

Insects were placed on the source, where the air dose was 3600 rad/h. They were given doses from 877-224 000 rad in 100% increments. Various sizes of nymphs of Acheta domestica, Tenebrio molitor, Periplaneta americana, and Blattella germanica were used. The insects were irradiated at room temperature, and kept at 28°C after irradiation. Effects were expressed as median life expectancy, corrected for control mortality. The gut does not appear to be a primary critical organ which probably lies closer to the skin. Dosages of 3600 rad/h of  $\beta$ - and 25 000 rad/h of  $\gamma$ -radiation were given in one experiment on large Acheta nymphs, when insects exposed to  $\beta$ -radiation were found to live twice as long as those exposed to an equivalent dose of  $\gamma$ -radiation. These findings are discussed.

- 861<sup>(2)</sup> Narayana, E. S., Chawla, S. S., Ghal, S. EFFECTS OF GAMMA RAYS ON MORTALITY, LONGEVITY AND FECUNDITY OF SOME SPECIES OF FRUIT FLIES. Proc. natn. Acad. Sci. India B, 29 (1963) 613-21.

The effects of  $\gamma$ -rays on mortality, longevity, and fecundity of some species of fruit flies showed that: the 2-d-old pupae were very susceptible to the rays as exposure to 2000 R brought 100% mortality in both the species studied; the resistance to the rays progressively increased with age; the fecundity was inversely proportional to the dosage used; the sterilizing effect started at ~2000 R in the adults emerging from 4-to 5-d-old pupae; and there was no apparent effect on the  $F_1$  generation emerging from 1000 R-exposed pupae. (Auth.)

- 862 Nöthel, H. DER EINFLUSS VON RÖNTGENSTRAHLEN AUF VITALITÄTSMERKMALE VON Drosophila melanogaster. I. UNTERSUCHUNGEN ÜBER DIE LEBENSDAUER. (The influence of x-radiation on the vitality characteristics of Drosophila melanogaster. I. Investigations on the lifetime). Strahlentherapie 126 (1965) 269-82. (In German)

The influence of x-rays (100 kV, 17 different doses ranging from 0 - 125 kR) on the viability of insect imagoes was studied by means of the lifespan of D. melanogaster. Compared with the unirradiated controls, a prolongation of female lifespan was apparent, which had a maximum of 50% at 11 kR. It was correlated with, and apparently due to the radioinduced sterilization. This was confirmed furthermore, especially with chemically (by TEM) sterilized females. With increasing dose, log mean survival time decreased linearly and parallelly in both sexes, except the increase mentioned: the LD50 is 46 kR in males and 96 kR in females. There was a normal distribution of the mortality rate in the time after exposition at each dose. Therefore, it is assumed, that always the same mechanism of damage is involved. At doses above 90 kR this mechanism was overlapped by an immediate death, as indicated especially by the appearance of an additional early mortality peak. The immediate death was identical in both sexes. According to the symptoms, it is interpreted as central nervous injury. (Auth.)

- 863 Sakka, M. RADIATION INDUCED SHORTENING OF LIFE OF Sarcophaga peregrina AND ITS MODIFICATION BY DOSE FRACTIONATION. Nippon Igaku Hoshasen Gakkai Zasshi (Nippon Acta radiol.) 24, 11 (1965) 1185-88. (In Japanese)

Life shortening of adult Sarcophaga is one of the major late effects of radiation delivered at the pupal stage. The effects were proportional to the dose, with a threshold of several hundred roentgens. Dose fractionation reduced the effects, suggesting that late effects such as life shortening are associated with acute irradiation.

- 864 Sakka, M. x-RAY INDUCED SHORTENING OF LIFE SPAN OF ADULT Sarcophaga peregrina AND ITS MODIFICATION BY DOSE FRACTIONATION. Tohoku J. exp. Med. 86 (1965) 325-33.

The life span of the adult flies was diminished after x-irradiation in the early pupal stage, and imago formation of irradiated pupae was also inhibited. In flies which received a single dose, a linear relation was seen between mean life span and rate of imago formation which suggests that early effects play important roles in delayed effects. Mean life span of control females was longer than the males. With the fractionated doses, linearity was lost in the high dose range. Male mortality increased whereas in the female it was nearly constant from the 4th - 10th week, after which it rose rapidly with age. Before the 4th week, no significant difference in mortality was observed between sexes. The increase in mortality rate after the 4th week in males was caused by acceleration of aging. On the other hand, in the female, no acceleration of aging in this period was noted. When pupae were irradiated with a single dose of 960 R, high mortality was observed from the beginning of adult life. This arose from residual injury produced during

pupal irradiation. The first part of the mortality curve paralleled the controls. Then it reached a shoulder at the 4th week, continued to hold the same value for weeks, and then sharply elevated hereafter. Slope of the last part of the curve simulated again that of the control. Radiation injury produced by a single dose of 960 R accumulated and accelerated aging as evidenced by shortening of the plateau. A linear relation was observed between mean life span and rate of imago formation, but a much higher dose was required to produce an identical effect in fractionated than in single irradiation. Thus, dose fractionation reduced early as well as late effects. As for rate of weekly mortality of irradiated male imagos, two fractions for a total dose of 1920 R was less effective than a single one of 1860 R. After single irradiation of 1860 R, adult mortality was high from the beginning of life and reached 100% at the 7th week without plateau. On the other hand, dose fractionation yielded lower initial mortality. Adults lived as long as 8 weeks and a plateau was not demonstrated. Thus radiation injury produced in pupae can be repaired but some of it is still operative in adult life and plays some role in killing adults. (NSA 20: 1966, 16291)

- 865 Strehler, B.L. STUDIES ON THE COMPARATIVE PHYSIOLOGY OF AGING. III. EFFECTS OF X-RADIATION DOSAGE ON AGE-SPECIFIC MORTALITY RATES OF Drosophila melanogaster AND Campanularia flexuosa.

Individually housed D. melanogaster were exposed to x-ray doses ranging from 1000 - 50 000 R and the subsequent mortality observed. 50 000 R causes a life shortening of approximately 1 d/2000 R as calculated from the age specific mortality rates 30-70 d after exposure. No detectable effect occurred up to 5000 R. The life span of C. flexuosa was strikingly increased by exposure to ionizing radiation; for example, 25 000 R actually doubled life span. These observations are in conflict with the somatic mutation hypothesis of aging, at least in these species. (Auth.)

- 866 Strickberger, M. W. EXPERIMENTAL CONTROL OVER THE EVOLUTION OF FITNESS IN LABORATORY POPULATIONS OF Drosophila pseudoobscura. Genetics 51 (1965) 795-800.

Four strains of D. pseudoobscura isogenic for the AR third chromosome arrangement were permitted to evolve for an 18-month period under different degrees of recombination in bottles and in population cages, and under two different degrees of mutation in the cages. The competitive ability of AR chromosomes from each of these sources was then tested under population cage conditions against strains carrying the CH arrangements. For both AR from bottle and cage origins, the degree of fitness evolved was enhanced by the extent of recombination that had been experienced. At the same time, the highest competitive frequencies achieved by AR chromosomes appeared to be limited by the amount of their initial genetic variability. The mutation effect produced by 8000 R of x-rays neither enhanced nor detracted from the evolution of fitness of the AR chromosomes to which it had been added. (Auth.)

- 867 Wood, V. G. THE EFFECTS OF X-RADIATION ON LONGEVITY IN Drosophila melanogaster. p. 21 of "Research and Development in Progress. Biology and Medicine. No. 3". Abstr. TID-4203, Division of Technical Information Extension, (AEC), Oak Ridge, Tenn. Apr. 1964, 290p.

- 868 Wood, V. G. THE EFFECT OF X RADIATION ON LONGEVITY IN Drosophila melanogaster. Final Technical Report. TID-20550, Taylor Univ., Upland, Ind. Apr. 1964, 83p.

The length of life of control and irradiated populations of D. melanogaster was investigated over a 4-year period. Two unrelated wild type strains of flies were crossed and inbred stock from this mating was exposed to doses of x-radiation ranging from 25 to 60 000 R. Both mated and unmated groups were studied and radiation exposure was given during each developmental period. The data indicate that females outlive males in both irradiated and control groups, and unmated flies live longer than mated flies. A slight increase in life span was noted in flies exposed to the lowest doses of radiation. Possible explanations are discussed. (NSA 18: 1964, 19554)

See also:

- 593 Viability of heterozygotes for induced mutations in Drosophila melanogaster. I. Irradiated X-chromosome. (Falk, R. et al., 1965)  
594 x-ray induced sex-linked lethal and detrimental mutations and their effect on the viability of Drosophila melanogaster. (Friedman, L. D., 1964)

- 649 Determination of the optimum sterilizing dosage for pink bollworm treated as pupae with gamma radiation. (Ouye, M. T. et al., 1964)
- 659 The potential application of  $\gamma$ -radiation for the sterilization of *Chloridea obsoleta* for the purpose of reducing its population. (Andreev, S. V. et al., 1964)
- 767 Gametogenesis and radiation effects in the cereal leaf beetle, *Oulema melanopa*. (Hoopingarner, R. A. et al., 1965)
- 785 The effects of high level x-irradiation on adult house fly flight ability and longevity. (Rockstein, M. et al., 1965)
- 812 Radiation sensitivity of immature stages of the giant milweed bug. (Crossley, D. A., Jr. et al., 1965)
- 816 Some effects of gamma irradiation on the gypsy moth, *Porthetria dispar*. (Godwin, P. A. et al., 1964)
- 818 Some observations on the effect of ionizing radiation against desert locust. (Huque, H., 1963)
- 819 Possibilities of controlling *Callosobruchus subinnotatus* Pic. (Huque, H., Khan, M. A., 1964)
- 820 Effects of ionizing radiation on eggs and adult insects. (Lippold, P. C., Gambrell, F. L., 1965)
- 823 Biological and histopathological effects of gamma radiation on three life stages of *Anthonomus grandis* Boheman. (Mayer, M. S., 1964)
- 829 The gamma irradiation of *Glossina* puparial stages and control. (Potts, W. H., 1965)
- 876 Mortality and life span of *D. melanogaster* (a wild-type and a mutant strain with a ring-X chromosome) exposed as young adults to x-rays or to high doses of cobalt-60 gamma-rays. (Sonnenblick, B. P., Rockford, D., 1964)
- 880 } The influence of gamma rays on the longevity of *Tribolium confusum* Duval. (Verecke, A.,  
881 } Pelereys, G., 1965)
- 886 Absence of "oxygen after-effects" in *Calandra granaria* during hibernation induced with low temperature. (Bychkovskaya, I. B., Ochinskaya, G. K., 1965)
- 891 } Influence of pathogens on the life span of irradiated insects. (Jafri, R. H., 1964)  
892 }
- 893 Prospects of integrated radiation and microbial control of harmful insects. (Jafri, R. H., 1965)
- 897 Action différentielle des rayons x et ultraviolets sur le tardigrade *Macrobiotus areolatus* à l'état actif et desséché. (May, R. M. et al., 1964)
- 908 Notes on the effect of preconditioning confused flour beetles with temperature variations or carbon dioxide prior to gamma irradiation. (Tilton, E. W. et al., 1965)
- 904 The effects of confining confused flour beetles in gelatin capsules before, during, and after gamma irradiation. (Tilton, E. W. et al., 1965)
- 912 Some supplementary data concerning the influence of  $\gamma$  rays on worker bees. (Pelereys, C., Brander, J. van den, 1963)
- 927 } Long-term effects of acute low-level x-rays on the population dynamics of the yellow fever  
928 } mosquito, *Aedes aegypti*. (Willard, W. K., 1965)
- 932 Progress report (on genetical studies), 1 October 1963 - 1 June 1964. (Dobzhansky, T., nd)
- 975 Cockchafer against cockchafer? An attempt at eradicating larvae of the field cockchafer *Melolontha vulgaris* Fabr. by means of x-rayed males. (Horber, E., 1963)
- 991 Summary of the mediterranean fruit fly investigation program June 1964 through May 1965. (Organismo Internacional Regional de Sanidad Agropecuaria, San Salvador (El Salvador), 1965)
- II/1270 The effect of radiation on the cockchafer, *Melolontha vulgaris*. (Lavrov, M. T., Bogomaz, V. A., 1958)

## 7. Lethal Effects

- 869 Banham, E. J., Crook, L. J. SUSCEPTIBILITY OF THE CONFUSED FLOUR BEETLE, *Tribolium confusum* Duv., AND THE RUST-RED FLOUR BEETLE, *Tribolium castaneum* (Herbst), TO GAMMA RADIATION. p. 107-118 of "The Entomology of Radiation Disinfestation of Grain", Cornwell, P. B., Ed. Oxford, Pergamon Press, 1966\*, 236p.

The study was carried out to compare the susceptibilities of the developmental stages of the two species, and to establish the efficacy of 16 000 rad for their control. All developmental stages of *T. castaneum* are more resistant to  $\gamma$ -radiation than *T. confusum*. Eggs, larvae, pupae, and

adults of T. confusum require doses of 4400, 5200, 14500, and 12800 rad, respectively, for 99.9% kill; the corresponding doses for T. castaneum are 10900, 10500, 25800, and 21500 rad. Production of progeny by T. confusum is reduced by 99.9% at 3400, 6400, 4700, and 7100 rad, respectively. Doses of 8600, 8100, 6200, and 8600 rad are required to obtain this reduction in T. castaneum. Fertility of adults of both species may be recovered to some extent after irradiation with substerilizing doses; there is no redevelopment of fertility in insects receiving doses approaching the evaluated commercial dose of 16000 rad. This dose controls both species although a small residual population (10%) of sterile T. castaneum may survive.

\* Since the work reported in this volume was carried out by the Entomology Group of the Wantage Research Laboratory, U.K.A.E.A., during the period 1955-61, individual papers are included in the present bibliography although they were actually not published in book form until 1966.

- 870 Cornwell, P.B. SUSCEPTIBILITY OF LABORATORY AND WILD STRAINS OF THE GRAIN WEEVIL Sitophilus granarius (L.) TO GAMMA RADIATION. p.19-26 of "The Entomology of Radiation Disinfestation of Grain", Cornwell, P.B., Ed. Oxford, Pergamon Press. 1966\*, 236p.

