaryotes, including man (Reviewed in Devineni et al. 2013). Culturing *Drosophila* is easy and inexpensive and they could be kept in large numbers. It has a short life cycle, hence could be used for any study which needs observation over generations. Libraries of several *Drosophila* species and mutant stocks of many species are available at different laboratories in the world. Presence of polytene chromosomes added advantage for taxonomic and genetic studies. *Drosophila* genome has also been sequenced. Because of these advantages, *Drosophila* is valuable in understanding the basic principles of genetics, molecular biology, adaptation and evolution. Fruit fly has also been extensively used to appreciate many intricacies concerned with the relationships between the ecological factors and population fluctuations (Da Cunha et al. 1951; Parshad and Paika 1964; Parshad and Duggal 1966; Heed 1968; Gupta and Ray Chaudhuri 1970a,b; Rajeshwari 1971; Reddy and Krishnamurthy 1968, 1973; Siddaveere Gowda et al. 1977; Hegde and Krishnamurthy 1979; Prakash and Reddy 1980; Bizzo and Sene 1982; Brncic et al. 1985; Singh and Chatterjee 1987; Putman 1995; Begon et al. 1996; Hegde et al. 2000; Nagabhushan 2002; Yenisetti et al. 2002; Mateus et al. 2006; Toress and Ravazzi 2006; Guru Prasad 2008 and Achumi et al. 2013).

The family Drosophilidae comprises of more than 3,500 described species including the genus *Drosophila* (Bachli 1998). It is estimated that there are more than 2240 biologically valid species of *Drosophila* (Wheeler 1986). Indian subcontinent with its vast array of vegetation and climates harbors variety of *Drosophila* species. Though studies on Indian Drosophilids was started by Bezzi (cf. Sturtevant 1921) much of our knowledge on eco-distribution of *Drosophila* in India was acquired only after 1964 (Parshad and Paika 1964; Gupta and Ray Chaudhuri 1970a,b; Rajeshwari 1971; Godbole and Vaidya 1972; Ranganath and Krishnamurthy 1972a,b; Nirmala and Krishnamurthy 1973; Gupta 1974; Nirmala and Reddy 1975; Dwivedi et al. 1979; Dwivedi and Gupta 1980; Prakash and

Significant progress has been made in the field of taxonomy and systematics of the family Drosophilidae (Diptera) in India. However, a vast area of great ecological interest still...
either awaits exploration or is poorly explored. Particularly, very little is known regarding *Drosophila* fauna of North-Eastern region of the Indian subcontinent. This region with its diverse climatic conditions, variable altitudes, deep valleys, luxuriant flora, running streams and moist surroundings, one of the richest repositories of biodiversity in the world. It provides an ideal location for the colonization of several *Drosophila* species (Singh and Gupta 1977, Dwivedi and Gupta 1979, Gupta and Singh 1979, Dwivedi *et al.* 1979, Singh 1987; Yenisetti *et al.* 2002; Achumi *et al.* 2011, 2013).


Nagaland state is one of the ‘Eight Sisters’ of North-East India. It is bordered by state of Assam in the west, by state of Arunachal Pradesh and part of Assam towards the north, on the east by the country of Burma and by the state of Manipur on towards the south. Nagaland is situated at the foot hills of Himalayas. Naga Hills are covered with the tropical evergreen and sub tropical forest that are endowed with rich flora and fauna. Geographically, Nagaland state lies between 26º 60’ N and 27º40’ N latitude and 93º20’ E and 95º15’ E longitude (area of about 16,579 sq. Kilometers). Nagaland is popular for the fact that its climate remains salubrious throughout the year. Annual average rainfall varies from 175 cm to 250 cm. Temperature varies from 4º C to 31ºC.
Very little work is done on *Drosophila* diversity of Nagaland. Singh (1987) conducted a pioneering preliminary survey on Drosophilids of Dimapur, Medziphema and Kohima of Nagaland. Yenisetti et al. (2002) published a preliminary report on Drosophilids of Mokokchung town. But for these maiden attempts no systematic comprehensive study was done on *Drosophila* of Nagaland. As most parts of Nagaland are unexplored virgin areas, it is possible that new *Drosophila* species can be identified from this region. In order to understand occurrence and distribution of *Drosophila* species, collections were made from wild localities of all the eleven districts of Nagaland state.
MATERIALS AND METHODS:

Collections were performed in eleven district head quarters of Nagaland state during post-monsoon months of 2012.

