wind exceeded 5 mi/hr but was probably not much more than 10 mi/hr. Each individual was released repeatedly from all four quarters of the compass until a consistent behavior pattern for that individual seemed evident.

Upon release no birds consistently altered course to alight either with or against the wind. Several regularly hovered instead of alighting immediately, and these, as well as several others, spiraled in the air before alighting, not generally changing direction more than 180°. Different individuals consistently spiral either clockwise or counterclockwise, without respect to wind direction, and this is interpreted as normal spiral movement, characteristic of free-moving organisms (*2*). A bird released into the wind and rotating 180° would cover about 25′ before alighting, because of the tail wind most of the way, and would come in contact with the earth with too much velocity (perhaps 15 mi/hr). The same individual, released with the wind and spiraling about 180° into the wind, would make a short, hovering flight of about 5′, alighting at near zero velocity. Generally, the birds simply fluttered to the ground in the direction released, regardless of wind direction. They obviously did not know how near to the ground they were at the instant of impact, and sprawled with wings and tail outspread.

The eardrum, only thinly screened by the auricular feathers, and with an area in small birds up to 10 times the relative area in man, may probably be eliminated from any role in detecting wind direction. The sparrows, juncos, and 3 pigeons were flown with auricular feathers removed, and no change in behavior was noted whether the ear was covered by the blindfold rubber or not.

These experiments should be repeated by investigators with larger numbers of species and individuals available. Interpretation of this kind of behavior is somewhat subjective, and a larger number of trials might result in different conclusions.

However, our results indicate that birds alight by visual cues. They normally turn to alight into the wind whenever it reaches velocities approaching 10 mi/hr. It is also known that, although birds hold their heads in a characteristic position of rest in arising and maneuvering, they turn them intently downward upon alighting. I believe they are observing the let-down point, in most cases binocularly. If they sense that their speed is too high, they know the wind is behind them and make a sharp turn of 90° to 180°, alighting the instant the wind cancels forward movement. If the wind is less than 5 mi/hr, they pay no evident attention to it, alighting indiscriminately from any direction.

The importance of vision in the alighting of birds may explain migration catastrophes like the one that occurred on the night of March 13–14, 1904, when millions of migrating Lapland longspurs encountered a cold front with heavy snow and were killed in violent collision with the earth. Most small birds migrate at night, feeding and resting by day; a migratory flight launched on a dark night may actually be unable to land safely until daylight. In fact, the well-known visual acuity of birds is largely due to the great cone-density of the retina, which is generally so poor in rods as to be inferior even to the human retina for night vision.[1]

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[1] For help in obtaining and flying birds I am indebted to R. Marlin Perkins, J. Lear Grimmer, Robert Smolker, and Karl Bartel.

Insect Resistance to Insecticides

THE problem of the development of resistance to insecticides among insects is becoming increasingly important. In laboratory studies and observations on the development of such resistance, advantage is taken of the dosage response, and it is generally assumed that individuals surviving high dosages of toxicants are inherently resistant. If chemically selected individuals are bred generation after generation, a resistant strain should be developed. This has indeed been demonstrated in some instances, but not in others. The development of resistance by physiologic mutation is a very real possibility, but it has not been possible to distinguish positively between mutation and selection of an existing natural resistance, as has been done with bacteria.

Some toxicologic data being prepared for publication elsewhere could not be explained satisfactorily on the basis of the variation expressed by the slope of the dosage-response curve. This variation relates directly to the standard deviation and can be viewed as the range of individual responses about the mean of the test group. In addition, there appear to be types of variation, not expressed by the dosage-response curve, which have been largely neglected in selecting for resistance, and which may be far more critical in the understanding of how resistance is developed.

One type of variation is that of the individual insect. The belief that an individual maintains a static position in the population of which it is a member, and hence that those individuals surviving chemical treatment are genotypically resistant, is probably without foundation. There is no way of knowing, of course, how all individuals would respond to a second administration of the toxicant when death is the criterion of response. If recovery time following the administration of a stupefacient (carbon dioxide, nicotine, cyanide) is used as a measure of susceptibility, it is found that a dynamic variation exists among the insects tested (*Galleria* larvae, *Oncopeltus* adults, *Habrobracon* adults). An individual recovering rapidly from one exposure may be slow to recover from the next, and vice versa. If a series of tests is made, each individual responds by recovering in times of different magnitude. Although a central tendency can be calculated, it varies among different insects. Thus, the mean would seem to be a much better measure of an individual's inherent susceptibility than response to a single test. If such dynamic variation exists when measured by recovery time, it is not unreasonable to assume that it exists when mortality is the end point observed. Unfortunately, a mean lethal dose cannot be estimated for each individual.

