zone (PZ) and pith meristem (PM) (figure 1). The peripheral zone forms a cylinder of 2-3 cell layers around the CMZ and PM zones. The cells are slightly elongated along the long axis of the shoot and densely stained (figure 1). Transverse divisions at the base of the CMZ result in a subjacent group of more or less regularly arranged cells which form the pith by further divisions.

At 5 weeks the apex passes from the vegetative to the intermediate and then gradually to the transitional and flowering stages in the next two weeks. The intermediate apex is larger than the vegetative apex and increased in height more than in diameter (table 1) and has common features with the vegetative and transitional apices. It resembles the vegetative apex in tunica-corpus organisation and continued production of leaves. The similarity to the transitional apex is the less marked zonation (figure 2). There is considerable variation in the degree of corpus stratification, though the outermost CMZ layers tend to simulate tunica layers (figure 2). The intermediate apex becomes elevated above the youngest leaves as a result of apical elongation and elongation of the youngest internode.

Once the apex reaches a critical stage it passes from the intermediate to the transitional stage. The transitional apex is broader than the intermediate apex (table 1). Stratification increases in the corpus region leading to the establishment of a 3-5 layered mantle with densely chromophilic cells and enclosing a lightly stained core of inner cells. Axial cells of the transitional apex are still lighlty stained (figure 3).

The term intermediate apex was first used by Lance[3]. The vegetative apex of *Cosmos* was reported[5] to change to the intermediate one when grown under conditions unfavourable to flowering. In *Delphinium* the intermediate type of apex was reported in plants grown under natural conditions[6]. The less prominent cytohistological zonation in the intermediate apex as compared to the vegetative apex may be in preparation for the changeover to the floral phase during which leaves become progressively smaller. It was mentioned[7] that increase in stratification and loss of zonation characteristic of earlier phase is one of the many changes in the shoot apex during changeover from vegetative to intermediate. The number of tunica layers seems to increase or it may be considered as the outermost corpus layers simulating the tunica to form a mantle over the shoot apex. This becomes a constant feature in the floral apex. Data presented indicate that the intermediate apex need not necessarily be the result of exposure to photoperiods unfavourable to flowering.

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INHERITANCE OF FROST RESISTANCE IN POTATO

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Information available on inheritance of frost resistance in potato is meagre and reports available merely indicate the presence of a continuous variation in segregating populations thereby inferring that the resistance is probably controlled by polygenes [1,2,3]. The studies are limited due to (i) the difficulty in quantifying frost resistance in individual plants and (ii) sterility in F_1 plants and parental clones. Although it is not feasible to obtain F_2 generations in potato, the available strains are highly heterozygous and right in F_1, the segregation and recombination are realised which have been utilized in several genetic studies in this crop. The present study was taken up to investigate (a) the mode of inheritance of frost resistance in Indian varieties and (b) the genetics of resistance by analysing F_1 and test-cross generations.

Frost resistant varieties Kufri Sheetman, Kufri Dewa and Phulwa were used in combination with susceptible varieties Kufri Lauvkar and Craigs Defiance. Kufri Sheetman was crossed reciprocally with Kufri Lauvkar. Because of its male sterility, Kufri Dewa was used only as female in cross with Kufri Lauvkar. Phulwa (P-18) was hybridised with the male sterile Craigs Defiance. Two selections from the cross Kufri Sheetman x Kufri Lauvkar were back-crossed with Kufri Lauvkar. The selections used were designated FR(R) for the resistant one, and FR(S) for the susceptible one. Crosses were also made between Craigs Defiance and Kufri Lauvkar.

About 200 seeds from each of these crosses were used to raise F_1 and test-cross generations in the field during late autumn season in Simla. Observations were recorded after natural frost exposure in January 1981. Visible injury in the foliage and the above ground parts of the plants was measured using a transparent square-sheet. The injury was recorded as levels of 0, 5, 10, 15 etc upto 100.

