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The possibility of breeding forest trees resistant to insects

Insects search for host plants to lay eggs on them, feed and hide there. Thus, the most important task of the insect is to find a host plant in the environment. The search for such a plant is a behavioural chain composed of the following elements:

1/ impulse, or the stimulating mechanism,

2/ a rigid motion scheme of activity,

3/ congenital evoking mechanism /sense mechanism/ triggering a reaction and responsible for its selective sensitivity to the combination of key stimuli,

4/ key stimulus /Szewczyk 1980/.

The presence of all elements of the behavioural chain is necessary for insects to find the host plant. The key stimulus is as a rule a combination of chemical substances of the host plant corresponding to the complex activity pattern in the insect's receptors /Jermy 1976/. Mono-, oligo-, and polyphages choose their plants in different ways. For a monophage the host plant is the only source of food so that the insect reacts mainly to the nutrient components and disregards the content of rejectants. Polyphagic insects have the possibility of choice between host plants and choose above all hosts with a moderate content of rejectants. They react but little to the content of nutrient components /Jermy 1965/.

Changes in the key gene loci conditioning choice of the plant may lead to a periodical or permanent change of host choice.

Plants defend themselves from insect attack:

- by failing to meet in space, that is changes in distribution of individuals within the population or species,

- by failing to meet in time, thus, changes in the phenology of the host plant in relation to the development phases of the pest,
- by biological associations with accompanying species,
- by adaptation enabling to support the attack without suffering damage,
- by development of morphological-structural barriers,
- by chemical resistance:

a/ deficit of nutrient components,

b/ excess of nutrient components noxious for the given insects,

c/ production of toxins and repellents,

d/ utilisation of feeding inhibitors /Harris 1980/.

Other ways of defence of plants from pests are also known.

The mechanisms of defence and the ability to change the defence system in plants are hereditary. Interrelations between types and mechanisms of resistance are complicated and their joint discussion is not possible in the present communication. They have been analysed by Piechota /1982/. Since the biological properties of both pests and hosts are genetically conditioned, it may be said that evolution of relationships between insects and plants is an evolution of genotype adaptation /Fig. 1/.

The systems of coevolution of plants and insects has been many times discussed in the world literature. According to the present author, Jermy is right when he states that the evolution of insect and plant relationships is not a coevolution, but a sequential evolution, that means that the changes in the hosts are primary and occur spontaneously, while adaptation of insects is secondary and induced by the changes in plants.

The character of interactions between insects and plants may be modified by the environment, forming a complicated system in a state of dynamic stability.

Insects are either directly or indirectly noxious to forest trees. Their direct effect consists in damaging plant organs and this results in debilitation, deformation or gradual dying of the plant. Indirect damage consists in transmission of fungal bacterial and viral diseases. For instance Scolytus multistriatus transmits the fungus Ceratocystis ulmi which destroyes one of the elm species. The losses caused by forest pests are well known and do not require discussion.