Whilst reduced variability in the gene constitution of laboratory strains makes them useful for preliminary studies on radiation susceptibility, wild strains must also be examined in evaluating radiation levels for commercial application. Tests on five laboratory strains and 30 wild strains of S. granarius (L.) from various parts of the world showed marked differences in susceptibility to killing by irradiation but only slight differences in response to sterilization. The dose level of 16500 rep, previously evaluated for the sterilization of large populations of a laboratory strain, may therefore be recommended for the commercial disinfestation of naturally occurring populations. (Auth.)

\* Since the work reported in this volume was carried out by the Entomology Group of the Wantage Research Laboratory, U.K.A.E.A., during the period 1955-61, individual papers are included in the present bibliography although they were actually not published in book form until 1966.

- 871 Jacklin, S.W., Smith, F.F., Boswell, A.L. EGG MORTALITY AFTER GAMMA IRRADIATION OF ADULTS OF THE OMNIVOROUS LEAF ROLLER. J. econ. Ent. 58, 6 (1965) 1188-9.

Pupae of Platynota stultana (Walsingham) were sexed, and subjected to  $\gamma$ -irradiation from a  $^{60}\text{Co}$ -source within 24 h of eclosion. Dosages of 4, 8, and 16 kR were tested on females, and 8, 16, 24, and 32 kR on males. Individual matings were arranged within the next 24 h. Up to 38 pairings were tested. For both male-treated and female-treated pairings the percentage of pairing which produced viable eggs decreased as the dosage increased. The observed egg mortalities, adjusted by Abbott's formula, showed that treatments of 16 kR for females and 32 kR for males produced over 90% egg mortality.

- 872 Jefferies, D.J., Banham, E.J. THE EFFECT OF DOSE RATE ON THE RESPONSE OF Tribolium confusum Duv., Oryzaephilus surinamensis (L.) AND Sitophilus granarius (L.) TO  $^{60}\text{Co}$  GAMMA RADIATION. p.177-185 of "The Entomology of Radiation Disinfestation of Grain". Cornwell, P.B., Ed. Oxford, Pergamon Press. 1966\*, 236p.

The lethal response of three stored products pests, T. confusum, O. surinamensis and S. granarius, to  $\gamma$ -radiation is modified by variations in dose rate in the range 1500-4700 rad/h; the higher the dose rate the greater the mortality and the lower the LD50. A similar response to radiation intensity is obtained in the level of sterility of O. surinamensis; no change in the level of sterility of S. granarius occurs within the range investigated. Comparison of the results with previous observations on S. granarius, irradiated at much higher dose rates, suggests a possible parabolic relationship between dose rate and LD50 (or SD50), modifications at low radiation intensities being attributable to processes of recovery and at high radiation intensities to depletion of oxygen. An optimum intensity for commercial disinfestation of grain by irradiation is suggested. The effect of dose rate is particularly marked at low radiation intensities normally used in laboratory investigations; to avoid modification of dose/response curves, the use of constant dose rates is preferable to constant time exposure. (Auth. summary)

\* Since the work reported in this volume was carried out by the Entomology Group of the Wantage Research Laboratory, U.K.A.E.A., during the period 1955-61, individual papers are included in the present bibliography although they were actually not published in book form until 1966.

- 873 Lee, W.R. PARTIAL BODY RADIATION OF QUEEN HONEYBEES. *J. Apic. Res.* 3, 2 (1964) 113-16.

Experiments were performed to develop methods of non-lethal irradiation of spermatheca or oögonia of a queen honey bee (*Apis mellifera*). Queens with abdominal segments III-V shielded survived otherwise lethal doses of radiation; irradiation of segments III-V, or whole-body irradiation, with 10 000 R killed all queens within 3 weeks. Protection of the regenerative cells of the ventriculus appeared necessary to prevent death of the queens. Lead shields for this purpose are described and illustrated. (BA 46: 1965, 82909)

- 874 Neharin, A., Calderon, M., Yacobi, O. SUSCEPTIBILITY OF *Callosobruchus maculatus* TO HIGH DOSE RATE GAMMA IRRADIATION. A Preliminary Study. IA-1010, Israel Atomic Energy Commission, Soreq Research Establishment, Rehovoth. Jan. 1965, 11p.

*C. maculatus* in various stages of development was irradiated at high dose rates with a  $^{60}\text{Co}$   $\gamma$ -source. High radiosensitivity was found, the most sensitive stage being the eggs, where 50% and 100% mortality were produced by 1000 and 3000 rad respectively. A mixed population of adults of both sexes was completely sterilized by a dose of 10 000 rad. Eggs were laid but they were not viable. The high radiosensitivity observed is attributed to the high dose rates used. (Auth.)

- 875<sup>(2)</sup> Rinehart, R.R., Valencia, R.M., Valencia, J.I. COMPARATIVE LETHAL RATES FROM X-IRRADIATED *D. melanogaster* MALES AND FEMALES MATED TOGETHER OR TO UNIRRADIATED PARTNERS. *Drosoph. Inf. Serv.* 38 (1963) 71-2.

- 876 Sonnenblick, B.P., Rockford, D. MORTALITY AND LIFE SPAN OF *D. melanogaster* (A WILD-TYPE AND A MUTANT STRAIN WITH A RING-X CHROMOSOME) EXPOSED AS YOUNG ADULTS TO X-RAYS OR TO HIGH DOSES OF COBALT-60 GAMMA-RAYS. *Drosoph. Inf. Serv.* 39 (1964) 113-4.

- 877<sup>(2)</sup> Szyszko, E., Wozniak, J., Malesa, J. EFFECTS OF IONIZING RADIATION ON PESTS IN CEREALS. II. EFFECTS OF COBALT-60 RADIATION ON *Tyroglyphus farinae* MITES. *Roczn. państ. Zakł. Hig.* 13, 5 (1962) 493-501. (In Polish)

After finding a stimulating action of small doses ( $5 \times 10^2$  -  $1.5 \times 10^4$  R) of x-ray radiation on the vitality of *T. farinae*, further studies on the effects of radiation from Co source on the same mites were carried out. The mites were put, together with feed, in vessels of special construction; after 3-5 d of acclimatization, one group of vessels was irradiated from a  $^{60}\text{Co}$  source. Observations of irradiated and non-irradiated mites were extended to 30-40 d. Doses of  $1.8 - 2 \times 10^4$  R were lethal to mites,  $1.4 - 1.6 \times 10^4$  R inhibited reproductive ability, and  $1.2 \times 10^4$  R destroyed eggs of the insects. Natural sources of radiation are much better than x-rays for practical application in mite control. (From CA 62: 1965, 13788g)

- 878 Ulrich, H., Würzler, F.E. GENETISCHE UND NICHTGENETISCHE STRAHLENEFFEKTE IN *Drosophila*-EIERN. (Genetic and non-genetic radiation effects on *Drosophila* eggs). *Zool. Anz., Suppl.* 27 (1964) 602-6. (In German)

The linear dose-effect curve obtained after 3 min exposures of 10-20-min-old eggs has been found to consist of various curves of different gradients and shapes which arise from nuclear division of the individual stages contained in eggs laid in a 10-min period. Embryonic mortality due to radiation must be broken down into at least early and late embryonic mortality. The straight-line dose-effect curve may therefore be broken down into non-linear curves in terms of the inhomogeneity of the irradiated egg batch laid over a period of 10 min and of the effects observed. The hypothesis according to which post-irradiation mortality of *Drosophila* eggs is due mainly to chromosome breaks and their effects must therefore be expanded to allow for other contributing radiation effects which are not of a chromosomal nature.

- 879 Upadhyaya, M.D., Brewbaker, J.L., Macion, E.A. EFFECT OF GAMMA IRRADIATION ON MANGO SEED WEEVIL (*Sternoderus mangiferae*) (Fabricius). p. 39-46 of "Dosimetry, Tolerance, and Shelf Life Extension Related to Disinfestation of Fruit and Vegetables by Gamma Irradiation". Annual Report, June 1, 1964 - May 31, 1965. UH-235P5-1, Hawaii Univ., Honolulu, Coll. of Tropical Agriculture. Jun. 1965, 78p.

Studies were conducted to determine the dose of  $\gamma$ -radiation necessary to completely kill seed weevils in mango fruits and the effects of these doses on the fruit. Preliminary results on two

mango varieties indicated that the effective killing dose for seed weevils was between 30 and 60 krad. Fruits of some varieties were damaged at above 60 krad. (NSA 20: 1966, 18298)

- 880 Vereecke, A., Pelerents, C. THE INFLUENCE OF GAMMA RAYS ON THE LONGEVITY OF Tribolium confusum Duval. For abstract, see 881. Presented at the "17th International Symposium on Crop Protection Rijkslandbouwhogeschool, Gent, Belgium, 4 May, 1965". \*

\* Pesticide Prog. 4, 1 (1966) 19. Abstr.

- 881 Vereecke, A., Pelerents, C. DE INVLOED VAN GAMMASTRALEN OP DE LEVENSDUUR VAN Tribolium confusum Duval. (The influence of gamma rays on the longevity of Tribolium confusum Duval). Meded. LandbHoogesch. OpzoekSms Gent 30, 3 (1965) 1824-35. (In Flemish, with English, French, and German summaries)

The applied doses ranged from 1000 - 60 000 rad. The mean life span and the survival curve are mentioned. Three groups of doses can be distinguished in terms of mortality rate. A dose of 40 000 rad is sufficient for direct control by  $\gamma$ -irradiation.

See also:

- 16 The effect of tritiated thymidine and gamma irradiation on the mortality of adult Drosophila melanogaster. (Kent, E., 1965)
- 17 } The effect of tritiated thymidine and gamma irradiation on the mortality of Drosophila
- 18 } melanogaster larvae. (Kent, E., 1964)
- 641 Susceptibility of the saw-toothed grain beetle, Oryzaephilus surinamensis (L.), to gamma radiation. (Jefferies, D. J., 1966)
- 647 Lethal and sterilising effects of cobalt-60 gamma rays on Argyroploce leucotreta. (Myburgh, A. C., 1963)
- 653 Susceptibility of Australian strains of Sitophilus and Tribolium species to gamma radiation. (Shipp, E., 1966)
- 658 Induced sterility of adult Diatraea saccharalis (Fab.) by gamma irradiation. (Walker, D. W. et al., 1964)
- 783 The effects of x-rays on the meal worm, Tenebrio molitor, embryo. (Po-Chedley, D. S., 1965)
- 807 Effect of gamma rays on immature stages of the Mexican fruit fly. (Benschoter, C. A., Telich, J., 1964)
- 811 Susceptibility of the grain and rice weevils, Sitophilus granarius (L.) and Sitophilus zeamais Mots. to gamma radiation. (Cornwell, P. B., 1966)
- 838 Irradiation effects on spermatogenesis in the gypsy moth, Porthetria dispar (L.). (Rule, H. D. et al., 1965)
- 843 The effects of gamma radiation on the biology and behavior of forest insects and the possibility of their control. (Stark, R. W., Wood, D. L., 1964)
- 846 Irradiation studies with insects infesting bulk-grain and packaged commodities. (Tilton, E. W., Brower, J. H., 1965)
- 861 Effects of gamma rays on mortality, longevity and fecundity of some species of fruit flies. (Narayana, E. S. et al., 1963)
- 883 The effect of culture environment on the susceptibility of Sitophilus granarius (L.) to gamma radiation. (Bull, J. O., Cornwell, P. B., 1966)
- 884 Analysis of the dependence of the protective action of hypoxia on the radiation dose. (Bychkovskaya, I. B., Ochinskaya, G. K., 1964)
- 885 Oxygen effect in x- and gamma-irradiation of grain weevils. (Bychkovskaya, I. B., Ochinskaya, G. K., 1964)
- 887 A comparison of the susceptibility of the grain weevil Sitophilus granarius (L.) to accelerated electrons and  $^{60}\text{Co}$  gamma radiation. (Bull, J. O., Cornwell, P. B., 1966)
- 892 Influence of pathogens on the life span of irradiated insects. (Jaffri, R. H., 1965)
- 899 The influence of temperature upon the radiation susceptibility of Sitophilus granarius (L.). (Pendlebury, J. B., 1966)
- 900 The effect of rearing medium on the susceptibility of Tribolium confusum Duv. and Sitophilus granarius (L.) to gamma radiation. (Shipp, E., 1966)

- 1001 Control of weevil populations (*Sitophilus granarius* (L.)) with sterilizing and substerilizing doses of gamma radiation. (Cornwell, P. B. et al., 1966)
- 1002 USDA research program and facilities for the use of gamma irradiation in the control of stored-product insects. (Laudani, H. et al., 1965)
- 1009 The possibility of using the  $^{60}\text{Co}$  radioisotope against grain storage insects. (Blazek, H. et al., 1964)
- 1010 The entomology of radiation disinfestation of grain. (Cornwell, 1966)
- 1013 Radiation treatment of grain and grain products. (Henderson, L. P., 1964)
- 1014 Effects of continuous and fractionated doses of gamma radiation on the survival and fertility of *Sitophilus granarius* (L.). (Jefferies, D. J., 1966)
- 1015 Post-harvest sterilization of oranges against Queensland fruit fly. (Leggo, D. et al., 1964)
- 1018 Dosimetry, tolerance, and shelf life extension related to disinfestation of fruits and vegetables by gamma irradiation. (Ross, E., Brewbaker, J. L., 1965)
- 1019 Disinfestation of dried fruits. (Shchegoleva, G. I., 1963)
- 1031 The killing of silkworm pupae and the preservation of silkworm cocoons by gamma rays. (Kipiani, R. Ya., Tsetskhladze, T. V., 1957)
- 1032 (Molnar, I. et al., 1962)
- 1033 A study of silk cocoons from the eggs of *Bombyx mori* L. irradiated with  $\text{Co}^{60}$ . (Molnar, I. et al., 1964)
- 1035 Differential effect of gamma radiation on fruit flies and fruit fly parasites. (Balock, J. W., 1965)

### 8. Modifying Factors

(Intensity. RBE. LET. Temperature. Synergists.  
Chemicals including Protective Agents.  
Environment at Irradiation. Medium. Pathogens. Etc.)