*Drosophila* collections were made following two methods:

1) **Bottle trapping method:** For bottle trapping method, milk bottles of 200 ml capacity containing a smashed ripe banana sprayed with yeast were tied to the twigs underneath small bushes at the height of three to five feet above the ground. Ten traps were kept in an area of 1 Km radius. After 2 days the mouth of each bottle was plugged with cotton and removed from the bushes. The flies which were attracted by the bait were collected in the bottles (soon after sun rise or just before sun set) and were transferred to fresh bottles containing wheat cream agar medium (medium was prepared by adding 100 g of sugar (jaggery) to 500 ml of water and boiled by gentle stirring till jaggery dissolved. Then, 500 ml of water, 100 g of wheat powder (soji), and 8 g of agar-agar were added to the boiling sugar water mixture. When the medium turns sticky 7.5 ml propionic acid (anti fungal agent) was added while continuous stirring the medium. This medium then becomes a thick fluid. It was then distributed to sterilized jam bottles (200 ml milk bottles) or vials of 1’x3’ size. The mouth of the bottles/vials was kept closed with cotton. Next day moisture was removed from bottles/vials and two drops of yeast solution was added to the medium. This medium was used after 24 hours).

2) **Net sweeping method:** For net sweeping method, a hand made *Drosophila* net containing a fine cloth cone tied to the rim of the net was used. Sweeping was made on fermenting fruits (crushed banana were spread in shaded areas of the bushes in the wild and flies were collected after 2 days) that were spread under four shady regions in an area of 1Km radius. After each sweep (three sweepes were performed) flies were collected at the bottom of the cone of the net and were transferred to the bottles containing freshly prepared wheat cream agar medium.

The flies were then brought to the laboratory, isolated and sex was identified. The males were directly used for identification of species basing on morphological characters such as
presence or absence of the sex comb; if present, the number of sex comb rows and teeth in each row and studying the characteristics of the genital plate. Individual females were kept in separate food vials and allowed to produce isofemale lines. The males of the F1 progeny of these gravid females were used for species identification.

Categorization of the collected *Drosophila* flies were made to respective taxonomic groups by employing the parameters as suggested by Bock (1971), Patterson and Stone (1952), Sturtevant (1921) and Throckmorton (1962). The most important parameters employed to identify the species are the morphological features like colour and size of imagoes, number and nature of aristal branches, nature and arrangement of genital arch, nature and number of acrostichal hairs, length of the wings and its indices, the internal characters of the adults, the shape and number of egg filaments, pupal characters, pupal spiracles, and behavior were also taken into consideration for species identification.

**Flora at collection sites of Dimapur:**


**Flora at collection sites of Kiphire:**

Pteridaceae); Brahmi booti, *Centella asiatica* (L.) (Apiaceae); khasi pine, *Pinus insularies* (Gordon) (Pinaceae); etc.

**Flora at collection sites of Kohima:**
Banana, *Musa* spp (Zingiberales: Musaceae); yellow himalayan raspberry, *Rubus* spp, (Rosaceae); jackfruit, *Artocarpus heterophyllus* (Lam), (Rosales: Moraceae); *Makania* spp; carrion flowers, *Simlax* spp (Liliales: Smilacaceae); pinyin, *Stemona* spp (Pandanales: Stemonaceae); currant tomato, *Solanum* spp (Solanales: Solanaceae); maibau, *Alnus nepalensis* (Don) (Fagales: Betulaceae); marda, *Terminalia elliptice* (Wright and Arn) (Myrtales: combretaceae); khasi pine, *Pinus insularies* (Gordon) (Pinaceae); etc.

