

Population Dynamics Of *Adelges knucheli* And Its Predators In The North-Western Himalayas I. Host phase : Gallicola *

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ABSTRACT

Studies on the populations of the gallicola phase of *Adelges knucheli* (Schneider-Orelli & Schneider) (Homoptera, Adelgidae) and its predators were carried out in the north-western Himalayas. Mortality of gallicolae occurred when hatching did not synchronise with flushing of spruce. Among biotic factors influencing mortality of gallicolae, two chamaemyiids *Mesoleucopis raoi* Tanas. and *Leucopis* sp. played a dominant role. Three lepidopterous borers indirectly affected the population by tunnelling the gall-chambers. Heavy mortality of the chamaemyiids occurred when there was no synchrony between hatching and maturing of pseudocones; another cause was probably the large number of eggs laid on a pseudocone, which was disproportionate to the host material available. The number of gallicolae that migrated and settled on the top crown of silver fir trees was about twice that settled in the lower crown. This probably accounted for the high incidence of dead and stunted growth of top crowns of silver fir.

KEY WORDS: *Adelges knucheli*, gallicola, *Mesoleucopis*, *Leucopis*, pseudocone, gall-chamber

In 1958, at the request of Canada, the Indian and Pakistan Stations of the CAB International Institute of Biological Control initiated investigations on the natural enemies of *Adelges knucheli* Schneider-Orelli & Schneider in the western and eastern Himalayas. Extensive surveys and studies on the ecology and biology of *A. knucheli* and its predators were made (Ghani and Rao, 1966; Rao and Ghani, 1972). A number of predators were introduced to the USA and Canada, but none of them became established. *A. knucheli* occurring in the north-western Himalayas, unlike *A. piceae*, has a pentamorphic, 2-year life-cycle having migratory forms developing on spruce (*Picea smithiana*) which is the primary host and on silver fir (*Abies pindrow*) which is the secondary and sistens and progrediens with sub-cycles of sistens from several parentages on silver fir. The maximum destruction on spruce is caused by gallicolae which form pseudocones on the flushed shoots and arrest further growth. Sistens and progrediens infesting bark, twig and top crown cause severe damage to silver fir. Studies carried out on the mortality factors of gallicolae and their predators are reported here.

MATERIALS AND METHODS

The localities selected for the investigations were Upper Bakrota (2,000 to 2,500 m), Dainkund (2,400

to 2,700 m) and Kalatop (2,400 m) in Dalhousie, Himachal Pradesh. In 1966, frequent visits were made to these localities for observations on the seasonal development of gallicolae and sampling of infested material. A large number of twigs bearing pseudocones were enclosed in fine muslin bags (Plate I, a,b) on randomly-selected spruce trees soon after the reproductive activity of the chamaemyiids was over in late June in order to evaluate the role of chamaemyiids and lepidopterous borers found in association with pseudocones. When dehiscence of pseudocones, which lasted 15 to 20 days, was over, 240 bags with pseudocones were recovered. These were examined in the laboratory and data on the following aspects were collected to determine direct and indirect causes of mortality :

1. Number of gall-chambers in the pseudocones
2. Initial population of chamaemyiids (number of egg shells)
3. Number of *Mesoleucopis raoi* Tanas. and *Leucopis* sp. (Diptera, Chamaemyiidae) that survived
4. Number of pseudocones attacked by borers in lower and upper crowns
5. Number of gallicola nymphs preyed upon by the chamaemyiids (by counting the remnants of host nymphs)
6. Number of gallicolae that survived (by counting the adults that emerged) and
7. Number of gall-pockets destroyed by *Homoeosoma* sp. (Lepidoptera, Pyralidae) and other lepidopterous borers.

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Assessment of host mortality due to biotic factors was made as follows : The live and dead gallicola adults in the bags indicated the total number. To determine the number of gallicolae preyed upon, the gall-chambers were dissected and examined. If the pseudocones were infested by the borers, the number of gall-chambers destroyed by them was estimated by deducting the number of undamaged chambers (represented by the swollen needles). By multiplying the number of gall-pockets destroyed and the mean number of gallicola nymphs per pocket, mortality due to the destruction of gall-pockets by the borers was estimated. Some of the observations on the predators were continued in 1967 and 1968.