Another type of variation than that expressed by the standard deviation is that of the means of the test groups. Even though the slope of the dosage-response curve for a given toxicant applied to a test insect is relatively stable, it is well known that the LD_{50} is found to vary from day to day, from culture to culture, from laboratory to laboratory, and from one condition (e.g., temperature) to another. It is thought that some of these observed differences are due to differences in technique, and certainly some of them are. But considering the world population of a single insect species, each test group is but a small sample of the population at a particular time. The means of all test groups must vary widely from place to place, from time to time, and under different conditions, even though the techniques for study might be identical. At present nothing is known about the distribution of these group means. The range of distribution might be so wide, however, that in localized areas little chemical selection would be required for segregation of resistant groups.

Of the three variations—variation in response by the individual insect, variation in response by individuals about the group mean at a particular time, and variation of the means of test groups (considering the entire population of the species at all times)—only the second can be described easily, and only this one has been used in selection for resistance. And yet this may be the one least likely to yield the desired results. If the first type of variation is to be found generally with different insects and with different toxicants, the apparent phenotype as judged by a single test may be quite different from the genotype, and genetic studies based on selection using the dosage-response curve may be faulty, success being largely fortuitous.

There is one technique that has been used with signal success in demonstrating development of resistance in the laboratory, probably because the first type of variation is unwittingly taken into consideration. This technique (Bruce and Decker, *Soap Sanit. Chemicals,* 26, [3], 122, 145 [1950], and others) involves the exposure of houseflies to DDT—not as a single application, but continuously throughout larval life. This treatment would eliminate any individual which was even temporarily susceptible and would permit survival of only those individuals that were consistently resistant.

By taking cognizance of these three types of variation, it may be possible to reconcile data that now appear conflicting, but to do so requires more information about the distribution of the respective variations, their interrelationships, and the physiologic and ecologic factors contributing to each. Certainly, genetic studies can be conducted on a more secure basis if this information becomes available.

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Research vs. Proprietary Interest

Why is it that many scientists are behaving like the "man in the street," who may be a well-balanced individual until someone brings up a controversial subject in religion or politics? I had always considered a good research man as the best available example of judicial detachment, able to study scientific matters objectively, and to discard even his own data if found to be of doubtful significance.

Now I am unhappily discovering that a considerable number of rather important scientists are unable to discuss security regulations or loyalty oaths without exhibiting either an attitude of sophomoric resentment or the type of prejudiced argument one expects from the man in the street, to whom the subject under discussion appears to be either all white or all black. Although there have been some calm and scholarly presentations of certain dangers to academic and scientific freedom, such have not seemed to be the rule. In a subcategory of this group, I find that some scientists who have served with, or been in contact with, the military allow themselves to sound off much like the ex-soldier who hated the first sergeant.

Enough of complaint. All our training and experience in research lead us automatically to consider both sides of a moot question. Matters of procedure now being argued—in typical American style—are of the gravest importance to the future of research and to the future of our country. Both these matters are important. It is the security of our country that makes possible the significant advances in all of science. Men of the greatest sincerity are trying to maintain that security, and those who are charged with that duty are obliged to set up rules, a procedure necessary in any institution of great size. It is true that some of the men who administer these rules, although possibly sincere, may be men of limited vision. It is also true that there are occasions when the earnest scientist, immersed in his own problems, finds a fence where he thought to find a gate, and in his frustration speaks out in unscientific style (most of us show such human frailty at times). May we not wait to cool off, however, before we write a book or a review about it?

It appears to the writer that scientific research, like all human existence, is beset with obstacles, differences of opinion, obstinate data, annoying rules, limitations of time and space, etc. To that is now added the occasional cooperation and sometimes the supervision of some government agency. Not all of us will admit that this supervision is necessary (some of us still dislike stop signs in traffic regulation), but the situation does exist. It is certainly not palatable to consider this as