NOTES ON THE BIOLOGY, ECOLOGY AND INCIDENCE OF *GILPINIA* SPP. (TENTHREDINIDAE) ATTACKING CONIFERS IN HIGH ALTITUDE FORESTS IN PAKISTAN

A. I. Mohyuddin, M.R. Attique, M.I. Arif and R.A. Mazhar*

Introduction

A survey was carried out for sawflies and their natural enemies in the northern forests of Pakistan between 1,600 and 2,800 m. The localities surveyed included Dhirkot, Rashian, Sudhengali, Gangatop, the Neelum and Leepa valleys in Azad Kashmir, Thandiani and the Kaghan valley in North Western Frontier Province (NWFP) and Malam Jabba in Swat.

Cladius pectinicornis (Geoffr.), *Arge nigrinodosa* (Motschulsky) and *A. annulitarsis* Rohwer were reared from roses (*Rosa* spp.), *Trichiocampus ulmi* (L.) and *A. praesternalis* Malaise from elm (*Ulmus wallichiana*), *Nematus melanaspis* Hartig from willow (*Salix wallichiana*) and *Gilpinia* spp. on conifers (*Pinus wallichiana, Picea smithiana* and *Cedrus deodara*). Investigations on the biology, ecology and population trends of *Gilpinia* spp. are reported.

Results

(i) *Gilpinia pindrowi* Benson

Benson (1961) described *Gilpinia pindrowi* from the Murree hills. It was found attacking blue pine *Pinus wallichiana* from 1,600 to 2,800 m. Larvae were sampled by beating young trees and 2.5–4 m long lower branches of older trees. Cocoons were collected under the crowns of infested trees. Field-collected larvae and cocoons were reared in the laboratory. At Murree, its population was highest in 1974 with a peak in August (Fig. 1).

In Azad Kashmir, where observations were made from 1,600 to 2,800 m, it was more abundant between 2,100 and 2,300 m in the Leepa valley (2,100 m), Rashian and Sudhengali (2,300 m). Infestations were low at lower altitudes (Dhirkot 1,600 m) and also at high altitudes (Gangatop 2,800 m) (Fig. 2).

The vertical distribution of larvae was studied. The trees were divided into four levels, 3–8 m, 15–27 m and above 27 m. The numbers of *G. pindrowi* were highest at the lowest level and decreased upwards being 23, 9 and 2 larvae per 5 twigs and zero above 27 m.

Phenology: It became active in April at Dhirkot during the first week, in the Leepa valley and sunny and semi-sunny areas around Murree in the second, at Rashian and Sudhengali in the third and at Gangatop in the fourth week.

When adults that emerged at the beginning of April were released on *P. wallichiana* shoots in small cages in the laboratory, the females started laying eggs immediately. These hatched in mid-April, the larvae pupated 3–4 weeks later and adults emerged during the first

* PARC-CIBC Station, Commonwealth Institute of Biological Control, Murree Road, P.O. Box 8, Rawalpindi.

week of June. The second generation was completed by the third week of July and the third in the first week of September. Larvae of the fourth generation spun cocoons by the end of October and entered diapause.

To ascertain whether adults emerge from overwintered cocoons through summer, 180 cocoons formed from last generation field-collected larvae, were placed in wiregauze field cages (10x6x3 cm) at Murree in January. Observations were made every second or third day from March to July. Adults started emerging at the beginning of April (8.3%) and continued to emerge in May (8.9%), June (24.4%) and July (2.2%) after which the remaining cocoons (56.2%) were dissected. They contained dead sawfly eonymphs and adults.

Some 246 cocoons collected from different areas in November and December were kept in the laboratory at 25 ± 2°C. Adults from 12% cocoons emerged in December, 8% in January, 13% in February, 14% each in March and April, 20.2% in May, 10.2% in June, 5% in July and 3.6% in August.

In the first generation 5% and in the second 9.5% larvate entered diapause and in subsequent generations this tendency increased.

Winter mortality: To study winter mortality 1,180 cocoons were collected from Dhirkot during December 1976. Of these 580 cocoons, in two replicates, were exposed in January at Murree in debris under pine trees in a semi-sunny area, another 300 were dissected in January to determine prewinter mortality so that the number of live eonymphs and parasites in the exposed cocoons could be estimated and further 300 were kept as control in the laboratory at room temperature to note emergence of adults. Of the 300 cocoons dissected 72.3% contained alive sawfly eonymphs and immature stages of various parasites, 20.1% were dead and 7.6% attacked by fungus (total prewinter mortality was 27.7%).

