

## 8. Summary

1. Study on insect association of *Alnus nepalensis* ('Utis' tree) from Sikkim indicated that the tree harboured insects of different taxonomic and feeding guilds throughout the year.
2. Taxonomic analysis of the entomofauna showed the dominance of morpho-species (Recognizable Taxonomic Unit =RTU) coleopterans followed by lepidopterans, homopterans, hemipterans, hymenopterans, orthopterans, neuropterans, thysanopterans and dipterans at both the altitudes [Pangthang (2160m amsl) and Kabi (1630m amsl)] and during three years (2000-2002) study period.
3. Excepting some of the haustillates (sap suckers) and a few lepidopterans, most of the insects occurred during spring and rainy-summer seasons. The tree had minimum entomofaunal association (diversity) in winters.
4. Abundance of insects in the spring and rainy seasons seemed to be due to sprouting of new leaves of *A. nepalensis*.
5. Low occurrence of insects in winter season, appeared to be mainly because of presence of mature and senescent leaves with low nutrient and moisture levels.
6. About 13 insects' species were known to commonly occur on *A. nepalensis* tree and *Amomum subulatum* (large cardamom) crop. Of

- these, the folivorous beetle *Chrysomela chlorina* severely attacked both.
7. The lepidopteran, *Gazalina chrysolopha* belonging to family Notodontidae and the coleopteran, *Chrysomela chlorina* belonging to family Chrysomelidae, caused regular defoliation of *A. nepalensis* during the three years of observation and, therefore, appeared to be major folivores.
  8. The caterpillars of *G. chrysolopha* appeared in winters from November till May, whereas the grubs of *C. chlorina* were active from May till August.
  9. The populations of both the folivores were found higher in year 2000 than 2001 and 2002. This may be due to 'phenological reasons' or the genetic programme of these insects.
  10. A tachinid fly mainly infested the caterpillars of *G. chrysolopha* and a coccinellid, *Aiolocaria hexaspilota* was recorded as the major predator of *C. chlorina* in nature.
  11. Temperature and rainfall were found to have significant negative correlation with the population of *G. chrysolopha*, whereas rainfall and cloud cover had significant positive correlation with the population of *C. chlorina*.

12. Males of *G. chrysolopha* lived longer than females; the female oviposited once or twice. Females of *C. chlorina* oviposited 2-3 times in one generation.
13. *G. chrysolopha* took about 10 to 11 months to complete its life cycle, showing only one generation in a year while the life cycle of *C. chlorina* was completed within 3 months and it completed two to three generations in a year.
14. Length and head-width of larvae of both the major folivores grew in geometric progression. *G. chrysolopha* had five larval instars while *C. chlorina* had four.
15. Age distribution of natural population of *G. chrysolopha*, showed dominance of the last two instars for longer period. Therefore, it can be expected that the maximum injury to the tree, *A. nepalensis* was done by last two instars of *G. chrysolopha*. Age distribution of *C. chlorina*, however, showed no fixed patterns of dominance of any larval stage at a particular point of time. Therefore, it can be inferred that no particular larval stage, predominantly, caused injury to the tree foliage of *A. nepalensis*.
16. Survivorship curves of both the major folivores showed similar trends. Despite the fact that *G. chrysolopha* fed on nutritionally poor quality food, it had good survival rate on its host *A. nepalensis*. This

- may presumably be due to an efficacious adaptation of *G. chrysolopha* to its principal host during colder period of the year.
17. Feeding preference tests of *G. chrysolopha* and *C. chlorina* was done using four types of leaves having different percentages of water content. *G. chrysolopha* showed preference for mature and senescent leaves with low water content while *C. chlorina* showed a clear choice for new succulent leaves with high moisture content.
  18. Analysis of the food consumed by the major folivores showed that *C. chlorina* consumed nutritionally much superior food than *G. chrysolopha*.
  19. The higher nutritional quality of food consumed by *C. chlorina* was reflected in its better growth and food utilization efficiencies. An overall slow growth rate and low utilization efficiencies of *G. chrysolopha* was most possibly due to poor quality of food available for its consumption.
  20. Study on the aspect of positive contribution of these folivores was conducted by considering the value of their faecal urine as manure. In both the cases, no significant change in the fertility of the soil was observed after natural mixing with the faecal urine of these folivores.
  21. Study on the injury inflicted by these herbivores indicated that *G. chrysolopha* caused more depredation to its host *A. nepalensis* in terms of leaf area consumed as compared to *C. chlorina*. Since *C.*

*chlorina* attacked both *Alnus* tree and large cardamom plant, it was doubly destructive to large cardamom agroforestry system.

22. In order to save *A. nepalensis* as a shade tree, as well as multi-purpose tree, on the slopes of Sikkim, a preventive cum control measure against the major folivorous insects species (*G. chrysolopha* and *C. chlorina*) has to be designed using the information generated on their bioecology in the present research work.