- 882 Baxter, R. C. RADIOBIOLOGIC STUDIES WITH *Drosophila*. p. 25 of "Research and Development in Progress. Biology and Medicine. No. 3". Abstr. TID-4203, Division of Technical Information Extension, (AEC), Oak Ridge, Tenn. Apr. 1964, 290p.

- 883 Bull, J. O., Cornwell, P. B. THE EFFECT OF CULTURE ENVIRONMENT ON THE SUSCEPTIBILITY OF *Sitophilus granarius* (L.) TO GAMMA RADIATION.\* p. 57-69 of "The Entomology of Radiation Disinfestation of Grain". Cornwell, P. B., Ed. Oxford, Pergamon Press. 1966. \*\* 236p.

An examination is made of the effects of eight culture densities and two post-irradiation treatments on the susceptibility of adult grain weevils to  $\gamma$ -radiation from  $^{60}\text{Co}$ . The lethal effect of  $\gamma$ -radiation is increased by culture densities which cause a substantial rise in metabolic temperature above  $26^\circ\text{C}$  during larval development. Densely crowded cultures in which temperatures during growth and maturation of larvae do not rise appreciably above  $26^\circ\text{C}$  fail to modify the adult's lethal response. Temperature fluctuations up to  $36^\circ\text{C}$  during development do not modify the susceptibility of the adult to radiation sterilization. Accordingly, the efficacy of 16 000 rad evaluated for the control of grain weevils is unlikely to be reduced by population densities normally encountered in commercial storage. (Auth.)

\* For an earlier report, AERE-R-3893, see II/1080.

\*\* Since the work reported in this volume was carried out by the Entomology Group of the Wantage Research Laboratory, U. K. A. E. A., during the period 1955-61, individual papers are included in the present bibliography although they were actually not published in book form until 1966.

- 884 Bychkovskaya, I. B., Ochinskaya, G. K. ANALYSIS OF THE DEPENDENCE OF THE PROTECTIVE ACTION OF HYPOXIA ON THE RADIATION DOSE. *Radiobiologiya* 4, 2 (1964) 203-9. (In Russian). English Translation: AEC-tr-6405. *Radiobiology* 4, 2 (1964) 29-37.

Grain weevils (*Calandra granaria*) were x-irradiated in a 2%  $\text{O}$  atmosphere (controls in the usual, 20%,  $\text{O}$  concentration) at 500 R/min with doses of 1 - 150 kR. Survival data, presented in tabular form, indicated that under ordinary  $\text{O}$  conditions, doses of 1 - 3.5 kR are not lethal at 50 d. Lethality increased with dose, to 100% at 8 kR. Length of life was dose-dependent up to 35 kR, averaging 20 d with 5 - 35 kR, decreasing to 14 d at 40 - 70 kR, and to about 10 d at 75 - 150 kR. Under

hypoxia conditions, 100% lethality at 50 d did not occur until the dose reached 13 kR, lifetimes averaged 30 d with from 9- to 50-kR doses, about 13 d with 55- to 80-kR, and about 10 d with 85- to 150-kR. The effects of hypoxia in decreasing the irradiation damage are presented as the ratio of doses, with an 8 kR dose under hypoxia conditions corresponding to 3.5 kR under ordinary conditions, or a ratio of 2.28. The ratio gradually decreased to 1.14 (85/75) at the higher levels. (NSA 18:1964, 31296)

- 885 Bychkovskaya, I. B., Ochinskaya, G. K. OXYGEN EFFECT IN x- AND GAMMA-IRRADIATION OF GRAIN WEEVILS. Radiobiologiya 4 (1964) 928-9. (In Russian)

x- and  $\gamma$ -irradiation of grain weevils (Calandra granaria) in the presence of a normal amount of  $O_2$  resulted in almost the same mortality. In the absence of  $O_2$ , mortality was lower for both, the decrease being greater for  $\gamma$ -irradiation.

- 886 Bychkovskaya, I. B., Ochinskaya, G. K. ABSENCE OF "OXYGEN AFTER-EFFECTS" IN Calandra granaria DURING HIBERNATION INDUCED WITH LOW TEMPERATURE. Radiobiologiya 5 (1965) 700-2. (In Russian)

The insects (C. granaria) were irradiated in special vacuum tubes at x-ray doses of 5, 6, 7, 8, 9, and 10 kR at a temperature of 1-5°C. The insects were held at a lowered temperature after irradiation for periods varying from 30 min - 12 d. The  $O_2$  concentration was varied from 20 - 2% during and after irradiation. The survival at 60 d and the average lifetime of the irradiated insects were taken as criteria of radiation damage. On maintaining conditions of hypoxia during and after irradiation, a definite protective effect was observed. On creating conditions of hypoxia from the moment that the weevils had been warmed up to room temperature, no protective effect could be observed. Thus, no oxygen after-effect could be detected by maintaining the weevils at low temperatures. (NSA 20:1966, 5385)

- 887 Bull, J. O., Cornwell, P. B. A COMPARISON OF THE SUSCEPTIBILITY OF THE GRAIN WEEVIL Sitophilus granarius (L.) TO ACCELERATED ELECTRONS AND  $^{60}Co$  GAMMA RADIATION.\* p.157-75 of "Entomology of Radiation Disinfestation of Grain". Cornwell, P. B., Ed. Oxford, Pergamon Press, 1966, 306 236p.

No difference could be detected in the numbers of emerged adults, rate of emergence or stage at death in the grain when two types of infested wheat, containing mostly pupae, were treated with  $\gamma$ -radiation and accelerated electrons. Electron irradiation was carried out with a 4 MeV linear accelerator, giving 4 rad/pulse each lasting 2.5  $\mu$ s and separated by 1660  $\mu$ s. The difference in dose for 99.9% mortality and sterility with the two radiations was ~5000 rad. Mature adults were more susceptible to killing and sterilization by  $\gamma$ -irradiation. Possible explanations of the observed results are discussed. There is little likelihood of grain weevils providing a useful biological dosimeter in engineering studies for radiation disinfestation of grain. Adults provide more accurate estimates than pupae.

- 888 Erdman, H. E. MODIFICATIONS OF PRODUCTIVITY IN FLOUR BEETLES, Tribolium castaneum Herbst, DUE TO x-RAY DOSE, HYPOTHERMIA AND THE SEX EXPOSED. Radiat. Res. 25 (1965) 341-51.

Day-old virgin flour beetles, T. castaneum, were x-irradiated with 0, 500, 1000, 2000, or 4000 R. Ten replicates each of control, male-exposed, female-exposed, and both-exposed mating combinations were established at 25°C, 29°C, and 32°C in 65 to 70% relative humidity. Daily for 2 weeks each pair was given 5 g of acclimated food. The day of reproductive onset, the number of fertile pairs, and the number of  $F_1$  adults were used as measures of productivity. Data are summarized and the modifications of the three parameters investigated for productivity are discussed from the standpoints of temperature effects and dose effects on the degree of development and differentiation of male and female germ cells. The dose-response curves were the multihit type, implicating chromosomal aberrations as the cause of altered productivity. (Auth.)

- 889<sup>(\*)</sup> Giavelli, S., Parazzi, E. EFFECT OF LOW TEMPERATURE ON RADIOSENSITIVITY OF Drosophila PUPAE. Int. J. Radiat. Biol. 7, 5 (1963) 465-71.

To study the differential radiosensitivity of male germ cells and whether this is due to different metabolic conditions of the flies, 24- and 48-h-old pupae of D. melanogaster were irradiated with



220 kV x-rays with a dose of 600 R at 0° and 25°C. Soon after emergence each male was mated to three M-5 virgin females, then transferred into a new vial with three virgin females every day for 10 d, to permit study of the radiation damage induced in germ cells irradiated at different periods of gametogenesis. The number of progeny of these matings and the recessive sex-linked lethal mutations were scored. A lower number of progeny was found in the broods of the experiments at 0 than at 25°C. No difference was observed in the mutation frequency induced by the treatments of 24- and 48-h-old pupae. With low temperature no difference appeared in the sensitivity pattern of pupae of different age. No evidence was found that different physiological conditions of pupae at different age may determine a different radiosensitivity. The effect of low-temperature treatment is discussed. (Auth.)

- 890(2) Jafri, R. H. SYNERGISTIC ACTION OF RADIATION AND OF Bacillus thuringiensis TOXIN ON PROTOZOAN DISEASES OF INSECTS. Int. Congr. Protozool. (1963) 510-15. (1st International Congress on Protozoology).

- 891 Jafri, R. H. INFLUENCE OF PATHOGENS ON THE LIFE SPAN OF IRRADIATED INSECTS. Revue Path. vég. Ent. agric. Fr. 43, 1 (1964) 37-41.

Experiments are reported on the effects of irradiation with x-rays, alone or in conjunction with infection with pathogenic Protozoa or bacteria, on the adults of Tribolium castaneum (Hbst.) and T. confusum Duv. and on the larvae of Galleria mellonella (L.). In the first series of tests, Galleria larvae were exposed to radiation doses of 1000 or 90 000 R. After the lower dose, slow dehydration took place; after the higher one, the larvae writhed as if burnt and, in spite of apparent recovery later, died within a few days, mid-gut microflora being found loose in the body cavity after death. In the second series, males and females of T. castaneum, some infected with Farinocystis tribolii, were exposed to doses of 1000-90 000 R. The subsequent life spans of the treated beetles were 10-40 and 1-45 d for infected males and females, respectively, and 15-115 and 1-115 d for uninfected ones and varied approximately according to the dose received except that, in the case of non-infected adults, doses of 30 000 and 50 000 R gave almost identical results. In the third series, healthy adults of T. confusum were irradiated in the same way and were then transferred immediately or after 24 or 144 h to flour contaminated with spores of Bacillus thuringiensis. Susceptibility to the bacterium was increased by irradiation at all doses, especially in beetles given non-lethal doses up to 10 000 R and fed 144 h later. The combination of F. tribolii and x-rays resulted in a more rapid mortality than did irradiation alone, since both caused consumption of the fat-body reserves. x-rays and B. thuringiensis both tended to break down the wall of the mid-gut, releasing the normal mid-gut bacteria into the body cavity. The usefulness of combined treatments for the control of stored-product pests not easily accessible to predators is discussed. (RAE-A 53: 1965, 8)

- 892 Jafri, R. H. INFLUENCE OF PATHOGENS ON THE LIFE SPAN OF IRRADIATED INSECTS. J. invertebrate Path. 7 (1965) 66-70.

Survival of flour beetles after exposure to x-radiation and infection with some of their natural pathogenic bacteria was investigated. The beetles infected by Adelina tribolii were more susceptible to Bacillus thuringiensis infection than were uninfected beetles. T. castaneum adults infected with Farinocystis tribolii were more radiosensitive to 1000, 10 000, 30 000, 50 000, and 90 000 R doses of x-rays than non-infected ones. The beetles receiving B. thuringiensis and having F. tribolii infection were much more damaged by sublethal and lethal doses of ionizing radiation. When T. confusum beetles received B. thuringiensis following exposure to sublethal and lethal doses of x-rays their life span was shortened to a week or at the most to two weeks. Neither sex showed any significant increased or decreased susceptibility when they received B. thuringiensis immediately and after an interval of 24 and 144 h following exposure to sublethal and lethal doses of x-rays. Ionizing radiation appears to act in the same way as B. thuringiensis, disintegrating the gut tissues and enabling the transgression of midgut bacteria into the body cavity of the host. (NSA 19: 1965, 45909)

- 893 Jafri, R. H. PROSPECTS OF INTEGRATED RADIATION AND MICROBIAL CONTROL OF HARMFUL INSECTS. p. 747-48 of "Proceedings of the 12th International Congress of Entomology, London, 8-18 Jul. 1964". Freeman, P., Ed. London, Royal Entomological Society of London. 1965.

In nature some insects appear to be so abundant that the use of sterile male technique may not be feasible without first processing the geographically isolated and non-isolated infested area with other control measures to bring wild population within reach. Such a situation can be tackled from two angles. Firstly, the population may be controlled by means of well tried viruses, bacteria and suitable protozoan such as Microsporidian and Coccidian parasites. Secondly, the release of sterile male insects carrying parasites or pathogens, in order to contaminate the environment and destroy the progeny, has the potential future. A new approach in the form of susceptibility of irradiated insects to pathogens is opening a new field of investigation. The life span of Tribolium castaneum and T. confusum beetles was shortened considerably when the test insects received Bacillus thuringiensis immediately and after an interval of 24 and 144 h following exposure to 1000 R, 10 000 R, 30 000 R, 50 000 R and 90 000 R doses of x-rays, respectively. The life span of the irradiated beetles was somewhat shortened by the presence of Farinocystis tribolii, Nosema whitei and Adelina tribolii protozoan parasites in the fat-body of the test insects.\* (From abstr.)

\* see Ref. 892

- 894 Krebs, A. T., Benson, B. W. ELECTRON SPIN RESONANCES IN Formicidae. Nature, Lond. 207 (1965) 1412-13.

Investigations on the effects of ionizing radiation on survival and behaviour of ants were extended into the field of microwave spectroscopy. The electron spin resonance spectra were recorded for 6 species of ants Lasius umbratus (Nyl.), Tetramorium caespitum (L.), Formica exsectoides Forel., Formica fusca L., Camponotus castaneus (Latr.), and Pogonomyrmex occidentalis (Cress). One species was examined for changes in the signal after exposure to  $\gamma$ -radiation and another for changes after annealing. Irradiation caused an increase in height of the signal, followed by a slow decay with time after irradiation. Annealing, however, completely depressed the 6-peak signal and enhanced the free radical region signal.

- 895 Levengood, W. C. FACTORS INFLUENCING BIOMAGNETIC ENVIRONMENTS DURING THE SOLAR CYCLE. Nature, Lond. 205 (1965) 465-70.