**Flora at collection sites of Longleng:**

**Flora at collection sites of Mokokchung:**
Blueberry ash, *Elaeocarpus* spp; (Oxalidales: Elaeocarpaceae); deer-eye beans, *Mucna perita* (Adans) (Fabales: Fabaceae); bologi, *Crossocephalum* spp (Asterales: Asteraceae); black musale, *Curculigo* spp (Asparaginaeae); blady grass, *Imperata cylindrica* (Drauv) (Poales: Poaceae); kamraj, *Helminhostachys zeylanica* (L.) (Ophioglossales: Ophioglossaceae); carrion flowers, *Simlax* spp (Liliales: Smilacaceae); banana, *Musa* spp (Zingiberales: Musaceae); etc.
Flora at collection sites of Mon:

Flora at collection sites of Peren:

Flora at collection sites of Phek:
Butterfly bush, *Buddleja* spp (Lamiales: Scrophulariaceae); brahmi booti, *Centella asiatica* (L.) (Apiales: Apiaceae); sirib large, *Entada pursathea* (Roux) (Fabales: Fabaceae); knotwood, *Polygonum* spp (Caryophyllales: Polygonaceae); maibau, *Alnus nepalensis* (Don) (Fagales: Betulaceae); khang, *Acacia pinnata* (Miller) (Fabales: Fabaceae); bologi, *Crossocephalum* spp (Asterales: Asteraceae); himalayan nettle, *Girardinia heterophylla* (Vahl) (Rosales: Urticaceae); banana, *Musa* spp (Zingiberales: Musaceae); currant tomato, *Solanum* spp (Solanales: Solanaceae); blady grass, *Imperata cylindrica* (Drauv) (Poales: Poaceae); etc.
Flora at collection sites of Tuensang:
Banana, *Musa* spp (Zingiberales: Musaceae); himalayan raspberry, *Rubus* spp (Rosaceae); jackfruit, *Artocarpus heterophyllus* (Lam), (Rosales: Moraceae); carrion flower, *Simlax* spp (Liliales: Smilacaceae); pinyin, *Stemona* spp (Pandanales: Stemonaceae); currant tomato, *Solanum* spp (Solanales: Solanaceae); marda, *Termenalia elliptice* (Wright and Arn) (Myrtales: combretaceae); cowich, *Mucuna pruriens* (L.) (Fabales: Fabaceae); begger-ticks, *Bidens* spp (Asterales: Asteraceae); wormwood, *Artemisia vulgaris* (L.) (Asterales: Asteraceae); etc.

Flora at collection sites of Wokha:
Sirib large, *Entada pursathea* (Roux) (Fabales: Fabaceae); knotwood, *Polygonum* spp (Caryophyllales: Polygonaceae); maibau, *Alnus nepalensis* (Don) (Fagales: Betulaceae); banana, *Musa* spp; (Zingiberales: Musaceae); timburni, *Dryopteris* spp (Ericales: Ebenaceae); cowich, *Mucuna pruriens* (L.) (Fabales: Fabaceae); himalayan nettle, *Girardinia heterophylla* (Vahl) (Rosales: Urticaceae); begger-ticks, *Bidens* spp (Asterales: Asteraceae); etc.

Flora at collection sites of Zunheboto:
Wormwood, *Artemisia vulgaris* (L.) (Asterales: Asteraceae); begger-ticks, *Bidens* spp (Asterales: Asteraceae); butterfly bush *Buddleja* spp (Lamiales: Scrophulariaceae); brahmi booti, *Centella asiatica* (L.) (Apiales: Apiaceae); black musale, *Curculigo* spp (Asparagales: Hypoxidaceae); khasi pine, *Pinus insularies* (Gordon) (Pinales: Pinaceae); cowich, *Mucuna pruriens* (L.) (Fabales: Fabaceae); butterfly bush *Buddleja* spp (Lamiales: Scrophulariaceae); carrion flowers, *Simlax* spp (Liliales: Smilacaceae); pinyin, *Stemona* spp (Pandanales: Stemonaceae); currant tomato, *Solanum* spp (Solanales: Solanaceae); etc.
OBSERVATIONS:

The list of *Drosophila* species collected in 11 districts of Nagaland and their taxonomic position is shown in table 1. Total of 16 species were collected belonging to four subgenera viz. *Sophophora*, *Drosophila*, *Dorsilopha* and *Scaptodrosophila*. Pooled data collected from 11 districts has yielded a total of 2326 individuals. Out of these 1463 individuals (62.89%) belonged to 10 species of sub genus *Sophophora*. 569 individuals (24.46%) belonged to 4 species of the subgenus *Drosophila*. 121 individuals (5.20%) belonged to 1 species of subgenus *Dorsilopha*. The remaining 173 individuals (7.43%) belonged to 1 species of subgenus *Scaptodrosophila*.