At the end of March the cocoons in the field were transferred to 15 x 10 x 3 cm wiregauze cages and reburied. They were examined on alternate days to note emergence. The cocoons from which adults did not emerge were dissected at the end of June.

Full-grown larvae were also collected in December and 180 cocoons formed from these were exposed in the semi-sunny area in January and were later transferred to wiregauze cages in March as described above. When emergence stopped at the end of June the remaining cocoons were dissected.

Adults emergence and mortality in these samples are presented in Table I. The total mortality of the field-collected cocoons was 37.4% but when prewinter mortality is excluded only 13.3% died during winter compared with 0.5% in the laboratory (control). Winter mortality in cocoons formed from field-collected larvae was higher (29.6%).

TABLE I.

Winter mortality in *Gilpinia pindrowi*, based on emergence from field-collected cocoons and cocoons formed from field-collected larvae exposed in the field.

Stage collected	Treatment	No. of cocoons	Sawfly and parasite adults emerged		Fungus attacked (%)	Dead (%)	Total mortality (%)
			No.	(%)			
Cocoons	Exposed	(580) 540**	338	62.6	10.0	27.4	37.4
		390*	338	86.7	3.2	10.1	13.3
Cocoons	Control	300	216	72.0	8.0	20.0	28.0
		217*	216	99.5	0.0	0.5	0.5
Larvae	Exposed	(180) 172**	121	70.4	1.7	27.9	29.6

* Figures obtained after subtracting 27.7% pre-winter mortality.

** Figures obtained after subtracting cocoons missing on transfer to cages.

To determine if cold shock would break diapause intact field-collected over-winteing cocoons were held in a refrigerator at 7°C during January in a 2.5 cm thick layer of soil in wooden cages measuring 8 x 8 x8 cm for 10 20, 30 and 40 days and then removed to laboratory temperature (25 ± 2°C). Seventy-five cocoons in three replicates were used for each and the same number was kept as control at room temperature (25 ± 2°C). The emergence of adults was noted up to May. It appears that cold shock did not break diapause rather it delayed emergence and had an adverse effect on survival of eonymphs (Table II).

Table II

Effect of cold shock on diapause of *Gilpinia pindrowi*. Seventy-five field collected intact cocoons each were kept at 7°C in January for 10, 20, 30 and 40 days and then removed to 25 ± 2°C.

Month	Adults 10 days	Emerged (%) 20 days	after cold 30 days	shocks of 40 days	Adults emergence in control (25 ± 2°C) (%)
January	0	0	–	–	5,3
February	1.3	0	0	0	5.3
March	2.7	1.3	0	0	8.0
April	2.7	1.3	2.7	1.3	4.0
May	5.3	6.7	6.7	4.0	28.0
Total	12.0	9.3	9.4	5.3	50.6