The results are presented of a study of the variation of the reproductive response of Drosophila melanogaster, when grown in magnetic fields, with solar activity. The flies were grown in culture bottles placed on the opposite poles of permanent magnets. The effects of cosmic radiation, solar flare activity, barometric pressure, and the outer Van Allen Radiation Belt on progeny yields were studied. Possible mechanisms for the observed trends are considered. (NS 19; 1965, 15136)

- 896 Masera, E. TRATTAMENTO CON I RAGGI X DELLE UOVA DI Bombyx mori L. PARASITATE DA Nosema bombycis Naeg. (The treatment with x-rays of eggs of Bombyx mori L. parasitized by Nosema bombycis Naeg). Agricoltura Venezia 19, 2 (1965) 55-66. (In Italian)

- 897 May, R. M., Maria, M., Guimard, J. ACTION DIFFERENTIELLE DES RAYONS X ET ULTRA-VIOLETS SUR LE TARDIGRADE Macrobiotus areolatus A L'ETAT ACTIF ET DESSECHE. Bull. biol. Fr. Belg. 98, 2 (1964) 349-67.

Les auteurs ont isolé de nombreux individus de Tardigrades de l'espèce Macrobiotus areolatus vivant dans les Mousses et ils ont mis des lots en état de dessiccation artificielle, d'autres lots étant maintenus vivants. Les Macrobiototes desséchés, en état de vie latente, sont résistants aux rayons X avec 300 000 R, puisque le pourcentage de reviviscents est le même que celui des témoins non irradiés. La dose létale 50% est de 570 000 R un jour après l'irradiation, et une dose de 1 200 000 R inhibe complètement la reviviscence de tous les Macrobiototes exposés. Les animaux qui ne peuvent passer à l'état de vie active entrent dans l'état asphyxique. Lors des expériences d'élevage, le temps de survie des animaux desséchés irradiés à des doses de 300 000 R, 400 000 R, 600 000 R et 700 000 R puis reviviscents, est fortement raccourci par rapport à celui des animaux témoins; les animaux irradiés à des doses de 800 000 R, 900 000 R et 1 000 000 R à l'état desséché succombent au 5<sup>e</sup> jour. Les Macrobiototes en état de vie active sont tout d'abord aussi résistants à des doses de 200 000 R que des témoins non irradiés. La dose létale 50% est de 540 000 R (2 h après l'irradiation). Une dose de 1 200 000 R tue tous les Macrobiototes dans ce même temps. Les animaux morts présentent l'aspect asphyxique ici aussi. Lors des expériences d'élevage, le temps de survie

des Macrobiotes actifs irradiés à des doses de 200 000 R est raccourci par rapport à la survie des témoins; les animaux irradiés à 900 000 R ne survivent pas au-delà du 4<sup>e</sup> jour, ceux irradiés à 800 000 R succombent le 8<sup>e</sup> jour, et ceux irradiés à 600 000 R succombent le 26<sup>e</sup> jour. Les animaux mis en état de vie latente, après une irradiation, ne peuvent revivre à partir d'une dose de 300 000 R.

- 898<sup>(2)</sup> Murakami, A., Kondo, S. RELATIVE BIOLOGICAL EFFECTIVENESS OF 14.1 MeV FAST NEUTRONS IN KILLING DORMANT SILKWORM EGGS. Rep. nat. Inst. Genet., Misima 14 (1963) 106-7.

Although the lethal effects of low ion density radiations, such as x- or  $\gamma$ -rays, upon silkworm eggs have been studied by many investigators, little is known about the effects of high ion density radiations. A study of RBE in mutation induction by high energy neutrons in dormant silkworm eggs was made. In these experiments the biological effectiveness of 14.1-MeV neutrons was compared with that of  $\gamma$ -radiation as concerns their killing effects on silkworm eggs in dormancy. The exposure to 14.1-MeV neutrons was conducted with the Cockcroft-Walton accelerator. Dormant silkworm eggs were exposed to neutron beams at a distance of 6.3 cm from the tritium target for a variable length of time, from 60 - 180 min. The neutron dose-rate was 5 rad/min and the total doses given were 500, 1000, and 1500 rad. In parallel to this, <sup>137</sup>Cs  $\gamma$ -ray treatment was carried out on the same material. The  $\gamma$ -ray doses were 500, 1000, 3000, and 5000 R at a dose rate of 100 R/min. The percentages of hatchability were plotted against doses given on semilogarithmic scale both for fast neutrons and  $\gamma$ -rays. The hatchability curve after exposure to 14.1-MeV neutrons declined more rapidly than that for <sup>137</sup>Cs  $\gamma$ -rays. The calculated doses that allow 50% hatchability LD50 were 800 rad and 2000 rad for 14.1-MeV neutrons and <sup>137</sup>Cs  $\gamma$ -rays, respectively. Thus 14.1-MeV neutrons are more effective than <sup>137</sup>Cs  $\gamma$ -radiation with regard to their killing action. The RBE thus calculated was 3.3. (NSA 20: 1966, 72)

- 899 Pendlebury, J.B. THE INFLUENCE OF TEMPERATURE UPON THE RADIATION SUSCEPTIBILITY OF Sitophilus granarius (L.).\* p. 27-40 of "Entomology of Radiation Disinfestation of Grain". Cornwell, P.B., Ed. Oxford, Pergamon Press, 1966, \*\* 236p.

Previous studies on the susceptibility of adult grain weevils to  $\gamma$ -radiation have been carried out at an optimal temperature for the species. The experiment described examines the lethal and sterilizing response of adult S. granarius to high and low temperatures, (30° and 15°C) before, during and after irradiation. These are near the limiting temperatures for oviposition and close to the extremes likely to be encountered in commercial practice. Rate of death was considerably increased by high temperature after irradiation. High temperature before irradiation resulted in a slight increase in lethality at doses between 3000 and 10 000 rad when compared with similar batches held at the lower temperature. During irradiation, the influence of temperature was reversed and insects irradiated at 15°C subsequently showed a greater mortality than those irradiated at 30°C. Susceptibility to radiation sterilization was unchanged. The minimum dose of 16 000 rad evaluated for control of grain weevils would thus be effective at all temperatures likely to be encountered in commercial practice. (Auth.)

\* For an earlier report, AERE-R-3641, see H/1103.

\*\* Since the work reported in this volume was carried out by the Entomology Group of the Wantage Research Laboratory, U.K.A.E.A., during the period 1955-61, individual papers are included in the present bibliography although they were actually not published in book form until 1966.

- 900 Shipp, E. THE EFFECT OF REARING MEDIUM ON THE SUSCEPTIBILITY OF Tribolium confusum Duv. AND Sitophilus granarius (L.) TO GAMMA RADIATION. p. 97-105 of "The Entomology of Radiation Disinfestation of Grain". Cornwell, P.B., Ed. Oxford, Pergamon Press, 1966, \* 236p.

Rate of development of T. confusum Duv. and the yield of adults on different milling fractions is influenced by the chemical composition of the cereal medium. Rapidly developing flour beetles are more susceptible to killing by  $\gamma$ -radiation when measured at 21 d; the period before latent radiation damage culminated in death is also shortened. Susceptibility at 28 d is not modified by rearing medium. Rate of development of S. granarius (L.) on different whole cereals and the yield of adults appear not to be directly correlated with chemical composition; they are more probably influenced by physical factors such as grain size. Weevils reared on different grains show

differences in susceptibility to  $\gamma$ -radiation at the LD50 which cannot be correlated with any of the experimental indices considered. (Auth.)

\* Since the work reported in this volume was carried out by the Entomology Group of the Wantage Research Laboratory, U.K.A.E.A., during the period 1955-61, individual papers are included in the present bibliography although they were actually not published in book form until 1966.

- 901 Slater, J.V., Yu, M.E., Tobias, C.A. OXYGEN DEPENDENCE FOR RADIATION SENSITIVITY DURING DEVELOPMENT IN INSECTS. Radiat. Res. 22, 1 (1964) 236. Abstr. 189.

As with most biological materials, the absence of oxygen during irradiation has been found to result in a considerable protective effect in developing Tribolium where the percentage of wing abnormalities is reduced. Nearly 3 times as much x-irradiation is required to produce the same effect in the absence of oxygen as when this gas is present. These studies were all done at 30°C. Studies on the effect of oxygen concentration have shown that 5% O<sub>2</sub> mixed with 95% N<sub>2</sub> results in half-maximal damage at 1500 R. When pupae are placed in 1.3 atm of pure O<sub>2</sub> for only a few seconds, the adults upon eclosion exhibit the same kinds of wing abnormalities which appear after x-irradiation in this organism except that missing antennae and limbs and burnt-off appearing limb stumps also result. Although radiation damage can be observed in Tribolium after exposure of the pupae to 1000 and 1200 R in air, post-irradiation exposure to N<sub>2</sub> at these dose levels appears to have no effect. At 1500 R, however, radiation damage is increased by nearly 20% when N<sub>2</sub> is passed through the exposure chamber containing pupae in the sensitive phase immediately after irradiation. (Abstr.)

- 902 Slater, J.V., Lyman, J., Tobias, C.A., Amer, N.M., Beck, J.S., Beck, M., Slater, A.J. HEAVY ION LOCALIZATION OF SENSITIVE EMBRYONIC SITES IN Tribolium. Radiat. Res. 21 (1964) 541-9.

The Berkeley heavy ion linear accelerator was used in probing for the embryonic sensitive sites responsible for wing morphogenesis and differentiation in Tribolium confusum Duv. The  $\alpha$ -beam was used because of the necessary range desired in most instances. In some experiments, neon ions were used, however, to evaluate the dose effect at significant depths which were quite shallow (~200  $\mu$ m). Neon was especially useful for determining the comparative intensities of these sites because of the sharp Bragg peak exhibiting little or no straggling. The existence of two shallow and equivalent sensitive sites for wing differentiation and development were indicated. The developmental interval during which radiation must be applied to give the bulk of malformation incidence is restricted to a very short time interval. A hypothesis has been advanced that the primary intracellular effect of radiation in the embryo is the induction of somatic chromosome aberrations resulting in cell lethal action prior to or during mitosis.

- 903 Tilton, E.W., Burkholder, W.E., Cogburn, R.R. NOTES ON THE EFFECT OF PRECONDITIONING CONFUSED FLOUR BEETLES WITH TEMPERATURE VARIATIONS OR CARBON DIOXIDE PRIOR TO GAMMA IRRADIATION. J. econ. Ent. 58, 1 (1965) 179-80.

The effects of temperature and CO<sub>2</sub> on the susceptibility of Tribolium confusum Duv. to  $\gamma$ -radiation were investigated in the laboratory. Pupae were isolated individually in gelatin capsules with sufficient food to sustain the adult for a week. When the adults were 7 to 9 d old, some were kept at 50-55 or 104°F for 24 h or anaesthetized with CO<sub>2</sub> for 30 min and treated 1 h later with a dose of 17500 rad of  $\gamma$ -radiation from a <sup>60</sup>Co-source; others were irradiated without special conditioning. They were then kept at 80°F and 50% relative humidity for 42 d. None of the preconditioning treatments had any significant effect on the mortality of the beetles, all of which were dead or moribund in 14 d and dead in 28 d. (RAE-A 53: 1965, 247)

- 904 Tilton, E.W., Burkholder, W.E., Cogburn, R.R. THE EFFECTS OF CONFINING CONFUSED FLOUR BEETLES IN GELATIN CAPSULES BEFORE, DURING, AND AFTER GAMMA IRRADIATION. J. econ. Ent. 58, 1 (1965) 175-6.

In preliminary experiments with  $\gamma$ -irradiated and untreated larvae, pupae and adults of Tribolium confusum Duv. that were reared individually in gelatin capsules on a medium consisting of equal parts of wheat flour and rice bran with 0.5% yeast at 80°F and 50% relative humidity, there were

no significant differences in mortality or rate of development between those kept in sealed and those kept in open capsules. (RAE-A 53:1965,246)

See also:

- 16 The effect of tritiated thymidine and gamma irradiation on the mortality of adult Drosophila melanogaster. (Kent, E., 1965)
- 17 } The effect of tritiated thymidine and gamma irradiation on the mortality of Drosophila
- 18 } melanogaster larvae. (Kent, E., 1964)
- 797 Survival of isolated embryonic heart fragments following treatment with some radiation protecting chemicals. (Larsen, W., 1964)
- 798 The effects of x irradiation on the embryos of invertebrate embryos. (Larsen, W., 1965)
- 799 Influence of radiation on ovarian maturation and histolysis of pupal fat body in Diptera. (Monro, J., Bailey, P.T., 1965)
- 802 Analysis, by means of x- and u.v.-irradiation, of the course of differentiation in the insect egg (Gryllus). (Seidel, F., 1964)
- 806 Dose fractionation and recovery from x rays in Rhodnius. (Baldwin, W.F., Shaver, E.L., 1964)
- 814 Differential responses of germ cells in flour beetles, Tribolium castaneum Herbst, due to x-ray dose, hypothermia, sex exposed and age. (Erdmann, H.E., 1964)
- 815 x-ray and gamma ray irradiation of Mormoniella vitripennis. (Farrow, M.G., Ulrich, V., 1964)
- 860 Effect of beta irradiation on insects. (Menhinick, E.F., Dodson, G.J., 1965)
- 863 Radiation induced shortening of life of Sarcophaga peregrina and its modification by dose fractionation. (Sakka, M., 1965)
- 864 x-ray induced shortening of life span of adult Sarcophaga peregrina and its modification by dose fractionation. (Sakka, M., 1965)
- 872 The effect of dose rate on the response of Tribolium confusum Duv., Oryzaephilus surinamensis (L.) and Sitophilus granarius (L.) to <sup>60</sup>Co gamma radiation. (Jefferies, D.J., Banham, E.I., 1966)
- 873 Partial body radiation of queen honeybees. (Lee, W.R., 1964)
- 918 The establishment of Tribolium confusum Duv. populations after stress by parasitism and x-irradiation. (Dowell, F.H., 1964)
- 1014 Effects of continuous and fractionated doses of gamma radiation on the survival and fertility of Sitophilus granarius (L.). (Jefferies, D.J., 1966)

## C. RADIATION EFFECTS ON INSECT POPULATIONS

### 1. Behaviour

- 905 Baumhover, A.H. SEXUAL AGGRESSIVENESS OF MALE SCREW-WORM FLIES MEASURED BY EFFECT ON FEMALE MORTALITY. J. econ. Ent. 58, 3 (1965) 544-8.  
Harassing by males of Callitroga (Cochliomyia) hominivorax (Coquerel) accelerated the death of the females. The sexual activity of the males was measured by a sexual aggressiveness (SAG) test, based on the mortality of females exposed to a high ratio of males, a 1:3 ratio being arbitrarily selected as the standard. The fallacy of using data on male survival as an index of sexual vigour was demonstrated in SAG tests in which, although some sexually inactive males lived as long as active ones, their vigour was less. The SAG test showed that the sexual activity of males resulting from pupae that had been exposed when 5-d-old to doses of  $\gamma$ -radiation from <sup>60</sup>Co of 3000 - 12 000 R decreased as the dose increased, the percentage mortality at 13 d of the females exposed to these males decreasing from about 80 to about 33; the length of life of the males was only slightly reduced, even at the highest radiation dose. The activity of males irradiated as pupae 6- to 7-d-old was affected only slightly at the highest dose. Males of a strain from Florida (Fla) and of a mutant

strain with yellow eyes (y) reduced the survival of y females, but that of Fla females was not reduced by exposure to y males. Males from both strains fertilized about twice as many y as Fla females when females of both strains were present in excess (40:1). These studies indicated some of the factors that may influence SAG tests, and their bearing on the choice of a strain for use in attempts at field control by the release of irradiated males is discussed.