*Drosophila* fauna at Dimapur:

The list of *Drosophila* species collected in Dimapur (headquarters of Dimapur district of Nagaland) and their taxonomic position is shown in table 1. Analysis of *Drosophila* collection of 279 flies from this locality revealed the occurrence of 14 species representing four subgenera viz. *Sophophora*, *Drosophila*, *Dorsilopha* and *Scaptodrosophila* of the genus *Drosophila*. Out of these 187 individuals (67.02%) belonged to 8 species of subgenus *Sophophora*, namely *D. bipectinata*, *D. eugracilis*, *D. jambulina*, *D. Kikkawai*, *D. melanogaster*, *D. malerkotliana*, *D. parvula* and *D. takahashii*. 59 individuals (21.14%) belonged to 4 species of the subgenus *Drosophila* (*D. immigrans*, *D. nasuta*, *D. parvula* and *D. paraimmigrans*). 22 individuals (7.88%) belonged to 1 species of subgenus *Dorsilopha* (*D. buskii*). The remaining 11 individuals (3.94%) belonged to 1 species of subgenus *Scaptodrosophila* (*D. nigra*).

*Drosophila* fauna of Kiphire:

The list of *Drosophila* species collected in Kiphire (headquarters of Kiphire district of Nagaland) and their taxonomic position was given in table 1. Total of 11 species were collected comprising of four subgenera viz. *Sophophora*, *Drosophila*, *Dorsilopha* and *Scaptodrosophila*. Pooled data collected from Kiphire district has yielded a total of 160 individuals. Out of these 109 individuals (68.12%) belonged to 6 species of sub genus *Sophophora* (*D. bipectinata*, *D. kikkawai*, *D. malerkotliana*, *D. melanogaster*, *D. parvula* and *D. rajasekari*). 36 individuals (22.5%) belonged to 3 species of the subgenus
Drosophila (D. immigrans, D. paraimmigrans and D. repleta). 3 individuals (1.87%) belonged to 1 species of subgenus Dorsilopha (D. buskii). The remaining 12 individuals (7.5%) belonged to 1 species of subgenus Scaptodrosophila (D. nigra).

**Drosophila fauna at Kohima:**
The list of Drosophila species collected at Kohima (headquarters of Kohima district of Nagaland) and their taxonomic position was given in table 1. Sample analyzed revealed a total of 15 species representing four subgenera viz. Sophophora, Drosophila, Dorsilopha and Scaptodrosophila. Pooled data collected from Kohima has yielded a total of 333 individuals. Out of these 209 individuals (62.76%) belonged to 9 species of sub genus Sophophora (D. bipectinata, D. eugracilis, D. jambulina, D. kikkawai, D. malerkotliana, D. melanogaster, D. parvula, D. rajasekari and D. takahashii). 95 individuals (28.52%) belonged to 4 species of the subgenus Drosophila (D. immigrans, D. nasuta, D. paraimmigrans and D. repleta). 7 individuals (2.10%) belonged to 1 species of subgenus Dorsilopha (D. buskii). The remaining 22 individuals (6.60%) belonged to 1 species of subgenus Scaptodrosophila (D. nigra). D. takahashii and D. bipectinata were found to dominate in this locality.

**Drosophila fauna of Longleng:**
The list of Drosophila species collected in Longleng (headquarters of Longleng district of Nagaland) and their taxonomic position was given in table 1. Total of 8 species were collected belonging to three subgenera viz. Sophophora Drosophila and Scaptodrosophila. Pooled data collected from Longleng district has yielded a total of 172 individuals. Out of these 100 individuals (58.13%) belonged to 4 species of sub genus Sophophora (D. eugracilis, D. malerkotliana, D. melanogaster and D. rajasekari). 56 individuals (32.55%) belonged to 3 species of the subgenus Drosophila (D. immigrans, D. paraimmigrans, and D. repleta). 16 individuals (9.30%) belonged to 1 species of subgenus Scaptodrosophila (D. nigra).
Drosophila fauna of Mokokchung:
The list of Drosophila species collected in Mokokchung (headquarters of Mokokchung district of Nagaland) and their taxonomic position was shown in table 1. Total of 11 species were collected belonging to four subgenera viz. Sophophora, Drosophila, Dorsilopha and Scaptodrosophila. Pooled data collected from Mokokchung district has yielded a total of 187 individuals. Out of these 135 individuals (72.19%) belonged to 7 species of sub genus Sophophora (D. bipectinata, D. eugracilis, D. jambulina, D. melanogaster, D. malerkotliana, D. parvula and D. takahashii). 23 individuals (12.29%) belonged to 2 species of the subgenus Drosophila (D. immigrans, and D. nasuta). 13 individuals belong to 1 species of subgenus Dorsilopha (D. buskii). 10 individuals (5.34%) belonged to 1 species of subgenus Scaptodrosophila (D. nigra).