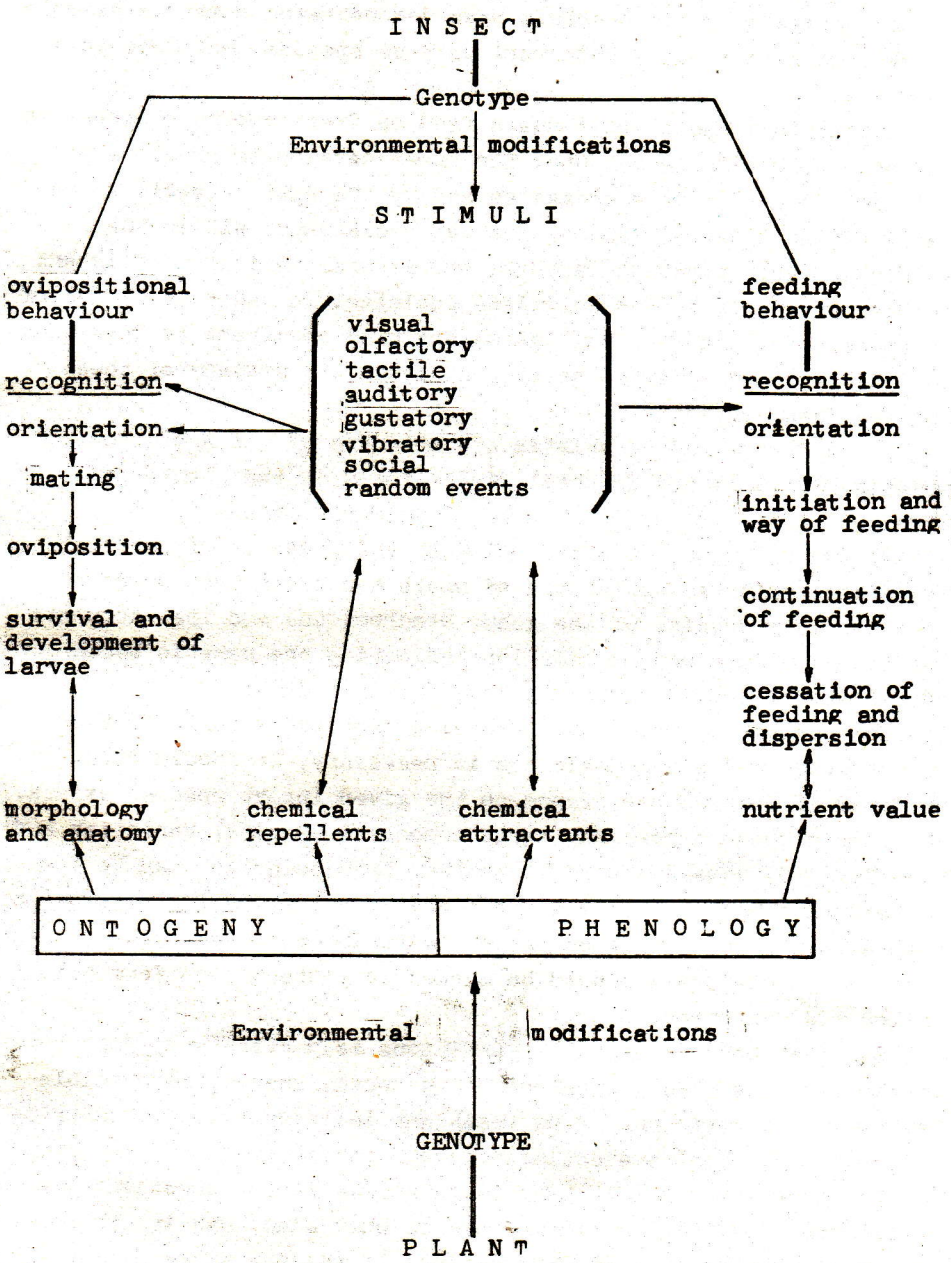

FIG. 1. Characteristic of relationships between insects and host plants /after Hanover 1975/

Investigations of foresters have demonstrated numerous examples of genetic resistance within various tree species. Here are some examples.

Lymantria monacha individuals feed on fresh shoots of trees in May and the beginning of June. The trees developing shoots late will not succumb to the damage caused by the pest caterpillars and may serve as material for crosses for resistance. Within the species Robinia pseudacacia there are several varieties resistant to the attacks by pest Megacyllene robiniae. In Japan varieties of Castanea crenata and C. mollissima are bred resistant to Dryocosmus kuriphilus, they arose by selection within the progeny of these species /Hanover 1980/.

Picea glauca and P. abietis are attacked by the aphid Adelges abietis. Thielges and Campbell /1972/ found in the plantation some trees which did not bear gallnuts. Strains resistant to these aphids can be quickly tested, owing to the presence of chemical resistance markers. Resistance of hosts has often been observed to attacks by species of the genus Dendroctonus and Ips. Accurate quantitative data and information indicating the genetic background of resistance are, however, lacking /Hanover 1980/.

For successful resistance breeding continuous collaboration of entomologists and geneticists is necessary. It should first be found if natural resistance to the given insect species exists. For this purpose a possibly large number of species, varieties and singular individuals should be tested. Tree selection can be done in natural stands. It is the basic way of acquiring information on natural resistance of trees. After selecting such trees the resistant individuals should be marked to protect them from being felled and destroyed.

Observation under natural conditions is particularly important in the period of heavy breakout of the pest, when it is possible to detect a greater number of resistant individuals, this ensuring a wide genetic pool preventing unfavourable inbreeding.

The next step in selection is an answer to the question: has resistance a genetic background and of what kind, can it, therefore, be transmitted by cloning or crossing? If so, the trees can be "exposed" to the attack of pests. Those which under natural or artificial pest impact preserve their resistance should be used as

parent forms for crossing or clonal multiplication. The course of selection is different in the case of various species of trees and pests and may be schematically represented as shown in Figure 2.

If during testing we detect a phenotypic variability in the damages caused by insects we must decide whether resistance may be transmitted by seeds.

The next step is an increase of the range of variability by crossing. The latter can be:

1/ fully controlled when both parent forms are strictly identified,

2/ partly controlled when only the maternal form is known,

3/ panmictic.

Fully and partly controlled crossing can be ensured by:

- castration of flowers of the maternal plant and artificial or free pollination with the chosen pollen,
- utilisation of the mechanisms of self-incompatibility,
- utilisation of the phenomenon of male sterility.

The outset plant forms obtained in the following ways are used for crossing:

1/ from natural populations,

2/ from nurseries where plants with an enhanced range of genetic variability are grown, for instance as the result of crossing, mutation etc.,

3/ from homozygous lines obtained by way of inbreeding, close-crossing or by haploidisation /e.g. stimulation of parthenogenetic development of egg cells in vitro/.

When choice of components is done appropriately, it is possible to obtain in a short time recombinants in which the genes conditioning resistance will be cumulated.

The following difficulties arise in resistance breeding:

1. Transmission of resistance conditioning genes from wild species is difficult since it requires repeated backcrosses, thus, repeated testing of resistance.

2. When inheritance is polygenic, the genes conditioning resistance undergo in the successive generations segregation together with the genes brought by the sensitive individuals, and owing to this resistance is frequently lower in the progeny.