- 906 Brower, J. H. BEHAVIORAL CHANGES IN AN ANT COLONY EXPOSED TO CHRONIC GAMMA IRRADIATION. *Bull. ent. Soc. Am.* 11, 3 (1965) 158. Abstr. 82. Presented at the "Annual Meeting of the Entomological Society of America, New Orleans, 29 Nov.-2 Dec. 1965".

Changes in behaviour of a colony of *Formica integra* were investigated in an area experimentally exposed to chronic  $\gamma$ -radiation. The habits of the colony changed so that ants were no longer exposed to high radiation levels. Possible explanations are presented. (Abstr.)

- 907 Dame, D. A., Woodard, D. B., Ford, H. R., Weidhaas, D. E. FIELD BEHAVIOR OF SEXUALLY STERILE *Anopheles quadrimaculatus* MALES. *Mosquito News* 24 (1964) 6-14.

Males of *Anopheles quadrimaculatus* were sexually sterilized by three methods. In the first method, they were contact-sterilized by exposure to thio-TEPA. In the second method, males were sterilized by feeding for the first 3-4 d after emergence on 1% apholate in 20% honey solution. In the third method, males were radiosterilized. Pupae from 0-24 h old were exposed to 12000 R of  $\gamma$ -radiation from a  $^{60}\text{Co}$  source (660 R/min). After each treatment the insects were held under standard lab conditions prior to release as 1- to 4-d-old males. Through the concurrent release of sterile males and virgin females it was shown that sterilized males of the colonized strain *A. quadrimaculatus* were sexually vigorous and compatible with females in nature. Thus the sterile colony males were able to induce a high degree of sterility in colony females in the field, demonstrating that mating activity of these males was not seriously affected by either radiosterilization or chemo-sterilization. Although the sexual vigour of the colony male may be reduced by radiation, the results showed that when sufficient numbers of either radiosterilized or chemosterilized colony males were present in a population of their own kind, they could effectively reduce the fertility of the female. Although lab-reared wild males increased the natural sterility by 480, the inability of the colony males to induce sterility in the wild females of the natural population indicated that severe behavioural deficiencies existed in these males. These deficiencies were brought on ostensibly by the colonization process. It is speculated that other species which prove particularly difficult to colonize because of flight or mating behaviour may not be suitable for the sterile-male release approach to control. (NSA 19:1965, 24315)

- 908 Hungate, F. P. RADIATION AVOIDANCE RESPONSES IN ANIMALS. p. 9 of "Research and Development In Progress. Biology and Medicine. No. 3". Abstr. TID-4203, Division of Technical Information Extension, (AEC), Oak Ridge, Tenn. Apr. 1964, 290p.

- 909 Kapił, R. LES EFFETS DES DOSES NON-LETALES DE RAYONS X SUR LE COMPORTEMENT EXPLORATEUR ET ALIMENTAIRE DE LA LARVE DE *Drosophila melanogaster* Meig. NP-15559, Lyon Univ. (France). Faculté des Sciences. 1964, 48p. Thèse.

Les données sur le mouvement de la tête avec le mouvement vertical synchronisé des mandibules des larves de *D. melanogaster* expliquent que cette fonction liée à la prise de nourriture peut être mesurée. La fonction évolue de façon comparable pendant la période larvaire pour les deux races - sauvage et vestigial - de *D. melanogaster*. La fonction dépend de l'âge et varie rapidement jusqu'à ce que les larves soient âgées de 12 h. Après 24 h, elle devient linéaire et les changements sont faibles jusqu'à ce que la larve se prépare à entrer en pupaison. Les expériences sur les effets des rayons x (p. 23-33) montrent que la réponse des deux races est différente. L'inhibition maximum de la fonction est observée à 500 et 1500 R pour les larves de sauvage et vestigial respectivement. Pour les deux races, l'effet d'inhibition aux doses faibles est remplacé par un effet d'excitation aux doses plus fortes. La réponse de la fonction reste presque la même chez sauvage, que l'on irradie les larves âgées de 2 h ou les embryons de 10 h. Les auteurs n'ont pas trouvé d'effets retardés concernant le comportement étudié, avec les doses employées dans les présentes expériences. (Du résumé)

- 910 Kvelland, I. SOME OBSERVATIONS ON THE MATING ACTIVITY AND FERTILITY OF *Drosophila melanogaster* MALES. *Hereditas* 53, 3 (1965) 281-306.

Data are presented on mating and fertility patterns of 0- to 2-h-old males and of 3-d-old non-irradiated and irradiated males (given 2000 R x-rays at 145 R/min). The males showed a higher mating activity in the 1st h of a 12-h period than in any interval. The youngest males showed an increase in mating frequency from the 1st day of mating up to a male age of 7d, with subsequent decrease. The older males (first mating period in light) showed a sharp drop in mating frequency from the 1st-2nd day of mating, an increase to the 7th day, and thereafter a gradual decrease. The irradiated males showed a mating frequency of the first 3 d of mating similar to that found for the non-irradiated older males; on the following 7 d, however, the irradiated males showed a noticeably lower mating frequency than did the control males. Male productivity (in the young group) increased from the 1st - 3rd day of mating, but for the older males (in the older group) productivity decreased significantly from the 1st - 2nd day of mating. For both groups of males productivity decreased gradually after the 3rd day of mating. Individual males in all groups showed great variations in mating capacity, fertility, fecundity, and productivity.

- 911 Mason, H. C., Papageorgiou, M. C., Jacklin, S. W. MATING PREFERENCE AND REPRODUCTION OF IRRADIATED *Drosophila melanogaster*. *Bull. ent. Soc. Am.* 11, 3 (1965) 159. Abstr. 83. Presented at the "Annual Meeting of the Entomological Society of America, New Orleans, 29 Nov. - 2 Dec. 1965".

*D. melanogaster* males showed no mating preference between irradiated and normal females. Reproduction in populations was lowered more by introduction of irradiated males than irradiated females. When both irradiated males and females were introduced the suppression of reproduction was the same as when only irradiated males were used. (Abstr.)

- 912 Pelerents, C., Brande, J. van den SOME SUPPLEMENTARY DATA CONCERNING THE INFLUENCE OF  $\gamma$  RAYS ON WORKER BEES. *Bull. Inst. agron. Stns Rech. Gembloux* 31 (1963) 576-83. (In French)

The reactions of bees immediately after irradiation with doses of 40 000, 50 000, and 60 000 rad is to form swarms that separate only after 6 or 7 h. Higher doses produce an atony. The effects of  $\gamma$ -rays on the life span and on the consumption of candy were determined. Doses higher than 10 000 rad affect the construction of the combs. Doses below 15 000 rad do not affect the production of combs. (NSA 19:1965, 17528)

See also:

- 639 Gamma radiation and the reproductive behavior of male *Rhodnius prolixus*. (Gomez-Nunez, J. C. et al., 1964)  
829 The gamma irradiation of *Glossina* puparial stages and control. (Potts, W. H., 1965)  
839 The effect of x rays on adult *Hyalomma asiaticum*. Communication I. (Sidorov, V. E., Grokhovskaya, I. M., 1964)  
843 The effects of gamma radiation on the biology and behavior of forest insects and the possibility of their control. (Stark, R. W., Wood, D. L., 1964)  
958 Ecological changes in the insect community of a pitch pine-oak forest subjected to chronic gamma irradiation. (Brower, J. H., 1965)  
975 Cockchafer against cockchafer? An attempt at eradicating larvae of the field cockchafer *Meloidonthe vulgaris* Fabr. by means of x-rayed males. (Horber, E., 1963)

## 2. Population Dynamics

- 913 Bell, A. E. THE EFFECTS OF X-RADIATION ON PLATEAUED POPULATIONS OF *Tribolium castaneum* IN REGARDS TO REPRODUCTIVE FITNESS AND RESPONSE TO SELECTION. p. 128-29 of "Research and Development in Progress. Biology and Medicine. No. 3". Abstr. TID-4203, Division of Technical Information Extension, (AEC), Oak Ridge, Tenn. Apr. 1964, 290p.  
914 Bell, A. E. THE EFFECTS OF X-RADIATION OF PLATEAUED POPULATIONS OF *Tribolium castaneum* IN REGARDS TO REPRODUCTIVE FITNESS AND RESPONSE TO SELECTION. Final Report. COO-965-21, Purdue Univ., Lafayette, Ind. 29 May 1964, 8p.

Results are summarized from a series of studies on the effects of various levels of x-radiation on the response to selection in plateaued population of the flour beetle, T. castaneum. The response of the plateaued population was compared with that of unselected base populations exposed to the same levels of radiation and selection intensity as to reproductive fitness and inheritance of qualitative genes or chromosome aberrations. A list is included of publications resulting from this study. (NSA 18:1964, 27061)

- 915 Bileva, D.S. A STUDY OF GENETIC PROCESSES IN IRRADIATED POPULATIONS. I. NUMERICAL DYNAMICS OF IRRADIATED POPULATIONS. Dokl. Akad. Nauk SSSR 164 (1965) 191-4. (In Russian)

The genetic processes occurring in populations exposed to various x-radiation doses were analysed in order to derive a numerical criterion for estimating the radiation effects and to derive dose relationships. Fifty males and females of an inbred line of Drosophila melanogaster were exposed to 500, 1500, 3000, and 5000 R of x-radiation, keeping the temperature constant at 24 - 26°C and using identical feeding conditions for all groups. It was assumed that after a certain number of generations, a numerical equilibrium will be reached. The results showed that during the period from 1 - 17 d, the irradiated populations lag behind the control group; however, within 22 - 45 d, some of the irradiated populations overtook the control group and from 55-144 d a numerical steady state was reached. This was followed by a second period of differences and a second equilibrium during the period from the 369th - 418th day. The initial decrease of the population seems to be due to radiation-induced mutations that reduce the fertility and the viability of the flies; they are rapidly eliminated under intensive breeding conditions. (NSA 20:1966, 18324)

- 916 Brower, J.H. CHANGES IN THE INSECT POPULATIONS OF THE LOW SHRUB SYNSUSIA IN A NATURAL FOREST COMMUNITY EXPOSED TO CHRONIC GAMMA RADIATION STRESS. M.S. Thesis. Massachusetts Univ., Amherst. Feb. 1964, 43p.

A pre-irradiation study in the summer of 1961 was followed in November by irradiation studies of a typical stand of pitch pine-oak on dry sandy soil. Abundance gradients were established by a reliable sweep sampling technique. The greatest changes in insect populations resulted from vegetational changes which tended to mask less striking direct effects. The fact that radiation did have some direct effect was indicated by several factors. Thus, although food for fungivorous forms such as Collembola and Psocoptera seemed to be plentiful in the entire area of low shrub death, their abundance near the source was less than further out where populations were actually greater than normal. Second, another and even more definite sign of direct radiation effect was the delay in peak abundance and thus probably maturation for Cicadellidae and Cercopidae near the source. The delay was as great as 2½ weeks for both groups. The peak abundance was the same date for all points beyond 50 m for each group. At the 50 m point where abundance of Clastoptera proteus (a cercopid) was greater than normal there was also a slight stimulatory effect on the date of peak abundance, since it occurred 3 d earlier than normal. A 9500 Ci <sup>137</sup>Cs unit was used.

- 917 Carson, H.L. POPULATION SIZE AND GENETIC LOAD IN IRRADIATED POPULATIONS OF Drosophila melanogaster. Genetics 49, 3 (1964) 521-8.

Two experimental populations of the sepia-spineless-rough stock of D. melanogaster each received 65 000 R of x-rays over a period of 2½ yr. Two control populations were handled in an identical manner but received no radiation. All four populations were discarded 1 yr after the cessation of irradiation of the experimentals. The method of handling permitted weekly measurements of population size of all populations, affording a measure of fitness of the populations. As expected, the size of the experimental populations declines under radiation. Population size is recovered rapidly when radiation is suspended. Although one of the experimental populations maintained an elevated fitness level at several times for a number of generations, these effects were reversed and at the end of the experiment, controls and experimentals did not differ from one another. Following the cessation of the irradiation, the genetic loads of the irradiated populations were found to be elevated relative to the controls. These increased loads, however, disappeared within a year. Newly induced mutations do not appear to provide an important source of genetic diversity whereby fitness can be improved in experimental population systems where natural selection is operating. (Auth.)



- 918 Dowell, F.H. THE ESTABLISHMENT OF *Tribolium confusum* Duv. POPULATIONS AFTER STRESS BY PARASITISM AND x-IRRADIATION. Diss. Abstr. 25, 5 (1964) 3170-1.