Clonal populations showed little variation as compared to F_1 and test-cross generations. Kufri Sheetman, Phulwa and FR(R) were found to be more resistant than Kufri Dewa whereas the other parents were highly susceptible to frost (table 1). F_1 and test-cross populations exhibited mid-parental distribution and mean values for frost injury. The F_1 from Cgaigs Defiance x Kufri Lauvkar and test-cross progeny from FR(S) x Kufri Lauvkar did not contain any resistant genotype. Frequency distribution was found to be multi-model and this relative discontinuity was used to group the progeny in differenct classes of frost injury. Ratios were ascertained by applying X^2-test (table 2).

Kufri Sheetman, Phulwa and FR(R), when crossed with susceptible varieties, gave a goodness of fit for the ratio 1 : 4 : 6 : 14 : 1 in the progeny obtained. Class frequencies in F_1 from Kufri Dewa x Kufri Lauvkar conformed to a ratio of 1 : 3 : 3 : 1. Crosses between susceptible parents gave only susceptible genotypes belonging to the class of 85 to 100% injury.

Behaviour of the crosses involving resistant and susceptible parents clearly showed the presence of 3-4 heterozygous loci with a cumulative effect towards resistance. The ratio of 1:3:3:1 obtained in F_1 from Kufri Dewa × Kufri Lauvkar could be due to the presence of three heterozygous loci in the resistant parent, Kufri Dewa, and a recessive homozygous genotype of the susceptible parent, Kufri Lauvkar. This ratio will be obtained if the dominant genes for resistance are assumed to be independent and exhibiting a cumulative effect. Similarly, the ratio of 1:4:6:4:1 showed the presence of four independent heterozygous loci showing cumulative effect as obtained in the crosses involving Kufri Sheetman, Phulwa and FR(R). Apparently, each resistance gene tended to decrease the frost injury by about 15%. Thus, individuals in the class of 25 to 40% injury would have four resistance genes as in case of Kufri Sheetman and Phulwa. Individuals in the class of 40 to 55% injury would have three resistance genes as in Kufri Dewa. Plants belonging to the class of 85 to 100% injury would have a homozygous recessive genotype similar to that of Kufri Lauvkar and Craigs Defiance.

This explanation appeared to be quite plausible when the FR(R), selected from 25 to 40% injury class, showed the presence of four heterozygous loci as expected in it on analysing the test-cross progeny. Further, the F_1s obtained by hybridising two

TABLE 1
Mean values of frost injury in different populations

Population	Mean injury (%)
Parents	
Kufri Sheetman	36·0 ± 4·7
Phulwa	33·3 ± 5·0
FR(R)	39·6 ± 4·8
Kufri Dewa	47·6 ± 4·7
Craigs Defiance	92·3 ± 5·1
Kufri Lauvkar	94·0 ± 4·7
FR(S)	93·1 ± 4·9
F_1s	
Kufri Sheetman × Kufri Lauvkar	67·2 ± 16·4
Kufri Lauvkar × Kufri Sheetman	65·4 ± 16·6
Craigs Defiance × Phulwa	65·2 ± 16·3
Kufri Dewa × Kufri Lauvkar	74·0 ± 14·1
Craigs Defiance × Kufri Lauvkar	91·2 ± 6·1
Test-crosses	
FR(R) × Kufri Lauvkar	63·7 ± 15·3
FR(S) × Kufri Lauvkar	93·5 ± 5·8