Drosophila fauna at Mon:
The list of Drosophila species collected at Mon (headquarters of Mon district of Nagaland) and their taxonomic position was given in table 1. A survey of Drosophila fauna here yielded a total of 227 flies comprising 13 species representing four subgenera viz. Sophophora, Drosophila, Dorsilopha and Scaptodrosophila. Out of these, 142 individuals (62.55%) belonged to 7 species of sub genus Sophophora (D. eugracilis, D. jambulina, D. kikkawai, D. malerkotliana, D. melanogaster, D. parvula, and D. takahashii). 51 individuals (22.46%) belonged to 4 species of the subgenus Drosophila (D. immigrans, D. nasuta, D. paraimmigrans and D. parvula). 11 individuals (4.84%) belonged to 1 species of subgenus Dorsilopha (D. buskii). The remaining 23 individuals (10.13%) belonged to 1 species of subgenus Scaptodrosophila (D. nigra).

Drosophila fauna of Peren:
The list of Drosophila species collected in Peren (headquarters of Peren district of Nagaland) and their taxonomic position was given in table 1. Analysis of the sample revealed the presence of 10 species comprising of four subgenera viz. Sophophora, Drosophila, Dorsilopha and Scaptodrosophila. Pooled data collected from Peren district has yielded a total of 223 individuals. Out of these 104 individuals (46.63%) belonged to 5 species of sub genus Sophophora (D. bipectinata, D. eugracilis, D. jambulina, D. malerkotliana and D. takahashii). 75 individuals (33.63%) belonged to 3 species of the
subgenus Drosophila (D. paraimmigrans, D. nasuta and D. repleta). 24 individuals (10.76%) belonged to 1 species of subgenus Dorsilopa (D. buskii). The remaining 20 individuals (8.96%) belonged to 1 species of subgenus Scaptodrosophila (D. nigra).

**Drosophila fauna of Phek:**
The list of Drosophila species collected in Phek (headquarters of Phek district of Nagaland) and their taxonomic position was given in table 1. Total of 10 species were collected comprising of three subgenera viz. Sophophora, Drosophila and Dorsilopa. Pooled data collected from Phek has yielded a total of 183 individuals. Out of these 112 individuals (61.20%) belonged to 6 species of sub genus Sophophora (D. bipectinata, D. eugracilis, D. jambulina, D. kikkawai, D. melanogaster and D. takahashii). 49 individuals (26.77%) belonged to 3 species of the subgenus Drosophila (D. immigrans, D. nasuta and D. paraimmigrans). 22 individuals (12.02%) belonged to 1 species of subgenus Dorsilopa (D. buskii).

**Drosophila fauna of Tuensang:**
The list of Drosophila species collected in Tuensang (headquarters of Tuensang district of Nagaland) and their taxonomic position is shown in table 1. Total of 11 species were collected belonging to three subgenera viz. Sophophora, Drosophila, and Scaptodrosophila. Pooled data collected from Tuensang district has yielded a total of 187 individuals. Out of these 121 individuals (32.35%) belonged to 7 species of sub genus Sophophora (D. bipectinata, D. eugracilis, D. jambulina, D. kikkawai, D. malerkotliana, D. rajasekari and D. takahashii). 44 individuals (11.76%) belonged to 3 species of the subgenus Drosophila (D. immigrans, D. paraimmigrans and D. repleta). 22 individuals (5.88%) belonged to 1 species of subgenus Scaptodrosophila (D. nigra).

**Drosophila fauna of Wokha:**
The list of Drosophila species collected in Wokha (headquarters of Wokha district of Nagaland) and their taxonomic position was given in table 1. Total of 11 species were collected. Comprising of four subgenera viz. Sophophora, Drosophila, Dorsilopa and Scaptodrosophila. Pooled data collected from Wokha district has yielded a total of 179
individuals. Out of these 118 individuals (65.92%) belonged to 7 species of sub genus *Sophophora* (*D. bipectinata, D. eugracilis, D. jambulina, D. malrekoltiana, D. melanogaster, D. parvula* and *D. takahashii*). 25 individuals (13.96%) belonged to 2 species of the subgenus *Drosophila* (*D. immigrans, D. paraimmigrans*). 13 individuals (7.26%) belonged to 1 species of subgenus *Dorsilopha* (*D. buskii*). 23 individuals (12.84%) belonged to 1 species of subgenus *Scaptodrosophila* (*D. nigra*).