Sampling of foliage was carried out in 1966 on the eastern slopes of Upper Bakrota soon after the migratory flight of gallicolae to study their population density and distribution on silver fir. Six trees, 4.75 to 5.49 m in height, were marked along zig-zag path on a slope descending from 2,300 to 2,000 m. Each tree was

visually divided into upper, middle and lower crowns to draw samples from 3 levels. Samples were also drawn separately from the western aspect facing the hill slope, and the eastern aspect which was in the open. A tree-trimmer with 3 extendable sections (Plate I c) was used to cut branches from different levels. A quantity of 0.465 sq m of branchlets from top crown and 0.93 sq m from each of the other 2 crowns were drawn, ensuring proportionate representation of foliage from the western and eastern aspects of each of the trees. The foliage was evenly spread out with the under surface facing upwards. A thread grid, each square measuring 7.62 x 7.62 cm (3" x 3"), was placed over the foliage (Plate I, d). The surface of each needle was carefully examined and the gallicolae that settled in every 16 such squares (0.0928 sq m or 1 sq ft) were counted and recorded. In many cases, the adults were missing either due to disturbance while sampling or due to predation, but their remains or egg masses were taken into account for counting. The total foliage sampled per tree was 4.65 sq m.

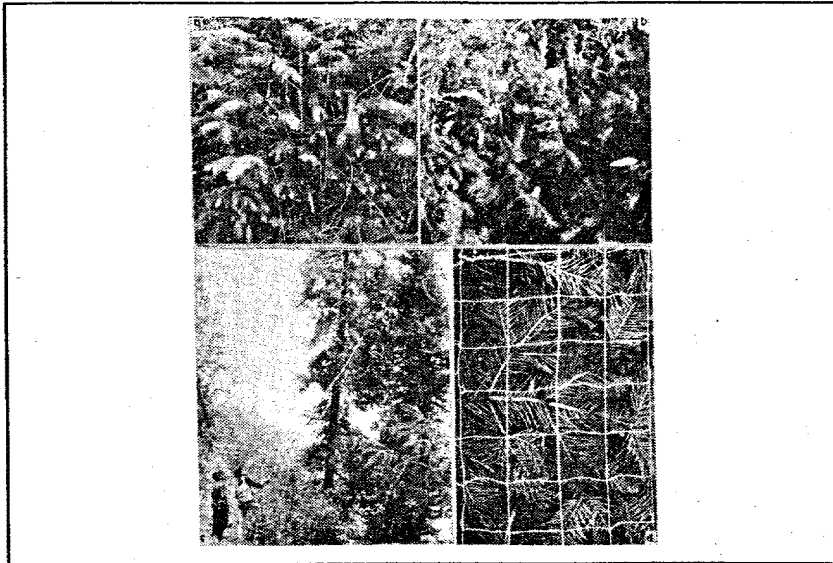


PLATE I

- a. Heavy gall infestation on a young spruce
- b. Pseudocones enclosed in cloth bags
- c. Using a tree trimmer
- d. Fir foliage evenly spread for sampling gallicolae

RESULTS AND DISCUSSION

Seasonal development of gallicolae

In spring, each fundatrix adult laid several hundreds of eggs at the base of a winter bud of spruce. In early April, gallicolae hatched at about the same time the winter buds flushed. A fundatrix-infested bud developed into an immature gall instead of a normal shoot as a result of feeding by the stem-mother. This

was precisely what was needed for the gallicolae to settle and develop. Lack of synchrony between hatching and flushing invariably resulted in total mortality of gallicolae as they were unable to develop on any other part of the tree. When hatching and flushing synchronized, the young nymphs readily crawled on to the immature gall (pseudocone) and settled at the base of short, spine-like needles. Here they commenced feeding and developed without undergoing