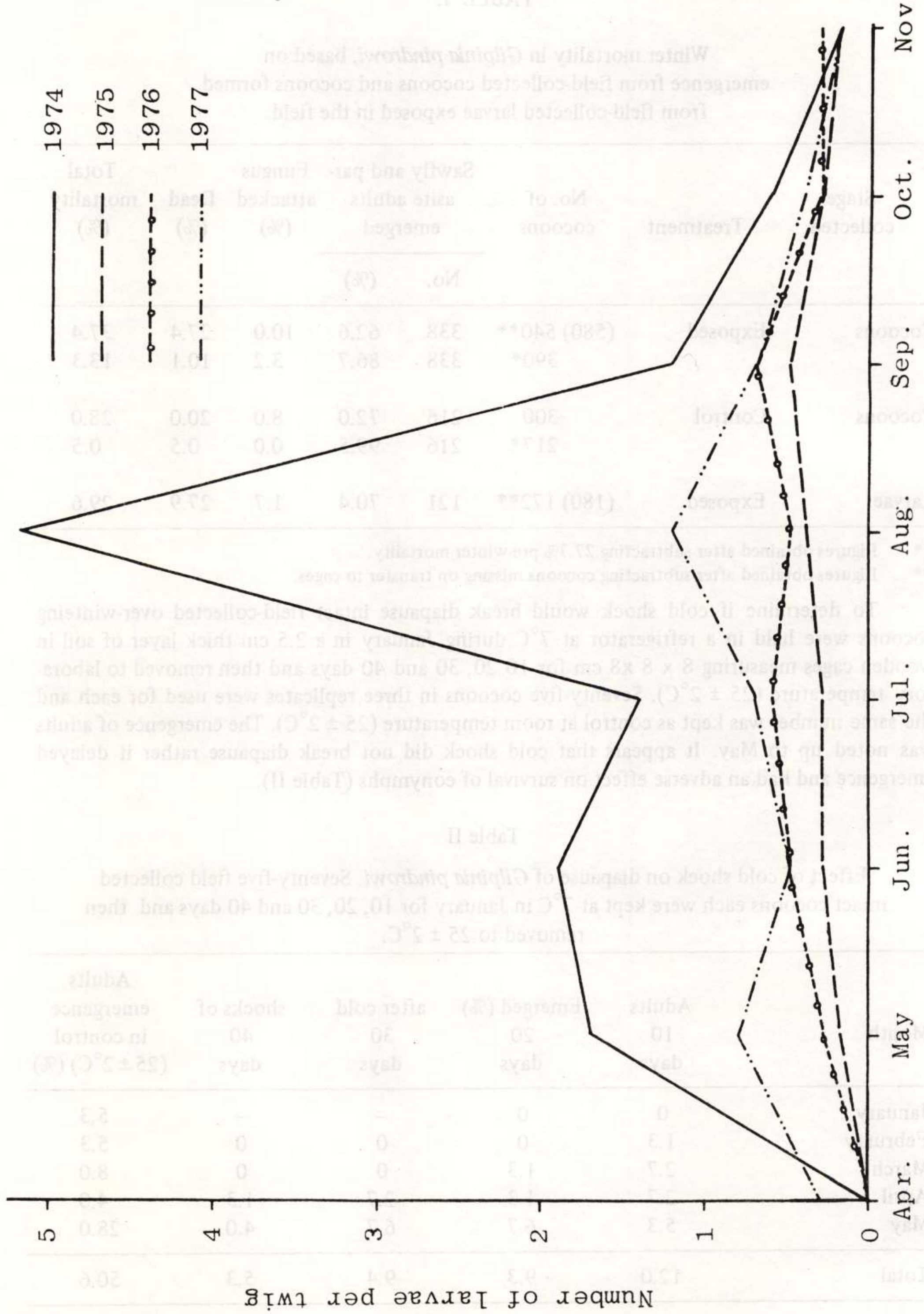

Fig. 1-Trends of larval population of *Gilpinia pindrowi* on *Pinus wallichiana* at Murree