**Drosophila fauna of Zunheboto:**

The list of *Drosophila* species collected in Zunheboto (headquarters of Zunheboto district of Nagaland) and their taxonomic position was given in table 1. Total of 11 species were collected belonging to three subgenera viz. *Sophophora, Drosophila* and *Scaptodrosophila*. Pooled data collected from Zunheboto district has yielded a total of 196 individuals. Out of these 126 individuals (64.28%) belonged to 7 species of sub genus *Sophophora* (*D. bipectinata, D. Hegdii, D. jambulina, D. Kikkawai, D. melanogaster, D. malerkotliana*, and *D. takahashii*). 56 individuals (28.57%) belonged to 3 species of the subgenus *Drosophila* (*D. immigrans, D. nasuta and D. repleta*). 14 individuals (7.14%) belonged to 1 species of subgenus *Scaptodrosophila* (*D. nigra*). A new species (*Drosophila hegddii*) identified from this collection (Description of this new species and its molecular phylogeny is discussed in Chapter III).

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Table 1. Occurrence and distribution of *Drosophila* species in 11 districts of Nagaland

<table>
<thead>
<tr>
<th>Species</th>
<th>Dimapur</th>
<th>Kiphire</th>
<th>Kohima</th>
<th>Longleng</th>
<th>Mokokchung</th>
<th>Mon</th>
<th>Peren</th>
<th>Phek</th>
<th>Tuensang</th>
<th>Wokha</th>
<th>Zunheboto</th>
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<td>22</td>
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<td>3. <em>D. paraimmigrans</em></td>
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<td>21</td>
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<td>4. <em>D. repleta</em></td>
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<td><strong>Total</strong></td>
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<td><strong>Subgenus ScaptoDrosophila</strong></td>
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<td><strong>Total</strong></td>
<td>11</td>
<td>12</td>
<td>22</td>
<td>16</td>
<td>10</td>
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<td>22</td>
<td>23</td>
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<tr>
<td><strong>Grand total</strong></td>
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<td>333</td>
<td>172</td>
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Figure 1. Geographical location of Nagaland state, India in Asia

(adapted from Googlemaps)
Figure 2. Map showing the localities of collections of Drosophila species in 11 districts of Nagaland (adapted from Google maps)
DISCUSSION:

The study of evolution in any group of animals or plants implies knowledge of the number and distribution of the species involved and the population structure and habits of the species in relation to their environment (Heed 1957). Genus *Drosophila* with its cosmopolitan nature and complexities in species compositions provides an excellent material to understand the eco-distributional pattern of various species. Systematic study concerning the variations in species composition and the distributional pattern of the members of this genus in different geographical regions of the earth will enable us to understand the principles underlying adaptive radiation and certain mechanisms involved in speciation (Dobzhansky 1937). The occurrence and the distributional pattern not only be correlated with the type of vegetation and climatic conditions of the area under consideration but also with the colonizing abilities of the species concerned (Prakash 1979).

Present study reveals that not only the numbers of *Drosophila* species vary among different places; but also the number of individuals belonging to same species differs among different places under study.

