

(Pl. 4, fig. 4). The tunnels of *Dryocates* are in some species, *affaber*, variably irregular, but are in others, such as *confusus* Sw., distinctly of this type.

Certain species of *Ips* and *Pityophthorus* have a preference for following the grain of the wood, and in some of these a few very long egg-tunnels are developed, more or less parallel to each other throughout much of the length, as with *Ips calligraphus* Germ., and *Ips perturbatus* Eichh. (Pl. 4, fig. 10). Certain species of *Pityogenes* and *Pityophthorus* cut elongate egg-tunnels in the bark of small twigs, and show a more or less distinct spiral arrangement.

*Cave Tunnels*.—Species of the genus *Cryphalus* excavate an irregular cavity in the bark, engraving the wood, in which the eggs are deposited (Pl. 23, figs. 6, 7). *Pityophthorus opaculus* Lec., and others, have a very similar habit, sometimes combining the cave type with short irregular egg-tunnels.

*Pith Tunnels*.—Certain species of *Pityophthorus*, *Stephanoderes* and *Micracis* cut their egg-tunnels through the pith of twigs (Pl. 4, fig. 5).

#### THE LARVAL MINES.

The larval mines of the bark-beetles have been described briefly on page 9, and are dealt with in detail under their respective species in the remaining parts of this series.

#### FACTORS INFLUENCING THE DEVELOPMENT OF BARK-BEETLES.

It is very noticeable that at different altitudes and latitudes and in different seasons the broods of the *Ipidæ* develop at different rates. A species which is single-brooded in northern Canada may have two broods in the middle or southern States. Certain species which have normally two broods, may have but one or only a partial second brood in cold, wet seasons, in the same locality. In the same locality, and during the same season, over-wintered individuals may appear from cold, swampy sections or northern slopes several weeks later than others of the same species, which have wintered in a sunny situation. It is evident that the factors which influence the development of the larvæ and the time of appearance of the adults are of great interest, and are of particular importance in economic studies. The chief of these factors are the moisture content of the air in the tunnels, the temperature of the air and of the bark, and the sunlight. The beetles are particularly sensitive to any change in humidity; they will leave all other activities to fill any openings made in the tunnel roof.

Valuable experimental studies upon the effect of different degrees of heat and moisture upon the development of bark-beetles have been made by several European writers, especially by Hennings upon *Ips typographus* Linn. The results of these studies agree on the whole with more general observations made in our forests under natural conditions. It has been a matter of common observation in Canadian forests that the greater number of our bark-beetles breed most rapidly in hot weather with a moderate supply of moisture. On the other hand, broods developing in the bark in the open sunlight of clearings are not uncommonly destroyed by the high temperature and dryness of the bark, which render the latter unfit for food, and also directly affect the life processes of the larvæ. It may be noticed in very hot, dry seasons that while broods in the thin bark exposed to the open sunlight may be partly or largely destroyed, those breeding in the thick bark of the trunk or moister stump, or in thick bark about the edge of the clearing, where the moisture has been partly conserved by the shade, may breed successfully and with great rapidity. It appears also that sunlight, aside from temperature, has a stimulating effect upon growth. Hennings refers to a "heat paralysis" of the larvæ which was noticed sometimes at 24°C. dry (55 per cent to 56 per cent air moisture). The highest life processes were reached just before that point. The addition