diapause. Their feeding induced such abnormal growth of the pseudocone that the nymphs became enclosed in gall-chambers beneath the spine-like needles. Within these chambers they fed and developed, well protected from the attack of natural enemies until they reached the late third or fourth stadium when the pressure exerted by the developing nymphs on the walls of the gall-chambers in July-August seemed to cause dehiscence of the galls. As the full grown nymphs emerged, some moulted to the adult stage. After unfurling and hardening of the wings, they migrated to the secondary host (silver fir). Sometimes migration was as simple as moving on to the needles of a fir tree close to, or even touching, a spruce tree while at other times it was as hazardous as being blown off by strong wind currents to a chance settling on a fir tree. After alighting on a fir needle, the adult crawled on to its lower surface, inserted its stylets into the leaf tissues and settled. Thereafter it laid a small cluster of eggs under the cover of its folded wings and died *in situ*.

Biotic factors influencing mortality of gallicola

During March-April, 2 chrysopids *Tumeochrysa indica* Needham and *Chrysopa* sp., a syrphid *Metasyrphus confrater* (Wied.) and occasionally the coccinellids *Coccinella septempunctata* L. and *Harmonia breiti* Mader attacked the fundatrix adult and its eggs (which would have developed into gallicolae). All these were general predators and caused only negligible mortality. Their appearance, however, was regular, but populations varied considerably.

In May and June, 2 univoltine species of chamaemyiids *Mesoleucopis raoi* and *Leucopis* sp. preyed on gallicola nymphs in pseudocones. These appeared to be specific. Their appearance was regular and more or less well synchronized with the development of gallicolae. They were abundant and efficient in host-searching. Eggs were laid at the base of pseudocones well before dehiscence. Newly hatched larvae forced their way into gall-chambers and fed on the third or fourth instars. These 2 chamaemyiids exerted a considerable check on the population of gallicolae. Yaseen and Krishnaswamy (1972) reported that a species of *Pachyneuron* (Hymenoptera, Pteromalidae) and *Cerchysius laticeps* Kerrich (Hymenoptera, Encyrtidae) attacked these chamaemyiids.

Three species of lepidopterous borers also infested the pseudocones in May and June, indirectly affecting

the gallicola population. These were a pyralid *Homoeosoma* sp., a tortricid *Udolemis trigrapha* Meyr. and an unidentified geometrid. They tunnelled through the gall-chambers and deprived the gallicola nymphs of their food (Plate II a, b). Among these, *Homoeosoma* sp. was the most common. These too were of regular occurrence and caused heavy mortality of gallicolae. It is possible that the borers killed some chamaemyiids also.

During July and August, when pseudocones dehiscence and gallicolae emerged, the coccinellids *C. septempunctata*, *Exochomus lituratus* Gorb. and *E. uropygialis* Muls. fed on adult gallicolae on spruce. They also preyed upon gallicolae that migrated to silver fir. Only adults of the coccinellid were observed feeding on gallicolae, as they did not breed on spruce and fir around Upper Bakrota. These did not appear regularly and their populations varied considerably from year to year.

Yet another mortality factor, which was rather passive, was spiders. Web-spinning on spruce and fir during the period of gallicola migration was a common phenomenon and accounted for considerable mortality of the adults which were caught in the webs (Plate II c).

Role of *Mesoleucopis raoi*, *Leucopis* sp. and lepidopterous borers in the suppression of gallicolae

Among the many enemies of gallicolae, *M. raoi*, *Leucopis* sp. and the lepidopterous borers were the most important. No studies on their role in the suppression of gallicolae have been previously conducted. The observations made by Yaseen and Krishnaswamy (1972) were on seasonal life history, feeding habits and distribution of chamaemyiids attacking the gallicola phase in Pakistan and India. They were of the opinion that the *Leucopis* sp. feeding on gallicolae at Beha, Mokshapuri and Otrora in Pakistan appeared to be the same as either *M. raoi* or *Leucopis* sp. occurring at Dalhousie in India.