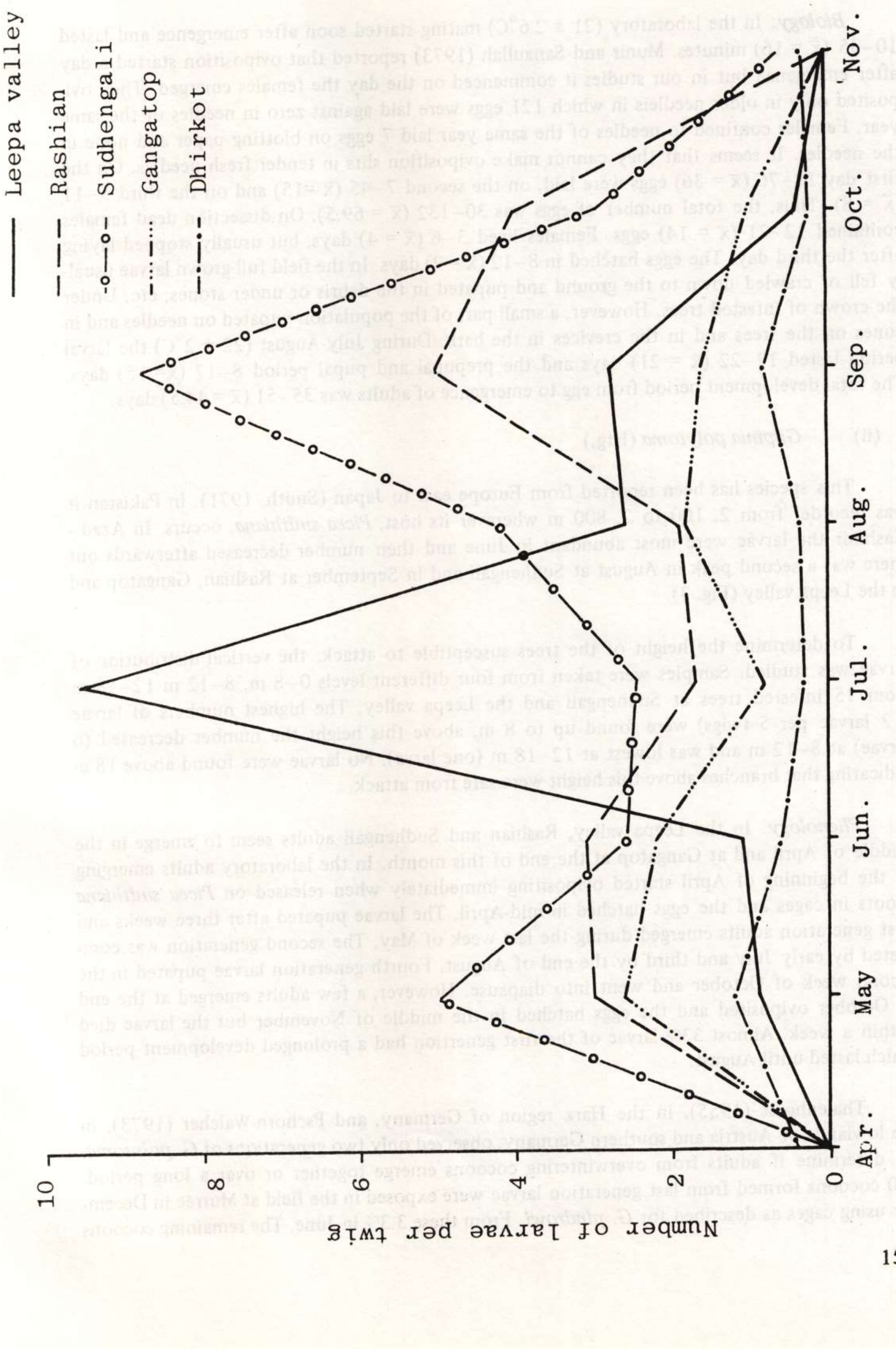

Fig. 2- Trends of larval population of Gilpinia pindrowi on Pinus wallichiana at different localities in Azad Kashmir

Biology: In the laboratory (21 ± 2.6°C) mating started soon after emergence and lasted 10–35 ($\bar{x}$ = 16) minutes. Munir and Sanaullah (1973) reported that oviposition started a day after emergence but in our studies it commenced on the day the females emerged. They oviposited only in older needleis in which 121 eggs were laid against zero in needles of the same year. Females confined to needles of the same year laid 7 eggs on blotting paper and none in the needles. It seems that they cannot make oviposition slits in tender fresh needles. On the first day 18–76 ($\bar{x}$ = 36) eggs were laid, on the second 7–45 ($\bar{x}$ =15) and on the third 5–11 ($\bar{x}$ = 8). Thus, the total number of eggs was 30–132 ($\bar{x}$ = 69.5). On dissection dead females contained 12–21 ($\bar{x}$ = 14) eggs. Females lived 3–6 ($\bar{x}$ = 4) days, but usually stopped laying after the third day. The eggs hatched in 8–12 ($\bar{x}$ = 9) days. In the field full-grown larvae usually fell or crawled down to the ground and pupated in the debris or under stones, etc. Under the crown of infested trees. However, a small part of the population pupated on needles and in cones on the trees and in the crevices in the bark. During July-August (22 ± 2°C) the larval period lasted 19–22 ($\bar{x}$ = 21) days and the prepupal and pupal period 8–17 ($\bar{x}$= 15) days. The total development period from egg to emergence of adults was 35–51 ($\bar{x}$ = 44.5) days.

(ii) *Gilpinia polytoma* (Htg.)

This species has been reported from Europe east to Japan (Smith, 1971). In Pakistan it was recordef from 2, 100 to 2, 800 m wherever its host, ***Picea smithiana***, occurs. In Azad - Kashmir the larvae were most abundant in June and their number decreased afterwards but there was a second peak in August at Sudhengali and in September at Rashian, Gangatop and in the Leepa valley (Fig. 3).

To determine the height of the trees susceptible to attack, the vertical distribution of larvae was studied. Samples were taken from four different levels 0–8 m, 8–12 m 12–18 m from 15 infested trees at Sudhengali and the Leepa valley. The highest numbers of larvae (12 larvae per 5 twigs) were found up to 8 m, above this height the number decreased (6 larvae) at 8–12 m and was lowest at 12–18 m (one larva). No larvae were found above 18 m indicating that branches above this height were safe from attack.