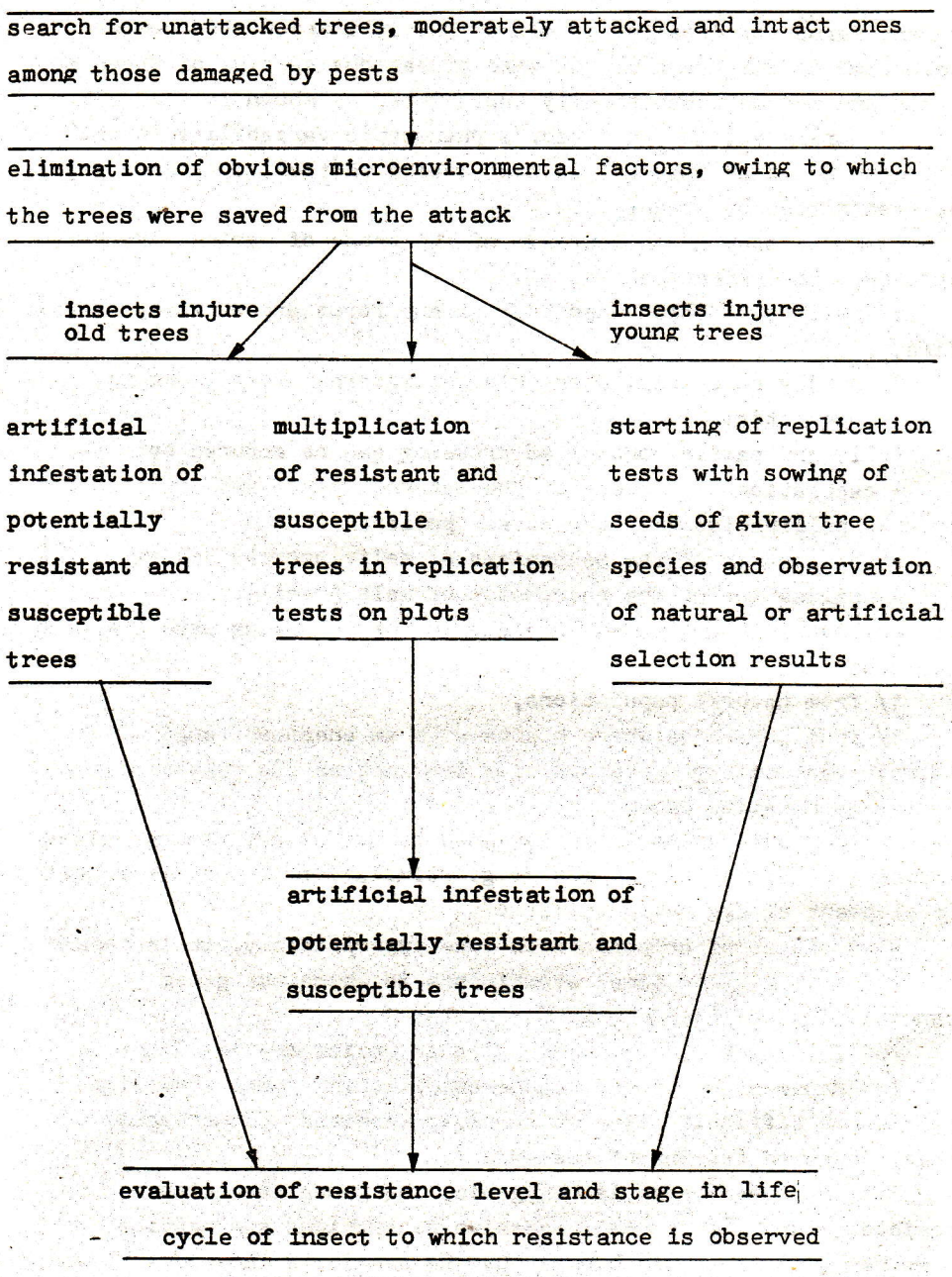

FIG. 2. Procedure for revealing resistance of trees to insect attacks /after Hanover 1975, modified/

3. Tree species are naturally crossed and highly heterozygous. Pure lines are difficult to obtain. Work has to be done on very extensive genetic material ensuring an appropriate genetic pool.

4. The size and longevity of trees makes selection difficult.

5. Some species are attacked only after attaining a certain size or age, this requiring a long period of study.

6. There exists a large number of tree - pest combinations for which breeding should be conducted.

7. One tree species is frequently attacked by several pest species.

8. An important participation of the environmental factor in the expression of resistance makes testing difficult.

9. There is a risk that forms of the pest may arise which will break the resistance of the plant.

A convenient feature of trees, making studies on breeding material easier is the ability of many species of vegetative reproduction.

The above described difficulties do not mean that it is not possible to obtain resistant forms. The author believes that with some efforts resistance breeding of pine and spruce in Poland is possible and purposeful, at least against attacks of main pests. For this it is necessary to undertake research on interrelations between insects and host plants, especially in the field of population genetics of pests and microevolution, so as to be able to follow currently the changes occurring in insect populations and to determine the genetic foundations of resistance inheritance to particular insect species.

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