TABLE 2
Ratios observed in F_1 and test-cross generations

Cross	Injury(%)					Ratio	X^2	*P*-value
	26–40	41–55	56–70	71–85	86–100			
Sheetman × Lauvkar	5	12	26	20	7	1 : 4 : 6 : 4 : 1	3·75	0·25–0·50
Lauvkar × Sheetman	4	17	23	18	5	"	0·44	0·97–0·99
Total of reciprocals (1 + 2)	9	29	49	38	12	"	2·73	0·50–0·75
Craigs Defiance × Phulwa	8	34	32	36	8	"	5·61	0·10–0·25
FR(R) × Lauvkar	3	20	29	24	5	"	1·60	0·75–0·90
Dewa × Lauvkar	—	9	23	32	12	1 : 3 : 3 : 1	2·17	0·50–0·75
Craigs Defiance × Lauvkar	—	—	—	—	192	0 : 1	—	—
FR(S) × Lauvkar	—	—	—	—	180	0 : 1	—	—

susceptible genotypes (85 to 100% injury) and test-cross involving FR (S), were found to contain only susceptible genotypes. This ascertained their homozygous recessive nature for this character. The genetic make-up of these Indian varieties is given below:

Moderately frost resistant varieties *viz.* Kufri Sheetman, Phulwa and FR(R) :

$$F^{r1}f^{r1}\ F^{r2}f^{r2}\ F^{r3}f^{r3}\ F^{r4}f^{r4}$$

Slightly frost resistant Kufri Dewa :

$$F^{r1}f^{r1}\ F^{r2}f^{r2}\ F^{r3}f^{r3}\ f^{r4}f^{r4}$$

Craigs Defiance, Kufri Lauvkar, FR (S) and other extremely frost susceptible varieties.

$$f^{r1}f^{r1}\ f^{r2}f^{r2}\ f^{r3}f^{r3}\ f^{r4}f^{r4}$$

The possibility of oligogenic nature of inheritance for frost resistance based on an experiment using electrolyte-leaching test was mentioned[4]. The present study confirms this under conditions of natural frost. It also suggests that the resistance in Indian frost-resistant varieties is due to the presence of 3-4 independent genes exhibiting a cumulative effect.

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SEXING OF THE 28-SPOTTED EPILACHNID, *HENOSEPILACHNA VIGINTIOCTOPUNCTATA* (F.) AND SOME OBSERVATIONS ON ITS FECUNDITY AND OVIPOSITION.

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THE 28 spotted epilachnid, *Henosepilachna vigintioctopunctata* (F.), is one of the most injurious pests of Solanaceous crops. Various attempts have been made for the control of this pest by chemicals and radiations. Sexing is an important step in any rationally planned attempt for the control of insects or pests.

Different morphological characters have been used for sexing the coleopteran insects. In some size, variation forms the discernible character for sexing[1]. while in others, morphological characters of the abdomen have been used[2,3]. In the present study, we have described a few important characters by which live beetles can be sexed without causing any damage to them. A few observations on the ovipositional behaviour of the female, longevity of the adult insect and the effect of removal of male after mating have also been described.

Potato epilachnid, *H. vigintioctopunctata* (F.), reared on potato leaves at 30°±1 and photoperiod of 17L:7D showed wide variation in size among both the sexes. Five-day old insects showed that the male was slightly smaller (5.4 mm long, 4.6 mm wide) than the female (6.0 mm long, 4.9 mm wide). But correct sexing could not be done on this basis. There was still a 40% chance of committing an error in sexing the beetles. Therefore, other features to sex them were investigated. The beetle was gently pressed to expose the tip of abdomen from elytra. In males, aedeagus can be revealed as a brown line running along the translucent abdominal sterna (figure 2). Abdominal tip of the male beetle is somewhat pointed and of the same colour as the venter. However, in the female it appears broader, dark coloured and is made of two distinct dark-brown plates (figure 1) as against one in male. On the basis of these characters a sex ratio (male to female) of 1:1 was obtained which agrees with the value reported by Pandey and Uma Shanker[4].

For observations on the mating behaviour and fecundity, newly emerged beetles were sexed and a pair was released in each of the 250 ml container. Each observation was replicated five times. In most of the cases mating started after 4 days of adult emergence.