Phenology: In the Leepa valley, Rashian and Sudhengali adults seem to emerge in the middle of April and at Gangatop at the end of this month. In the laboratory adults emerging at the beginning of April started ovipositing immediately when released on *Picea smithiana* shoots in cages and the eggs hatched in mid-April. The larvae pupated after three weeks and first generation adults emerged during the last week of May. The second generation was completed by early July and third by the end of August. Fourth generation larvae pupated in the second week of October and went into diapause. However, a few adults emerged at the end of October oviposited and the eggs hatched in the middle of November but the larvae died within a week. Almost 33% larvae of the first genertion had a prolonged development period which lasted until August.

Thalenhorst (1955), in the Harz region of Germany, and Pschorn-Walcher (1973), in the lowlands of Austria and southern Germany, observed only two generations of *G. polytoma*. To determine if adults from overwintering cocoons emerge together or over a long period, 120 cocoons formed from last generation larvae were exposed in the field at Murree in December using cages as described for *G. pindrowi*. From these 3.3% in June. The remaining cocoons were dissected in the middle of July and all contained dead eonymphs or adults indicating that adults continue to emerge for four months.

To determine whether there is an obligatory diapause, 99 cocoons collected during November-December were kept at 25±2°C. From these 42% adults emerged during November and December, 31% in January, 9% in February, 2% in March 12% in April and 4% in July. When 139 cocoons collected in April were kept at 25± 2°C, 35% of the adults emerged in April, 23% in May, 3.6% in June, 20.4% in July and 18% in August.

Winter mortality: To determine winter mortality cocoons and last generation full-grown larvae of *G. polytoma* were collected in mid-November from Sudhengali. Sixty cocoons (field-collected and formed from field-collected larvae) were exposed in January on the ground without protection and an equal number was kept in moist soil in a 12 x 12 x 12 cm wooden cage with wiregauze on one side. The same number of cocoons was dissected to determine prewinter mortality in eonymphs and parasites. The exposed cocoons were not preyed upon during winter and were transferred to wiregauze cages in March and placed along with the others in moist soil.

Prewinter mortality in the field-collected cocoons was quite high but the total mortality in cocoons esposed in debris and those in moist soil in cages was almost the same (Table III) However, the percentage of cocoons attacked by fungus was almost double in the cages compared with the debris.

As the fungus was saprophytic attacking dead eonymphs it does not seem to contribute to winter mortality.

Of the cocoons formed from field-collected larvae 6.7% died as eonymphs at the time of exposure and almost the same number from fungus attack both in the cage and soil. Thus winter mortality was almost the same in both treatments and was lower than in field-collected cocoons.

Table III

Winter mortality in *Gilpinia polytoma* based on field-collected cocoons and cocoons formed from field-collected larvae

Stage collected	Treat ment	Adults emerged (%)	Dead (%)	Fungus attacked (%)	Total mortality (%)	Calculated winter mortality(%)	
Cocoons	A	20.0	45.0	35.0	80.0	21.7	(A-C)
	B	16.7	10.0	73.3	83.3	25.0	(B-C)
	C	–	30.0	28.3	58.3	–	
Larvae	A	80.0	15.0	5.0	20.0	13.3	(A-C)
	B	76.7	15.3	8.0	23.3	16.6	(B-C)
	C	–	6.7	0.0	6.7	–	