The hypothesis tested was that parasitism of *T. confusum* by the cysticercoids of *Hymenolepis microstoma* Duj. (1945) reduces reproductive potential to an extent directly proportional to the level of such parasitism, this reduction being additive to the reduction caused by x-irradiation. Eight groups of larvae were used, consisting of all combinations of parasitism, no parasitism, three levels of irradiation [3000, 5000 and 15 000 R, at 24°C], and no irradiation, with an original sample size of 30 larvae and three replicates. Larvae selected for smallness show the highest per cent infestation and the greatest degree of replication, yet the smallest number of cysticercoids per beetle. There is a difference between non-irradiated, non-parasitized and non-irradiated, parasitized populations in the ability to establish themselves (the latter having less ability), but apparently this difference disappears as the total size of the population increases with population age. Decreasing ratio of parasitized to non-parasitized beetles with the passage of time and the increase in size of the total population is a possible explanation of this relationship. There is no difference between irradiated, parasitized and irradiated, non-parasitized populations in ability to establish themselves, regardless, from the limited data available, of the total size of the population. A tendency of irradiation to kill heavily parasitized beetles more readily than non-parasitized or lightly parasitized beetles is the probable explanation of this phenomenon. The results may be explained in terms of the hypothesis that both parasitism and irradiation (as limited above) reduce reproductive potential, that these reductions are additive, and that the reduction caused by parasitism is directly proportional to the level of parasitism.

- 919 Erdman, H.E. FAST-NEUTRON EFFECTS ON PRODUCTIVITY OF YOUNG AND OLD FLOUR BEETLES, *Tribolium castaneum* Herbst, AND ALTERATIONS AT DIFFERENT TEMPERATURES AND AFTER EXPOSURE OF EITHER OR BOTH SEXES. Int. J. Radiat. Biol. 9, 4 (1965) 305-11.

Virgin day-old and 3-week-old *T. castaneum* were given approximately 830 and 970 rad, respectively, of 4.6 MeV fast neutrons. Ten replicates of mating combinations in which neither sex, one sex, or both sexes were exposed were cultured at 25°C, 29°C, and 32°C in 65 - 70% relative humidity. Productivity, measured as adult progeny per reproducing female per day, was scored for 14 d. Decreases in temperature progressively delayed reproductive onset. Further delay in reproductive onset occurred when young female beetles were irradiated, indicating a greater radiation sensitivity of immature oögonia. Productivity of young beetles reached a plateau during the 2nd week; that of old beetles after the 1st day. When either sex only was irradiated, productivities were not significantly different at a particular temperature, but they were lower than the values obtained without any exposure and higher than when both sexes of a pair had been exposed. (From auth.)

- 920 Erdman, H.E. FAST NEUTRON EFFECTS ON FLOUR BEETLES. p.147-9 of "Hanford Biology Research Annual Report for 1963". HW-80500, General Electric Co. Hanford Atomic Products Operation, Richland, Wash. 15 Jan. 1964.

Effects on productivity of temperature, fast neutron irradiation, and the sex irradiated were investigated for the flour beetle, *Tribolium castaneum*. Earlier onset of reproduction and greater productivity were associated with increasing temperatures from 25 - 32°C. Exposure to fast neutrons delayed the onset of reproduction in females, and reduced the numbers of  $F_1$  adults following male or female exposures. (Auth.)

- 921 Erdman, H.E. FAST NEUTRON EFFECTS ON PRODUCTIVITY OF YOUNG AND OLD FLOUR BEETLES, *Tribolium castaneum* Herbst AND ALTERATIONS DUE TO TEMPERATURE AND SEX EXPOSED. HW-SA-3537, General Electric Co., Richland, Wash. Hanford Atomic Products Operation. 6 Oct. 1964, 16p.

Virgin day-old and 3 week old flour beetles, *T. castaneum*, strain Brazil CI, were given approximately 830 and 970 rad, respectively, of fast neutrons of average energy 4.6 MeV. Ten replicates of the mating combinations control, male-exposed, female-exposed, and both-exposed were cultured at 25°C, 29°C and 32°C in 65 to 70% relative humidity. Productivity, measured as adult progeny per reproducing female per day, was scored for 14 d. Decreases in temperature progressively delayed reproductive onset. Additional delay in reproductive onset occurred when young female beetles were irradiated, indicating a greater radiation sensitivity at this stage of oögonial maturation. Thereafter, no other indication of a differential radiosensitivity of germ

cells was noted. Productivity of young beetles plateaued during the second week; that of old beetles after the first day. Male- and female-exposed productivities were not significantly different within a temperature but were less than control and greater than both-exposed. Neutron irradiation effects appeared additive in that both-exposed mating combinations had the expected number of progeny compared to those in which one sex only was exposed. (Auth.)

- 922 Erdman, H. E. AGE, TEMPERATURE, COEXISTENCE, AND x-RADIATION EFFECTS ON FLOUR BEETLES' PRODUCTIVITY. p. 144-6 of "Hanford Biology Research Annual Report for 1963". HW-80500, General Electric Co. Hanford Atomic Products Operation, Richland, Wash. 15 Jan. 1964.

Age, temperature, coexistence, and x-radiation influenced reproductive performance of flour beetles. The performance of Tribolium castaneum was superior to that of T. confusum. (Auth.)

- 923 Erdman, H. E. REPRODUCTIVE PERFORMANCE OF x-RAYED SINGLE-SPECIES AND MIXED-SPECIES CULTURES OF Tribolium confusum AND T. castaneum REARED AT DIFFERENT TEMPERATURES. HW-SA-3748, General Electric Co., Richland, Wash. Hanford Atomic Products Operation, 1964, 20p.

Adult flour beetles, T. confusum and T. castaneum, sexed as pupae and maintained separately for 3 weeks after adult emergence, were given 0, 1575, or 2625 R of x-rays. Single- and mixed-species populations were established and incubated at 25, 29, or 32°C at 65 to 70% relative humidity. Productivity was determined during 10 weeks post-irradiation. Reproductive abilities increased with increased temperature and decreased with increased x-ray exposure for a given temperature. The reproductive fitness of T. castaneum was superior in all environments except at 0 R, 32°C. The frequencies of dominant lethals (which included lethality due to coexistence in mixed-species populations) increased with higher x-ray doses, but temperature and cohabitation influenced their expression within a species. Coexistence was responsible for a considerable reduction of productivity, which was also altered by temperature and x-radiation. The rigours of coexistence were lessened at 2625 R exposures (undoubtedly due to reduced population density). Interpretations of dose-response curves on the bases of single-hit and multi-hit radiation phenomena were inferred from similar responses of diverse organisms. Most lethality occurred in the early (eggs to young larvae) part of the life cycle for both species. Species proportions in coexistent populations varied with temperature and x-radiation but T. castaneum was consistently superior compared to T. confusum. The greater variability of T. castaneum probably makes it more fit in environments featuring different temperatures and x-radiation exposures plus coexistence. Responses to radiation of single-species populations cannot be used to predict those of mixed-species populations. (Auth.)

- 924 Myser, W. C. A STUDY OF RADIATION ON THE BIOLOGY AND POPULATION DYNAMICS OF THE CEREAL LEAF BEETLE, Oulema melanopa (L.) ORDER COLEOPTERA, FAMILY CHRYSOMELIDAE. p. 66 of "Offsite Ecological Research of the Division of Biology and Medicine Terrestrial and Freshwater". TID-13358 (2nd rev.), March 1965.

This crop pest became established in Michigan and Indiana and had, by 1964, migrated to north-western Ohio. In order to study the effects of radiation on ecology, including life stage development and behaviour, and to determine the radiosensitivity of the insect and to study its general physiological responses to radiation, a number of experiments are reported as being set up. Rearing facilities are arranged in the laboratory. Germ cell development, the number of eggs laid following adult irradiation, egg viability, life span, sperm viability, and motility are items to be studied, and the existence of a radiation threshold, and radiation levels for inhibiting development and for causing sterility are to be determined.

- 925 Riordan, D. F. EFFECT OF CONTINUOUS LOW-LEVEL GAMMA-IRRADIATION ON SUCCESSIVE GENERATIONS OF Dahlbominus fuscipennis (Zett.) (HYMENOPTERA: EULOPHIDAE). Can. J. Zool. 42 (1964) 685-8.

The chalcid, a hymenopterous parasite, was  $\gamma$ -irradiated continuously through seven generations; the experiment was halted at this point by lack of host cocoons (D. fuscipennis was reared on larval cocoons of the sawfly Neodiprion lecontei). The dose rates were 10, 5, and 2.5 R/h. At 10 R/h the population failed to reach the third generation. After two generations at 5 R/h the population was reduced in numbers to 20% or less of the control population but managed to survive for the seven generations. At 2.5 R/h the numbers in the first five generations were reduced below

those of the controls, but had completely recovered by the sixth generation. The time, in days, between oviposition and emergence in the 7 generations of the untreated controls was 19 - 21. The corresponding times for the groups that were treated at 2.5 R/h were 21 - 25 d. When treatments were at 5.0 R/h, the times to emergence were 23 - 29 d, and for the single generation surviving treatment at 10 R/h 27 d (total dosage 6240 - 6480 R). At 5 R/h the population appeared to have reached a roughly stable state after the second generation. The results of the treatment at 2.5 R/h showed that the numbers of females in the first five generations of progeny fluctuated to some extent but in the same pattern as those in the corresponding control generations. The population had fully recovered by the sixth and seventh generations, and recovery was also apparent in the generations relieved from irradiation. This is further indicated by the manner in which the development times shortened after the second generation. This was a self-accelerating process, as a shorter development time resulted, in turn, in a lesser total dose. These results suggest selection of a radiation-resistant strain of parasites. The small numbers of insects used precluded assessing separate, but interdependent, subeffects; however, data from the 5-R/h treatment show that reduced fertility of the females was the major cause of the lesser numbers of females in the successive generations. (NSA 19:1965, 3918)

- 926 Sankaranarayanan, K. GENETIC LOADS IN IRRADIATED EXPERIMENTAL POPULATIONS OF *Drosophila melanogaster*. Genetics 50 (1964) 131-50.

The influence of x-radiation-induced genetic loads on the viability of experimental populations of *D. melanogaster* maintained under relatively relaxed selection conditions was studied. Four dose levels (2000 R, 4000 R, 6000 R and 7000 R) were used and only the males were irradiated. Three populations received radiation in every generation; sub-populations were derived from these after 1, 5, 10, 15, 20, and 25 generations and propagated without further irradiation. The components of viability investigated were hatchability of the eggs, larva-adult survival, and egg-adult survival. In the chronically irradiated populations, viability decreased for the first few generations and then fluctuated about an equilibrium level depending on the amount and the history of the irradiation. The sub-populations derived from the irradiated ones manifested a rapid recovery to almost the control levels of viability in three to seven generations. The preliminary data on chromosome analysis indicate that, under the influence of induced mutation pressure, the populations tend to accumulate recessive lethals and semilethals. The mean viability of the homozygotes for the quasi-normal chromosomes is below that of the heterozygotes. (Auth.)

- 927 Willard, W.K. LONG TERM EFFECTS OF ACUTE LOW-LEVEL x-RAYS ON THE POPULATION DYNAMICS OF THE YELLOW FEVER MOSQUITO, *Aedes aegypti*. Diss. Abstr. 26, 4 (1965) 2394.

Four life history stages (eggs, larvae, pupae, and adults) of the yellow fever mosquito, *A. aegypti* (Rockefeller strain), were subjected to acute low-level x-rays. The stages were divided into seven groups; each group received a single dose of x-rays, the dosage ranging from 0 - 3200 R. The following population characteristics were measured through three generations succeeding the irradiation: fecundity, egg viability, larval survival, and mean longevity. Radiation effects of acute low-level x-rays on populations of *A. aegypti* were most evident in the first generation and gradually disappeared in subsequent generations. The eggs were most radiosensitive, followed in rank by larvae, pupae, and adults. Egg viability was the characteristic most drastically affected, in that the viability of eggs produced by adults which arose from irradiated eggs, larvae, pupae, or young adults was reduced, in some cases, through three generations. A dose of 3200 R of x-radiation delivered to *A. aegypti* populations in each developmental stage resulted in the extinction of the populations in the first generation. Only a few eggs or larvae irradiated with an acute dose of 1600 R survived to the adult stage. Pupae populations irradiated with 1600 R of x-rays had a lowered fecundity in the first generation followed by second generation recovery. The fecundity of adults irradiated with 1600 R was significantly lower than the controls in the first and second generations; however, recovery occurred by the third generation. A dose of 800 R to all stages resulted in a significantly

Fecundity, egg viability, larval growth rate, and mean longevity were population parameters utilized in evaluating the long term effects of acute low-level x-rays on eggs, 1st-instar larvae, pupae and adults. Effects were most strongly exerted in the first generation and gradually subsided in subsequent generations. Doses of 50 - 400 R were found to be stimulatory in some cases, while doses of 800 R and above were detrimental. The egg stage was found to be most sensitive followed by the larval, pupal, and adult stages.

\* See also 927.

See also:

- 675 x-ray and fast neutron effects on productivity of flour beetles. (Erdman, H.E., 1965)
- 911 Mating preference and reproduction of irradiated Drosophila melanogaster. (Mason, H.C. et al., 1965)
- 957 Changes in an aphid population in a forest community damaged by chronic gamma irradiation. (Brower, J.H., 1964)
- 958 Ecological changes in the insect community of a pitch pine-oak forest subjected to chronic gamma irradiation. (Brower, J.H., 1965)

### 3. Physiological Characteristics

See:

- 926 Genetic loads in irradiated experimental populations of Drosophila melanogaster. (Sankaranarayanan, K., 1964)
- 929 The effects of selection and irradiation on quantitative traits in Tribolium. (Bartlett, A.C., Bell, A.E., 1964)
- 932 Progress report (on genetical studies), 1 October 1963 - 1 June 1964. (Dobzhansky, T., nd)
- 941 Genetic loads in irradiated populations of Drosophila melanogaster. (Sankaranarayanan, K., 1965)
- 942 Further data on the genetic loads in irradiated experimental populations of Drosophila melanogaster. (Sankaranarayanan, K., 1965)
- 944 Inbreeding and genetic loads in irradiated experimental populations of Drosophila melanogaster. (Sankaranarayanan, K., 1965)

### 4. Genetic Changes

- 929 Bartlett, A.C., Bell, A.E. THE EFFECTS OF SELECTION AND IRRADIATION ON QUANTITATIVE TRAITS IN Tribolium. Genetics 50, 2 (1964) 234. Abstr.