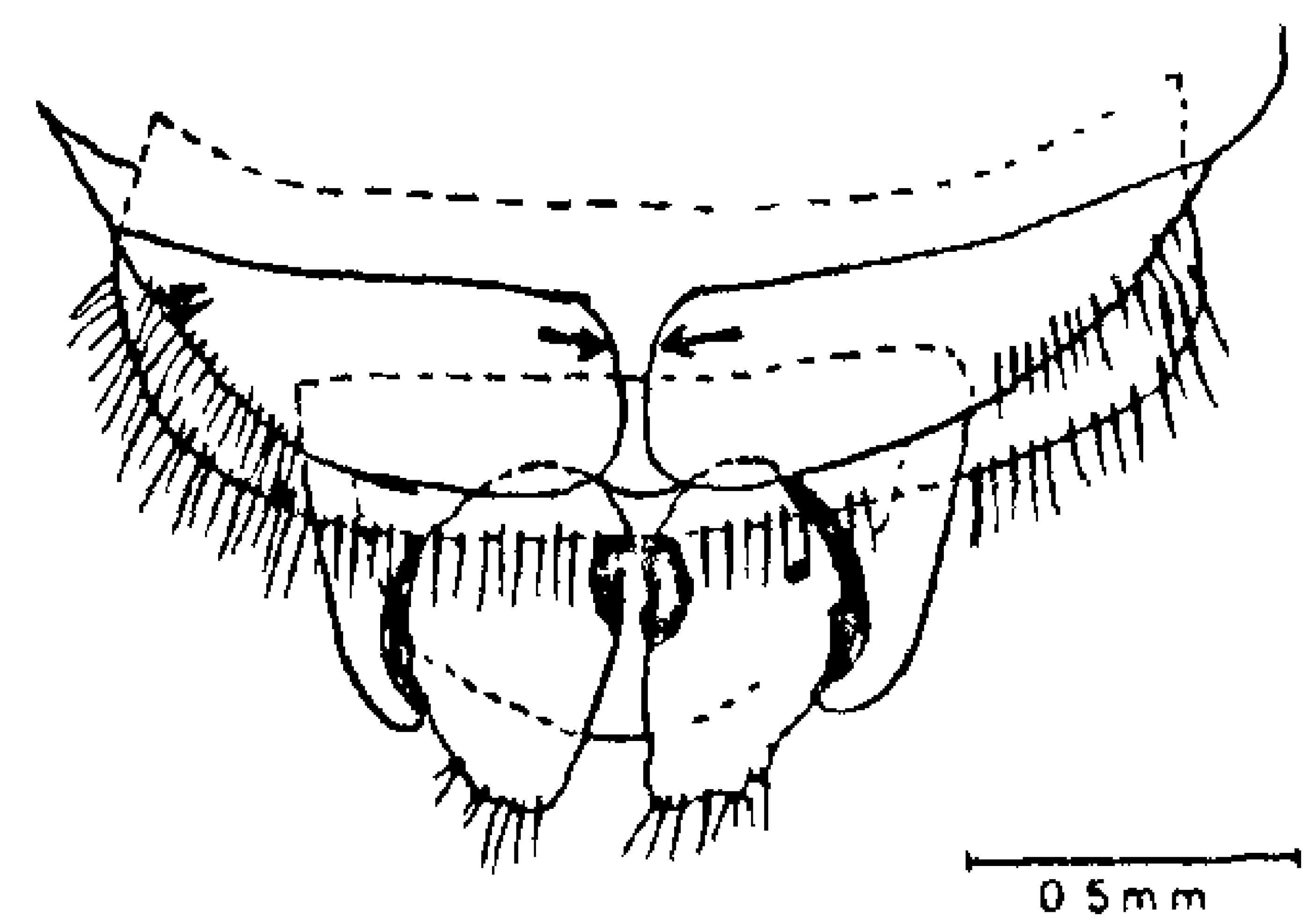

Figure 1. Terminal abdominal sterna of female *H. vigintioctopunctata*. Arrows indicate divided sternal plate of eighth uromere which forms a discernible character to sex the female.