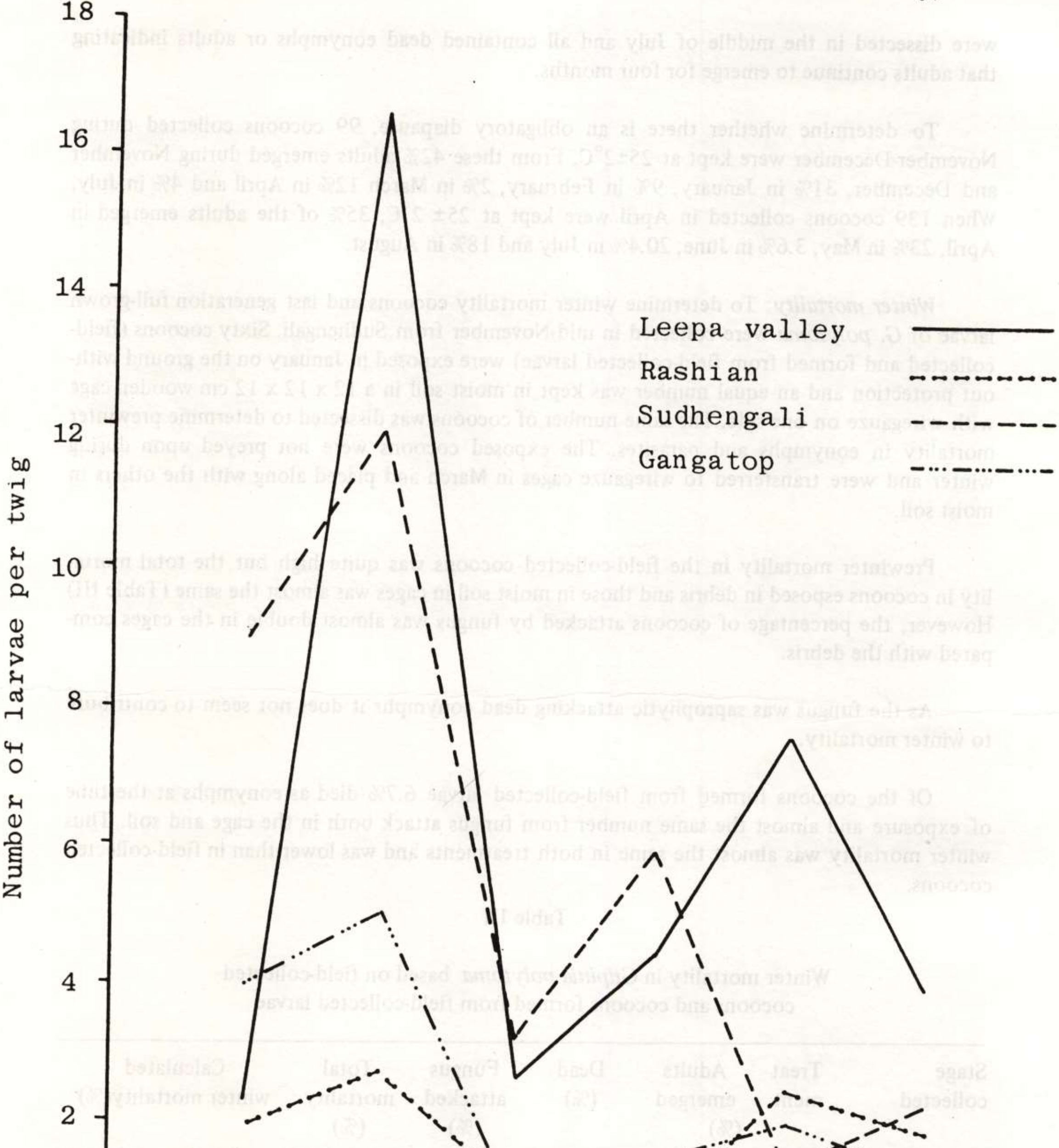

Fig. 3–Trends of larval population of Gilpinia polytoma on Picea smithiana at different localities in Azad Kashmir