Though a large number of pseudocones were bagged in the field, many of them were disturbed by black-faced monkeys and by inquisitive people. Only 240 bags with pseudocones were left undisturbed. These were examined soon after dehiscence when most of the surviving gallicolae had emerged from the gall-pockets and some had died. Many were in the process of moulting to the adult stage. At the base of

pseudocones under the cover of the calyx, shells of chamaemyiid eggs (laid before caging) were present (Plate III a - c). Most of the chamaemyiid larvae in the

gall-pockets were in the pre-pupal or pupal stage. The 2 species could be differentiated by their morphological characters (Plate III d, e).

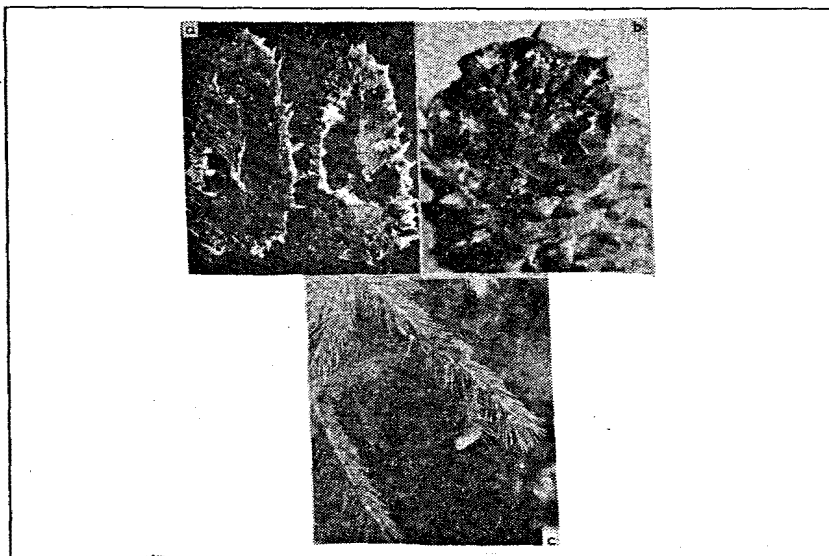


PLATE II

- a. & b. Vertical and horizontal sections of pseudocones showing tunnels made by *Homoeosoma* sp.
c. *Gallicola* adults caught in spider webs on spruce

All the pseudocones had chamaemyiid eggs on them prior to bagging. The number on an individual pseudocone ranged from 2 to 48 with a mean of 23.5 ± 5.25 , the total eggs on the 240 galls being 5,640. Only 49.1% (2,770 individuals) survived to the pupal stage, the survival in the case of *M. raoi* being 34.4% (1,941) and of *Leucopis* sp. 14.7% (829). Of the total that survived (2,770), 70% (1,941) were *M. raoi* and 30% (829) *Leucopis* sp. Observations made while examining the pseudocones indicated that the heavy mortality of chamaemyiids could be attributed to two factors. The first was lack of synchrony between hatching and maturing of pseudocones. When the eggs hatched before the galls attained maturity, the young larvae were unable to force their way into the gall-chambers through the tightly pressed lips of the membrane. Only when the gallicolae reached the third stadium did the galls develop to maturity when the lips of the gall-chambers were not tightly closed and the young could force their way in. The second factor was the incompatible host-predator ratio affecting the survival of the chamaemyiids. In each pseudocone, the capacity of host insects was limited to the number of gall-pockets whereas many chamaemyiid eggs, up to 48, were laid on a pseudocone. These two factors, individually or in combination, seemed to affect the predator population.

Fortyone of the pseudocones (17.0%) harboured lepidopterous borers, *Homoeosoma* sp. being the predominant one and *U. trigrapha* and the unidentified geometrid in lesser numbers. The relative abundance of the borers at 2 height levels, 0 to 1 m and 1 to 2 m, was assessed. Out of 152 pseudocones up to a height of 1 m, 18 (11.8%) were borer-infested while out of 88 cones between 1 and 2 m, 23 (26.1%) were infested. Thus pseudocones at a height of 1 to 2 m had a higher borer incidence, more than twice that of those between 0 to 1 m.