The consequences of various combinations of selection (high and random) and levels of x-radiation (0, 100 and 1000 R/generation) on body weight at the pupal stage were investigated over 11 generations in two strains of T. castaneum. Reproductive fitness in terms of fertility, number of offspring, and adult viability was measured each generation. One strain, called Foundation, was an unselected panmictic population which had been maintained since its formation in 1954 by mass cultures containing 250 or more parents each generation. Average body weight of this strain was 2.10 mg. The second strain, referred to as Large, originated from the first and had been selected for a large body weight for 44 generations. At the beginning of the present study, average body weight of the second strain was 5.66 mg. High selection contributed to significant responses in body weight in all lines so treated; but the degree of response was negatively correlated with the amount of irradiation. Even though an increase in the additive genetic variance was observed in some of the irradiated lines, a decline in reproductive fitness contributed to a smaller selection differential. - The results for this experiment suggest that artificial irradiation will not become an efficient method of enhancing response to selection until techniques are devised to eliminate more rapidly those mutations deleterious to reproductive fitness. (Abstr.)

- 930 Blaylock, B.G. CHROMOSOMAL ABERRATIONS IN A NATURAL POPULATION OF *Chironomus tentans* EXPOSED TO CHRONIC LOW-LEVEL RADIATION. \* *Evolution* 19 (1965) 421-9.

Salivary chromosomes of larvae from the vicinity of Oak Ridge, Tenn., were analysed. Three paracentric inversions were found at a relatively high frequency (8:7-25.3%) in three different populations. Samples from White Oak Creek (contaminated with low-level radioactive waste) were compared with samples from two other populations. The amount of chromosomal polymorphism in the irradiated and non-irradiated populations was approximately the same with an average of 0.53 and 0.55 aberrations/larva respectively. However, ten aberrations which occurred at a very low frequency (nine were found only one time) were unique to the irradiated population. The occurrence of new aberrations in the White Oak Creek population was concluded to increase due to the high background radiation level, but were rapidly eliminated by selection or genetic drift. The frequency of inversion of 1 Ra decreased from 55.6% in Sep. to 16.1% in Dec. During this decrease the observed larval types were significantly different from the expected Hardy-Weinberg frequencies. An explanation is put forward.

\* A thesis of the same title was published in 1963, see II/1388.

- 931 Clayton, G. A., Robertson, A. THE EFFECTS OF x-RAYS ON QUANTITATIVE CHARACTERS. *Genet. Res.* 5 (1964) 410-22.

The rate of production by x-rays of new genetic variation in two quantitative characters in *Drosophila melanogaster* (sternital and sternopleural bristles) was investigated, using plateaued populations which had reached the limit under artificial selection and, for sternital bristles only, populations which were made genetically invariant by inbreeding. The genetic variation was always measured by the response of the population to selection. The x-ray dose given in any generation was always 1800 R to adults. Seven plateaued lines had eight cycles of alternate irradiation and selection, each with its non-irradiated control. All the responses were small but in three lines they were significantly greater after irradiation. Selection was applied to three different inbred lines, genetically marked to detect contamination, after varying periods of irradiation. At the same time, the inbred lines and lines derived from them which had been mass mated in bottles were selected. The irradiated populations showed a greater response. The new genetic variance produced by the irradiation was approximately  $10^{-6}$  units/R. The estimate of the dose required to introduce new variation equal to that in a standard outbred population was 500 000 R. The effective population size was an important factor in the interpretation of some of these results on the long-term effects of radiation. By observing the variation between replicate lines in the frequency of a gene with a visible effect under these culture conditions (i.e. in a single culture bottle) the effective population size was estimated at 60. Outbred populations kept under these conditions for many generations showed a reduction of genetic variability in agreement with this value. To investigate the possibility that the deleterious genes produced by irradiation would interfere with the response to artificial selection, a standard outbred population was irradiated and selected. In spite of the observed high frequency of recessive lethals produced, the response to selection was very similar to that of the standard population. (Auth.)

- 932 Dobzhansky, T. PROGRESS REPORT (ON GENETICAL STUDIES), 1 OCTOBER 1963 - 1 JUNE 1964. TID-20728, Rockefeller Inst., New York. nd, 9p.

Genetic loads of irradiated experimental populations of *Drosophila pseudoobscura* were studied, and Malthusian parameters (the innate capacity for increase) were used for statistical fitness estimates at 25° and 16°C. Males were subjected to 18 000 R doses of x-rays, and subsequently crossed with untreated females, followed by free breeding. Examinations made 27-37 generations later for lethals and semilethals showed these to decline sharply in both the second and third chromosomes, compared with those in a natural population. At least some of them are by this time neutral or heterotic in heterozygous conditions. The adaptiveness to the environment of the irradiated populations improved by means of increased fecundity in spite of deterioration in longevity, and no change in viability or speed of development. Viability losses were remarkably small. Other work planned and in progress is discussed. (See work by Torroja, Mourad, Sankaranarayanan).

- 933 Dobzhansky, T. PROGRESS REPORT [ON GENETIC STRUCTURE OF NATURAL POPULATIONS] FOR 1 OCTOBER 1964 - 1 JUNE 1965. TID-22031, Rockefeller Inst., New York. nd, 17p.

Progress is reported in studies of genetic loads in natural and irradiated populations of *Drosophila*. Data are included from studies of epistatic interactions of the components of the genetic load in natural populations; the relation of genetic loads and genetic backgrounds; the genetic consequences of exposure to doses of 2000, 4000, or 8000 R x-radiation in experimental populations maintained under conditions of relaxed natural selection after exposure for three successive generations; studies of chromosomal polymorphism in natural populations; and genetic diversity and selection in *Drosophila* populations. (NSA 19:1965, 35948)

- 934 Eiche, A. DURING SEVERAL GENERATIONS IRRADIATED SPERMATOGONIA IN *Drosophila melanogaster*. A POPULATION ANALYSIS. *Hereditas* 52, 2(1964)243. Abstr. Presented at the "3rd Meeting of the Scandinavian Association of Geneticists, Helsinki, Finland, 10 - 12 Jun. 1964".

Two different wild type strains of *D. melanogaster* were studied during the course of several generations with an x-ray dose to the spermatogonia in each generation. The x-rays were administered to 17 ± 1 h old larvae at which stage only primary spermatogonia are present. The newly irradiated gene mass thus came from the male side in each generation. The effects of the x-rays were not measurable in the individual generations, however, from the total material, based on the number of tested larvae which reached the adult stage, it may be seen that such effects exist. Of the other genetic tests only that for recessive lethals showed a difference between the x-ray and control populations. (Abstr.)

- 935 Magalhães, L.E. de, Brito da Cunha, A., Toledo, J.S. de, Toledo, S.A., Souza, H.L. de, Targa, H.J., Setzer, V., Pavan, C. ON LETHALS AND THEIR SUPPRESSORS IN EXPERIMENTAL POPULATIONS OF *Drosophila willistoni*. *Mutation Res.* 2 (1965) 45-54.

Naturally occurring and radio-induced\* lethals were studied in experimental populations maintained in population cages. The populations were started with four lethals, two wild and two induced, each of them having a frequency of 0.25. The lethals still had frequencies from 0.03 - 0.18 when the populations were 348-d-old. Analysis of the lethals showed that all of them were able to survive in homozygous condition. The survival of the flies homozygous for the lethals was due to the presence of recessive suppressors. The proportion of the lethals accompanied by their own suppressors was measured in a sample taken when the populations were 866 d old and varied from 0 - 58.3%. The implications of the presence of suppressors regarding the behaviour of lethals in populations were analysed and the results are discussed. (Auth.)

\* 800 R from a <sup>137</sup>Cs-source.

- 936 Molnar, I., Gubicza, A. THE EFFECT OF GAMMA RAYS ON THE VARO RACE OF *Bombyx mori* L. (COMPARATIVE STUDY OF THE SECOND GENERATION). *Magy. Text-Tech.* 17, 3 (1965) 106-8. (In Hungarian)

- 937 Mourad, A.E. - K.M. LETHAL AND SEMILETHAL CHROMOSOMES IN IRRADIATED EXPERIMENTAL POPULATIONS IN *Drosophila pseudoobscura*. *Genetics* 50 (1964) 1279-87.

Experimental *Drosophila* populations, in which some of the chromosomes were exposed in one generation to 16000 R of x-rays, were studied approximately 2½ yr later (estimated to correspond to between 28 and 37 generations). Frequencies of the second and third chromosomes lethal, semilethal, and quasi-normal in double dose were determined. Lethals and semilethals were much less numerous than they were immediately after the irradiation, although more frequent than before the irradiation. Few of the quasi-normal chromosomes were subvital in double dose. It is concluded that the genetic variants found in natural and in experimental populations are, because of the action of natural selection, very biased samples of those arising by mutation. (Auth.)

- 938 Mukai, T. POLYGENIC MUTATIONS AFFECTING QUANTITATIVE CHARACTERS OF *Drosophila melanogaster*. *Gamma Field Symp.* 3 (1964) 13-29.

Results are reported from a study of spontaneous and x-ray induced polygenic mutations that affect the quantitative characters of *D. melanogaster*. The evolutionary significance of polygenic mutations in natural populations and their possible application in animal and plant breeding programmes are discussed. (NSA 20:1966, 18415)

- 939 Mukai, T., Yoshikawa, I. HETEROZYGOUS EFFECTS OF RADIATION-INDUCED MUTATIONS ON VIABILITY IN HOMOZYGOUS AND HETEROZYGOUS GENETIC BACKGROUND IN Drosophila melanogaster (Preliminary Report). Idengaku Zasshi (Jap. J. Genet.) 38 (1964) 282-7.
- Heterozygous effects of mutations induced by low doses of x-irradiation on viability were tested both in otherwise homozygous genetic background and in heterozygous genetic background in D. melanogaster. On the basis of counting approximately 1.46 million flies, it was found that radio-induced mutations that occurred in homozygous genetic background were heterozygously beneficial to their carriers, while those induced in hybrids between individuals originated from two unrelated populations were slightly detrimental to their carriers. (Auth.)
- 940 Nelson, D.J., Auerbach, S.I., Blaylock, B.G. et al. CLINCH RIVER AND RELATED AQUATIC STUDIES. p. 95-104 of "Health Physics Division Annual Progress Report for Period Ending July 31, 1964". ORNL-3697, Oak Ridge National Lab., Tenn., Oct. 1964, 268p.
- An increase of newly occurring chromosomal aberrations is reported in the natural population of Chironomus tentans from White Oak Creek. These newly occurring aberrations are eliminated by selection or genetic drift and are not maintained in the gene pool of the population. The increased mutation rate produced by the chronic irradiation in the White Oak Creek population has not reduced the amount of chromosomal polymorphism in this natural population. (From auth.)
- 941 Sankaranarayanan, K. GENETIC LOADS IN IRRADIATED POPULATIONS OF Drosophila melanogaster. Diss. Abstr. 25, 6 (1965) 3766.
- The influence of radiation-induced genetic loads on the viability of experimental populations of D. melanogaster maintained under relatively relaxed selection conditions was studied. Four dose levels (2000 R, 4000 R, 6000 R and 7000 R) were used. Some populations (II-ER, IV-ER and VI-ER) were irradiated in every generation. In some, the irradiation was relaxed after varying numbers of generations of irradiation at every dose level (II-ER-1, IV-ER-5, VI-ER-10 etc.). The components of viability investigated were (a) the hatchability of the eggs, (b) larva-adult survival, and (c) egg-adult survival. In chronically irradiated populations, viability decreased for the first few generations and then fluctuated about an equilibrium level depending on the amount and the history of the irradiation. The populations relaxed after several generations of irradiation manifested a quick return to almost the control levels of viability in 3-7 generations. The preliminary data on chromosome analysis indicates that, under the influence of the induced mutation pressure, the populations tend to accumulate recessive lethals and semilethals. These do not necessarily constitute a dead weight on the population. (DA)
- 942 Sankaranarayanan, K. FURTHER DATA ON THE GENETIC LOADS IN IRRADIATED EXPERIMENTAL POPULATIONS OF Drosophila melanogaster. Genetics 52, 1 (1965) 153-64.
- Populations were maintained under conditions designed to minimize the natural selection due to larval competition and crowding, and were maintained under conditions of relaxed natural selection. Males in every generation were irradiated with 2000 R, 4000 R, and 6000 R doses of x-rays. The egg to adult viability was studied. In all populations, viability decreased for the first few generations, and then fluctuated at equilibrium levels depending on the amount and the history of irradiation. Three sub-populations were derived, one from each of the chronically irradiated populations, at the total accumulated dose of 120 000 R. When relaxed from radiation, the sub-populations rapidly recovered in about four to five generations to 70-75% viability level. For a given total dose of radiation, the frequencies of accumulated lethals and semilethals vary depending on the number of generations during which the total dose was delivered. Thus, at the cumulative dose level of 120 000 R administered at the rate of 6000, 4000, and 2000 R per generation for 20, 30, and 60 generations respectively, the frequencies of second chromosome lethals and semilethals in the first two populations were close to 90%, compared with only 57% population. The genetic variances of the homozygotes proved higher than in the heterozygotes; the frequencies of subvitals were greater in the heavily irradiated populations than in the others.
- 943 Sankaranarayanan, K. RELATIVE MAGNITUDE OF GENETIC LOADS IN EXPERIMENTAL POPULATIONS OF Drosophila melanogaster RELAXED FROM x-IRRADIATION. Genetics 52, 2, Pt. 2 (1965) 471-2. Abstr.

Three populations were relaxed from x-irradiation after being exposed to a cumulative dose of 120 000 R delivered in 20 (VI-ER-20), 30 (IV-ER-30) and 60 (II-EGR-60) generations, at the rate of 6000 R, 4000 R and 2000 R per generation respectively. The radiations were acute and administered only to the males. The populations were maintained without further irradiation and under conditions designed to minimize the natural selection due to larval competition and crowding. The egg-adult viability in each of these populations rapidly increased and in 4-5 generations reached a level of 70-75% and has remained there for over 50 generations in VI-ER-20, 40 generations in IV-ER-30 and 30 generations in II-EGR-60. - At the time of relaxation from radiation, VI-ER-20 and IV-ER-30 contained about 90% lethal and semilethal second chromosomes while II-EGR-60 contained only 57% of such chromosomes. After 19 generations of relaxation, the lethal and semilethal frequencies dropped to 76% in VI-ER-20, to 60% in IV-ER-30 and 41% in II-EGR-60. Thus, despite relatively different concealed genetic loads, these populations have similar egg-adult viabilities, suggesting that the magnitude of the concealed genetic loads per se is not a priori an index of the fitness (egg-adult viability in these experiments) of the population. Inbreeding studies are currently underway to estimate the magnitude of the genetic loads in these populations. (Abstr.)