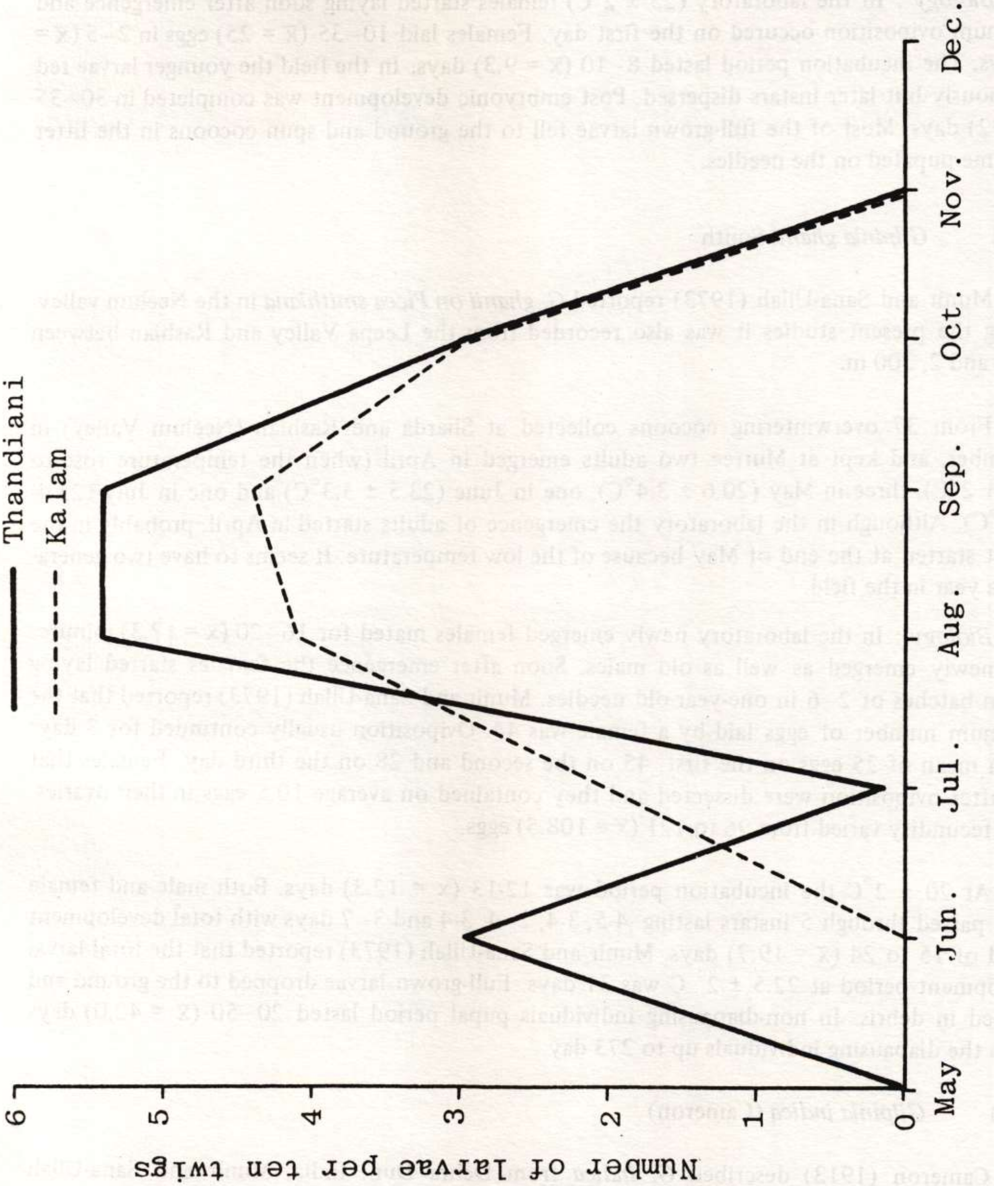

Fig 4 Trends of larval population of Gilpinia indica on Cedrus deodara at Thandiani and Kalam

A – Cocoons exposed in debris.
B – Cocoons exposed in moist soil in wooden cages.
C – Result of cocoons dissected at the time of exposing other cocoons in the field.

Biology : In the laboratory (25 ± 2°C) females started laying soon after emergence and maximum oviposition occured on the first day. Females laid 10–35 ($\bar{x}$ = 25) eggs in 2–5 ($\bar{x}$ = 3) days. The incubation period lasted 8–10 ($\bar{x}$ = 9.3) days. In the field the younger larvae fed gregariously but later instars dispersed. Post embryonic development was completed in 30–35 ($\bar{x}$ = 32) days. Most of the full-grown larvae fell to the ground and spun cocoons in the litter but some pupated on the needles.

(iii *Gilpinia ghanii* Smith

Munir and Sana-Ullah (1973) reported *G. ghanii on Picea smithiana* in the Neelum valley. During the present studies it was also recorded from the Leepa Valley and Rashian between 2,000 and 2, 300 m.

From 37 overwintering cocoons collected at Sharda and Rashian (Neelum Valley) in November, and kept at Murree two adults emerged in April (when the temperature rose to 14.0 ± 2°C), three in May (20.6 ± 3.4°C). one in June (23.5 ± 3.3°C) and one in July (23.4- ± 2.5°C). Although in the laboratory the emergence of adults started in April, probably in the field it started at the end of May because of the low temperature. It seems to have two generations a year in the field.

Biology : In the laboratory newly emerged females mated for 16–20 ($\bar{x}$ = 17.3) minutes with newly emerged as well as old males. Soon after emergence the females started laying eggs in batches of 2–6 in one-year-old needles. Munir and Sana-Ullah (1973) reported that the maximum number of eggs laid by a female was 44. Oviposition usually continued for 3 days with a mean of 25 eggs on the first, 45 on the second and 28 on the third day. Females that died after oviposition were dissected and they contained on average 10.5 eggs in their ovaries. Total fecundity varied from 96 to 121 ($\bar{x}$ = 108.5) eggs.