The abundance of *Drosophila* species collected in 11 district headquarters of Nagaland and their taxonomic position was shown in Table 1. Total of 16 species (including one new species *Drosophila hegdii*) were collected. Pooled data collected from 11 districts has yielded a total of 2326 individuals, belonging to 4 subgenera namely, *Sophophora*, *Drosophila*, *Dorsilopha* and *Scaptodrosophila*. The subgenus *Sophophora* was represented by 10 species, namely *D. bipectinata*, *D. eugracilis*, *D. jambulina*, *D. kikkawai*, *D. malerkotiana*, *D. melanogaster*, *D. parvula*, *D. rajasekari*, *D. takahashii* and *D. hegdii*. *Drosophila* was represented by 4 species namely *D. immigrans*, *D. nasuta*, *D. paraimmigrans* and *D. repleta*. *Dorsilopha* was represented by 2 species namely *D. buskii* and *Scaptodrosophila* was represented by *D. nigra*. Thus the study indicates that the *Drosophila* fauna of Nagaland is diverse.
In Dimapur a total of 279 individuals were collected, out of these 187 individuals (67.02%) belonged to 8 species of sub genus *Sophophora*, namely *D. bipectinata*, *D. eugracilis*, *D. jambulina*, *D. kikkawai*, *D. malerkotliana*, *D. melanogaster*, *D. parvula* and *D. takahashii*. 59 individuals (21.14%) belonged to 4 species of the subgenus *Drosophila* (*D. immigrans*, *D. nasuta* *D. parvula* and *D. paraimmigrans*). 22 individuals (7.88%) belonged to 1 species of subgenus *Dorsilopha* (*D. buskii*). The remaining 11 individuals (3.94%) belonged to 1 species of subgenus *Scaptodrosophila* (*D.nigra*). Singh (1987) surveyed Dimapur locality and reported 10 species namely- *D. buski*, *D. nasuta*, *D. immigrans* *D. lacertosa*, *D. kikkawai*, *D. bipectinata*, *D. ananassae*, *D. melanogaster*, *D. malerkotliana* and *D. jambulina*. Of the above mentioned species *D. kikkawai*, *D. buskii*, *D. immigrans*, *D. nasuta*, *D. bipectinata*, *D. malerkotliana* and *D. jambulina* were observed in the present study. However *D. lactertosa* and *D. nepalensis* were absent in the present collection.

Collection analyzed from Kohima revealed a total of 15 species. Pooled data collected from Kohima district has yielded a total of 333 individuals. Out of these 209 individuals (62.76%) belonged to 9 species of sub genus *Sophophora* (*D. bipectinata*, *D. eugracilis*, *D. jambulina*, *D. kikkawai*, *D. malerkotliana*, *D. melanogaster*, *D. parvula*, *D. rajasekari* and *D. takahashii*). 95 individuals (28.52%) belonged to 4 species of the subgenus *Drosophila* (*D. immigrans*, *D. nasuta*, *D. paraimmigrans* and *D. repleta*). 7 individuals (2.10%) belonged to 1 species of subgenus *Dorsilopha* (*D. buskii*). The remaining 22 individuals (6.60%) belonged to 1 species of subgenus *Scaptodrosophila* (*D. nigra*). Singh (1987) surveyed Kohima locality and found 8 species namely, *D. buskii*, *D. nasuta*, *D. immigrans* *D. lacertosa*, *D. kikkawai* *D. ananassae*, *D. melanogaster* *D. nepalensis*. Of the above mentioned species *D. kikkawai*, *D. buskii*, *D. immigrans* and *D. nasuta* were observed in the present study too. However, *D. lactertosa* and *D. nepalensis* were absent.

Catch analyzed from Mokokchung has yielded a total of 187 individuals. Out of these 135 individuals (72.19%) belonged to 7 species of sub genus *Sophophora* (*D. bipectinata*, *D. eugracilis*, *D. jambulina*, *D. melanogaster*, *D. malerkotliana*, *D. parvula*, and *D. takahashii*). 23 individuals (12.29%) belonged to 2 species of the subgenus *Drosophila* (*D. immigrans*, *D. nasuta*). 13 individuals belong to 1 species of subgenus *Dorsilopha* (*D. buskii*). 10 individuals (5.34%) belonged to 1 species of subgenus *Scaptodrosophila* (D.
nigra). D. parvula and D. jambulina were found in abundance in this locality. Yenisetti et al. (2002) surveyed Mokokchung locality and identified 6 species namely, D. immigrans, D. kikkawai, D. nasuta, D. nepalensis, D. Suzuki, and D. takahashii and two picture winged Drosophila species (unidentified). Of the above mentioned species D. takahashii, D. immigrans and D. nasuta were observed in the present study. However, D. nepalensis and D. Suzuki and picture winged Drosophila species were absent.