The relative mortality caused by chamaemyiids and borers was estimated. The total number of gallicola nymphs in the pseudocones were 11,075 of which 4,238 were destroyed by the chamaemyiids and borers. The chamaemyiids accounted for 2,805 nymphs (25.0%) and the borers 1,430 (13.0%), total mortality being 38.0%.

Density and distribution of gallicola adults on silver fir

The annual trend of sistens population on silver fir was partly determined by the success of gallicola migration to silver fir and the sub-cycle of sistens. On an average, 7 ± 2.89 gallicola adults settled per sample

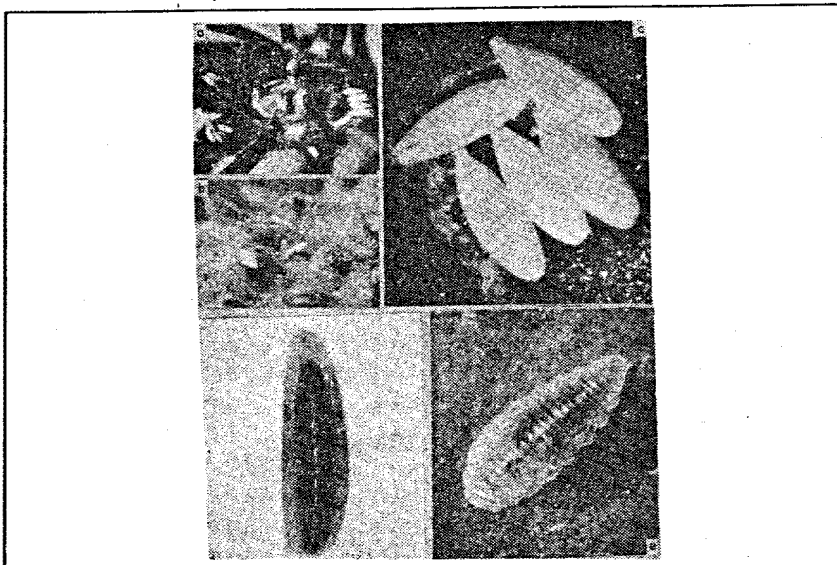


PLATE III

- a. Chamaemyiid eggs on bud scales at base of pseudocone
- b. Chamaemyiid eggs partially inserted between lips of gall chamber
- c. A group of chamaemyiid eggs, enlarged
- d. A full grown larva of *Mesoleucopis raoi* Tanas
- e. A full grown larva of *Leucopis* sp. nov.

unit of 0.0928 sq m of fir foliage. The extent of infestation of the secondary host by progeny of the gallicolae could be estimated : with an average fecundity of 102 (Ghani and Rao, 1966), about 700 eggs per 0.0928 sq m foliage area were produced to augment the progeny of sistens.

Adults that settled on the top crown were nearly twice the number that settled in the lower crown. Analysis of variance showed that the differences between trees and between crowns were significant at the 1% level. The means of trees and crowns are presented in Table 1. The top crown had higher infestation; about 47.0% of the migrated gallicolae settled here. It was also observed that on the upper crown of trees at lower elevations in the study area, the gallicolae settled in greater numbers than on those at higher elevations. It is inferred that the direction and orientation of the migratory flight was from a higher to a lower elevation. It may be construed that the gallicolae emerging from pseudocones at higher altitudes on a hill slope migrated downwards and the first encounters were with the top crowns of the trees. This probably explains why there was a high incidence of dead as well as stunted and suppressed growth at the top crowns of fir trees at lower elevations in the north-western Himalayas when recurring attack by *A. knucheli* occurred.

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TABLE 1 : Settling of adult *A. knucheli* on spruce

Tree	Mean	Crown	Mean
1	4.96	Upper	10.47
2	7.48	Middle	6.39
3	10.97	Lower	5.53
4	8.48		
5	4.70		
6	8.18		
SEm 0.81		SEm 0.57	
CD 5% 2.52		CD 5% 1.79	

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