At 20 ± 2°C the incubation period was 12-13 (x = 12.3) days. Both male and female larvae passed through 5 instars lasting 4-5, 3-4, 2–4, 3-4 and 3–7 days with total development period of 15 to 24 ($\bar{x}$ = 19.7) days. Munir and Sana-Ullah (1973) reported that the total larval development period at 22.5 ± 2° C was 31 days. Full-grown larvae dropped to the ground and pupated in debris. In non-diapausing individuals pupal period lasted 20–50 ($\bar{x}$ = 42.0) days and in the diapausing individuals up to 273 day.

(iv) *Gilpinia indica* (Cameron)

Cameron (1913) described *G. indica* from Dehra Dun, India. Munir and Sana-Ullah (1973) reported it from deodar, *Cedrus deodara* from Galis, the Neelum Valley (2,000 m) and Thandiani (2,100 m) where there are thin and mixed stands of *C. deodara* and *Pinus wallichiana*. They did not find it in pure stands of *C. deodara* but during the present investigations it was also recorded from a pure stand of *C. deodara* at Kalam (2,100 m) in the Swat Valley between 2, 000 and 2400 m but the highest density was between 2,00 to 2, 200 m.

At Thandiani (2, 100 m) activity started at the end of May and at Kalam (2,100 m) in the middle of June. its late resumption of activity at Kalam may be because it is a cooler locality due to the presence of rivers on both sides of the forest and the adjoining high mountains. Its population trends at both localities are given in Fig. 4.

Biology : females started oviposition the day they emerged laying groups of 2–4 eggs in one-year-old needles. They did not oviposition young needles probably because they are too tender. Munir and Sanaullah (1973) reported that *G. indica* females laid 5–32 eggs, whereas, during present studies they laid 37.8 eggs on average and total fecundity was 42–48 ($\bar{x}$ = 44.8). They lived up to 5 days but oviposition usually stopped on the third day.

In the laboratory at 22 ± 2°C the incubation period was 10–16 ($\bar{x}$ = 12.6) days. Larvae developing into females passed through 6 or 7 instars, lasting on average 30.5 and 31.5 days, respectively. Those developing into males had 4 or 5 instars lasting, respectively, 26 and 29 days. The last instar of larvae having fewer moults was prolonged in both sexes.

Discussion and Conclusions

The higher attack of *Gilpinia pindrowi* and *G. polytoma* in the Leepa Valley and Sudhengali compared with the Murree hills could be because the Leepa Valley and Sudhengali are comparatively more humid and have relatively thick vegetation. Sellers (1942) reported that in Europe *G. polytoma* was more abundant in warm and humid areas compared with drier habitats.

At Murree (2,000 m) *G. pindrowi* completed four generations in the laboratory from April to October but in the field full-grown larvae were present until November, possibly because of slow development in last generation larvae due to lower temperature. At lower altitudes (Dhirkot, 1, 600 m) larvae were found until December and there may be an additional generation because here activity also started earlier than at Murree.

The adults from overwintered cocoons emerged from April to August in the field. Not all individuals of *G. pindrowi* do have an obligatory diapause because when cocoons were kept at high temperatures in the laboratory adults emerged from 33% cocoons during December, January and February. Yet, a proportion of each generation went into diapause during summer. Therefore, the number of generations completed by this species in the field during each season is not certain.

Some 13.3% field collected cocoons of *G. pindrowi* and 29.6% cocoons formed from last generation larvae collected in December died during winter. The higher winter mortality in cocoons formed from larvae held in the laboratory could be because majority of the larvae had already spun cocoons and entered diapause, and those collected during this month contained non-diapausing larvae that failed to survive winter.

In Europe *G. polytoma* has one generation at high and two at low altitudes (Pschorn-Walcher, 1973). In the laboratory at Murree it completed four generations but (it is not found naturally in this area because its host *Picea smithiana* does not grow at low altitudes) it seems to have fewer generations in its area of natural distribution. Moreover as with *G. pindrowi* the entire population does not have obligatory diapause, because adults emerged from 82% cocoons during winter. Therefore, the exact number of generations in Pakistan is uncertain.

Gilpinia pindrowi G. polytoma G. ghanii and *G. indica* seem to be under control and natural enemies appear to play an important role. Mohyuddin (1974) recommended that if the natural balance is disturbed, sawflies might become a problem.

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