Present study on Drosophila fauna of Nagaland reveals the presence of D. malerkotliana in abundance. D. malerkotliana is considered to be sub-cosmopolitan and widespread in South-East Asia, Borneo, West Malaysia Australia and several island groups in the Oriental region (O’Grady and Markow 2006). It is important to note the fact that this species was reported in all previous collections made by multiple workers from north eastern parts of the country (Dwivedi and Gupta 1979; Gupta and Singh 1979; Gupta and Singh 1980; Gupta and Singh 1981; Singh 1987; Yenisetti et al. 2002 and Achumi et al. 2013). This observation suggests that Nagaland’s Drosophila diversity denotes confluence of South Asia and East Asia. Dominance of D. malerkotliana over others can be due to its ecological versatility to exploit diverse habitats.

Present collection reveals that D. bipectinata is the second dominant species in Nagaland. Literature review denotes that D. bipectinata is widespread in Kula Lampur west Malaysia. This species also widely distributed in Borneo, Philipins, Thailand, West Malaysia, Nepal, Japan, Taiwan and India (O’Grady and Markow 2006).

In present collection D. immigrans found to be the third abundant species. D. immigrans is a cosmopolitan species and is found from Taiwan to Southeast Asia, Indonesia, India (O’Grady and Markow 2006). From their studies on Drosophila diversity on Western Ghats, Ranganath and Krishnamurthy (1972b) observed that D. immigrans is abundant at higher altitudes. In light of this observation, presence of D. immigrans in sub-Himalayan hilly regions suggests its adaptability to higher altitudes.
Present collection reports *D. takahashii*, *D. parvula*, *D. nasuta*, *D. repleta*, *D. eugracilis*, *D. jambulina*, *D. kikkawai*, *D. rajasekari*, *D. nigra* and *D. paraimmigrans* in Nagaland populations. *D. takahashii* is most widespread being found from India to Japan and into Micronesia; *D. parvula* is found from South East Asia, west Malaysia and Thailand; *D. nasuta* is thought to be from eastern Africa although this species has become widespread from South East Asia into Micronesia; *D. repleta* species is cosmopolitan in distribution; *D. eugracilis* is widespread in Indian subcontinent, found throughout South East Asia and into Australia; *D. jambulina* is widespread from India to southern China to South East Asia; *D. kikkawai* is circumtropical in distribution; *D. rajasekari* is found in India, Cambodia and Thailand; *D. nigra* is found in Australia, new Guina, Borneo, Phillippines, Malaysia, Thailand and India; and *D. paraimmigrans* is found in India, Taiwan to Southeast Asia (O'Grady and Markow 2006).

Carson (1965) based on the pattern of distribution of various members of *Drosophila*, has recognized three distinct groups, namely 1. Virtually cosmopolitan species, 2. Species having a tendency for wide spreading but not cosmopolitan and 3. Species having restricted distribution (endemic species). He included five species namely, *D. melanogaster*, *D. simulans*, *D. ananassae*, *D. buskii* and *D. repleta* as truly cosmopolitan. Incidentally, *D. melanogaster*, *D. simulans*, and *D. ananassae* are domestic, while *D. buskii* and *D. repleta* are semi-domestic. In the present study *D. melanogaster*, *D. repleta* and *D. buskii* were present. Though *Drosophila simulans* is cosmopolitan in distribution (O’Grady and Markow 2006), in the present study in none of the eleven locations of Nagaland this species was found. Contrarily David *et al.* (2007) observed that *D. simulans* was absent from most of West Africa and was very rare in the Cote d’ Ivoire and was absent in most parts of East Asia (David *et al.* 2007). Collections in Nagaland state were made from wild localities. This can be the rationale behind the absence of *D. ananassae* and *D. simulans*.

The striking feature of the collection was that in all the eleven locations of Nagaland state *Drosophila* species belonging to two sub genera namely *Sophophora* and *Drosophila* dominated in their relative proportions of different species and their densities. This finding is in agreement with the observation of Bock and Wheeler (1972) who stated that if
Drosophila collection made in any part of the South East Asian or New Guinean area, only two species groups comprise all or practically of all the catch, that is the melanogaster species group of the subgenus Sophophora and immigrans species group of the subgenus Drosophila. They further supplemented their argument by hypothesizing that the melanogaster and immigrans species group might have originated in South East Asia and then colonized in other regions. As Nagaland is a sub Himalayan hilly state, which is a part of South East Asia, the prevalence of Sophophora and immigrans species groups in the present collection reaffirms the observation made by Bock and Wheeler (1972).

Present study reveals the fact that Drosophila fauna of Nagaland state shows similarity not only with South Asia but also with that of East Asia which can be explained from geographical location of this north eastern state.