- 944 Sankaranarayanan, K. INBREEDING AND GENETIC LOADS IN IRRADIATED EXPERIMENTAL POPULATIONS OF Drosophila melanogaster. Nature, Lond. 207 (1965) 1216-7.

The magnitudes of the genetic loads in experimental populations was compared. Males were exposed to x-rays for a number of generations (6000 R/generation for 20 generations; 4000 R for 30; and 2000 R for 60), and then maintained for varying periods of time. The populations received a cumulative dose of 120 000 R. A total of 140 single-pair matings were set up per population, and from each of the single-pair progenies, virgin females and males were collected and three types of crosses set up: 1) unrelated (between groups of 10 ♀ from one culture and 10 ♂ from a different culture); 2) brother-sister matings; 3) half-sib matings (a single ♂ was crossed to a ♀ from one culture and 2 d later crossed to a ♀ from a different culture, and from the progenies groups of 10 ♀ and ♂ were taken and intercrossed). The egg-adult viability was studied in the progenies of these three types of mating. The viability in the irradiated populations was lower (see Table 2 for percentages of egg-adult survival). Mean viabilities observed for the inbred and outbred progenies were tabulated (Table 2), and A and B statistics, and the B/A ratios and their standard errors summarized in Table 3. The results are discussed.

- 945(2) Scossitelli, R.E. INHERITANCE OF QUANTITATIVE CHARACTERISTICS AND METHODS FOR INCREASING THE GENETIC MUTABILITY OF POPULATIONS. Mag. tudem. Akad. biol. Osztál Kézl. 6 (1963) 297-318. (In Hungarian)

Experiments with fruit flies indicated that irradiation of the population results in a faster evolution than is possible with unirradiated groups. Thus, the radioinduced mutability is responsible for the accelerated rate of evolution. The problem of artificial selection was studied on the Drosophila, exposing the first three generations to 3000 R of x-radiation. The inheritance of the variation in the growth of the sternopleural hair was used as the indicator. The results showed that exposure to x-radiation is an effective tool for creating minor gene mutations which result in additive genetic mutability. This new genetic mutability may be used for artificial selection to improve the desired characteristics of plants and animals. The ionizing radiation helps to overcome the establishment of stable levels in the characteristics. Such tests were carried out with economically important plants, such as corn, wheat (T. durum cultivar Cappelli) and tobacco. It was concluded that high exposures, useful for studying the mutation of individual genes, are not suitable for inducing genetic mutability. The optimum irradiation level must be determined separately for each species. (From NSA 19:1965, 15113)

- 946 Stone, W.S. RESEARCH IN GENETICS TO INCLUDE (1) THE DIRECT AND INDIRECT EFFECTS OF RADIATIONS AND THEIR MODIFICATION ON GENETIC SYSTEMS, AND (2) POPULATION AND EVOLUTIONARY STUDIES OF Drosophila. p.130 of "Research and Development in Progress. Biology and Medicine. No.3". Abstr. TID-4203, Division of Technical Information Extension, (AEC), Oak Ridge, Tenn. Apr.1964, 290p.

- 947 Tobari, I., Nei, M. GENETIC EFFECTS OF x RAYS ON QUANTITATIVE CHARACTERS IN A HETEROGENEOUS POPULATION OF Drosophila melanogaster. Genetics 52, 5 (1965) 1007-15.



An outbred population was exposed to 1000 R of x-rays at 100 R/min. The numbers of abdominal and sternopleural bristles were studied after three generations of random mating. The mean values of the two characters showed no appreciable change due to radiation. In view of the practical equality of positive and negative mutation rates in these characters, this result suggests that the frequencies of positive and negative alleles in the outbred population are nearly equal, on the average. The phenotypic variance was increased in both abdominal and sternopleural bristles. Partitioning of the phenotypic variance has shown that this increase is mainly due to the increase in genetic variance. The increase in genetic variance in sternopleural bristles was also detected by the parent-offspring covariance, which was larger in the irradiated than in the control population. The amount of variance increase per roentgen has suggested that the increase of genetic variance in the irradiated population is caused mainly by mutations at fixed or nearly fixed loci rather than at loci with intermediate gene frequencies. (Auth.)

- 948 Torroja, E. GENETIC LOADS IN IRRADIATED EXPERIMENTAL POPULATIONS OF Drosophila pseudoobscura. Genetics 50 (1964) 1288-90.

The genetic loads have been studied by two methods. First, the egg-to-adult viability has been determined in the progenies of matings in which the parents were full sibs, half sibs, or not closely related genetically. Secondly, the viability of individuals made homozygous for certain chromosomes by means of a series of crosses was measured in relation to that of their heterozygous siblings. The experiments conducted utilizing both methods lead to concordant results. The recently irradiated populations carry very heavy genetic loads, consisting mainly of genetic variants which are deleterious in heterozygous, and doubtless also in homozygous condition. Some 28-37 generations after the irradiation is discontinued, the genetic loads are found very greatly reduced, in fact, reduced below the levels observed in natural populations. The genetic variants composing the genetic loads in natural populations are evidently not random samples of the variants arising by mutation under the influence of irradiation. (Auth.)

- 949 Vandehey, R.C. GENETIC VARIABILITY IN Aedes aegypti (DIPTERA: CULICIDAE). III. PLASTICITY IN LABORATORY POPULATIONS. Ann. ent. Soc. Am. 57 (1964) 488-96.

In addition to the analysis of naturally occurring genetic variability, a preliminary investigation was conducted to assay possible effects of radiation. Three groups of mosquitoes were irradiated with  $\gamma$ -rays (2000 R, 3250 R, and 4000 R at 13 000 R/min from a  $^{60}\text{Co}$ -source). The method of analysis used was similar throughout, in principle. The TEXAS strain was used for irradiation. Each irradiated male was mated to a virgin female from the stock colony. Their progeny, whether male or female, were backcrossed to stock colony individuals, a mating was designated as the parental generation of the analysis. Visible mutations recovered in the  $F_1$  or  $F_2$  generations could therefore be attributed to irradiation of a particular gamete. An abundance of natural variation was found in A. aegypti, not the case in Culex pipiens L., or not to any comparable extent. The number of mutations recovered from irradiated material was always less than that from controls. Moreover, the mutation frequency obtained at higher dosages was lower than at 2000 R. However, there was an increase in lethality at higher dosages. Most of the visible mutations recovered from the irradiated material were similar in phenotype to those found in the controls. Only three mutations, Half-genitalia, scale row, and bent wing were unique to the irradiated series. There appeared to be a reduction in the rate of recovery of the naturally occurring mutations, possibly due to selective action of radiation-induced lethality. The need for more work is stressed.

- 950 Auerbach, S.I. RADIATION EFFECTS ON Chironomus tentans. p.312 of "Research and Development in Progress. Biology and Medicine. No.3". Abstr. TID-4203, Division of Technical Information Extension, (AEC), Oak Ridge, Tenn. Apr. 1964, 290p.

See also:

- 915 A study of genetic processes in irradiated populations. I. Numerical dynamics of irradiated populations. (Bileva, D.S., 1965)  
 917 Population size and genetic load in irradiated populations of Drosophila melanogaster. (Carson, H.L., 1964)  
 928 Genetic loads in irradiated experimental populations of Drosophila melanogaster. (Sankaranarayanan, K., 1964)

## 5. Ecological Aspects

- 951 Allred, D.M., Beck, D.E. ARTHROPOD ASSOCIATES OF PLANTS AT THE NEVADA TEST SITE. Biological Series, Volume V, Number 2. TID-21394, Brigham Young Univ., Provo, Utah, Sep. 1964, 20p.

An ecological study was made of plant-anthropod associations related to the predominant plants in selected plant communities at the Nevada Test Site. Emphasis was placed on the identification of kinds, relative numbers, seasonal incidence, and ecological distribution of the insects relative to the plant communities as well as individual plants of 11 species. (NSA 19:1965, 6901)

- 952 Auerbach, S.I. RADIATION ECOLOGY. p.43-100 of "Health Physics Division Annual Progress Report for Period Ending July 31, 1965". ORNL-3849, Oak Ridge National Lab., Tenn. Oct. 1965, 263p.

Results of investigations concerning radiation effects on insects, plants, and animals in reactor and waste areas are summarized. Investigation results are also summarized on processes and components of terrestrial ecosystems. Clinch River and related aquatic studies are reported along with theoretical studies of food chains and systems ecology. (NSA 20:1965, 6711)

- 953 Auerbach, S.I., Brown, G.N., Crossley, D.A., Jr. et al. RADIOACTIVE WASTE AREA AND RADIATION EFFECTS STUDIES. p. 65-84 of "Health Physics Division Annual Progress Report for Period Ending July 31, 1964". ORNL-3697, Oak Ridge National Lab., Tenn. Oct. 1964, 266p.

Statistical analyses of sedges growing on White Oak Lake bed indicated that length of inflorescence was mostly correlated with the air dose rate of  $\gamma$ -radiation at 1 m above ground surface. Some of the natural vegetation around the unshielded Health Physics Research Reactor exhibited the first visible effects of radiation damage. Radiation effects studies completed this year included fast-neutron exposures from the HPRR, and  $\gamma$ -radiation exposures from both a  $^{137}\text{Cs}$  field source and the White Oak Lake bed. Insect studies showed that mud-dauber wasps that used radioactive mud from the liquid waste pits were affected by the ionizing radiation. Continuing studies on  $^{137}\text{Cs}$  accumulation and elimination by various species of insects demonstrated the usefulness of these techniques for measuring food consumption and insect production under field conditions. Energy flow through the herbivorous insect population was estimated by using food consumption rates calculated with steady-state equilibria for  $^{137}\text{Cs}$ . Preliminary studies of radiation response of several insect species including crickets and grain beetles were reported.

- 954 Blaylock, B.G. CHROMOSOMAL ABERRATIONS IN A NATURAL POPULATION OF Chironomus tentans EXPOSED TO CHRONIC LOW-LEVEL ENVIRONMENTAL RADIATION. Diss. Abstr. 24 (1963/4) 3022.

For abstract, see 955.

- 955 Blaylock, B.G., Auerbach, S.I., Nelson, D.J. CHROMOSOMAL ABERRATIONS IN A NATURAL POPULATION OF Chironomus tentans EXPOSED TO CHRONIC LOW-LEVEL ENVIRONMENTAL RADIATION. ORNL-3531, Oak Ridge National Lab., Tenn. 29 Jan. 1964, 88p. Thesis submitted to Univ. of Tennessee, Knoxville.

The salivary gland chromosomes of C. tentans larvae collected from White Oak Creek, an area contaminated by radioactive waste from the Oak Ridge National Laboratory, and from 6 uncontaminated areas were examined for chromosomal aberrations. White Oak Creek populations were exposed to absorbed doses as high as 230 rad/yr or about 1000-times background. Chromosomal maps were constructed to make a general comparison of the banding pattern of the salivary chromosomes of the C. tentans in the East Tennessee area with those of Canada and Europe. These maps were used as a reference in scoring aberrations. Fifteen different chromosomal aberrations were found in 365 larvae taken from the irradiated population as compared with 5 different aberrations observed in 356 larvae from 6 control populations, but the mean number of aberrations per larva did not differ in any of the populations. The quantitative amount of heterozygosity was essentially the same in the irradiated and the control population, but there were 3-times the variety of chromosomal aberrations found in the irradiated area. From this evidence it was concluded that chronic low-level irradiation from radioactive waste was increasing the variability of chromosomal aberra-

tions without significantly increasing the frequency. It was also concluded that chromosomal polymorphism can be maintained in a natural population without superiority of the heterozygous individuals. (NSA 18:1964, 8108)

- 956(2) Brower, J.H. CHANGES IN INSECT POPULATION IN A NATURAL FOREST COMMUNITY EXPOSED TO CHRONIC GAMMA RADIATION STRESS. Bull. ecol. Soc. Am. 44, 3 (1963) 69. Abstr.

This study was designed to determine basic information about changes in insect populations of a chronically irradiated forest ecosystem. Insect populations of the low shrub synusis were sampled with a standardized sweep netting technique. Since profound changes occurred in the vegetation near the source of radiation, populations of phytophagous species were greatly reduced. Populations of their parasites and predators also reacted similarly. Not all populations of insects were reduced; some actually built up to much greater abundance than in the normal forest. The increase is probably attributable to increased food availability. Although the larger, vegetationally influenced, changes partially masked any direct effects on insects, a number of indications of direct effects were noticed. (Abstr.)

- 957 Brower, J.H. CHANGES IN AN APHID POPULATION IN A FOREST COMMUNITY DAMAGED BY CHRONIC GAMMA IRRADIATION. Bull. ent. Soc. Am. 10, 3 (1964) 172. Abstr.

Population dynamics of an aphid (Myzocallis discolor Monell) were studied in an oak-pine forest community which had been subjected to chronic  $\gamma$ -irradiation for 18 months. This species underwent a population explosion on radiation damaged white oak trees. Possible explanations will be presented. (Abstr.)

- 958 Brower, J.H. ECOLOGICAL CHANGES IN THE INSECT COMMUNITY OF A PITCH PINE-OAK FOREST SUBJECTED TO CHRONIC GAMMA IRRADIATION. BNL-9253, Brookhaven National Lab., Upton, N.Y. 28 May 1965, 184p. Thesis.

A project was established in 1961 at Brookhaven National Laboratory to study the effects of chronic  $\gamma$ -radiation on the insect fauna of a natural forest community. The area of pitch pine-oak-blueberry was irradiated for 20 h each day with a 9500 Ci  $^{137}\text{Cs}$  source. A sweep sampling technique was employed to give reliable samples of the shrub insects. A numerical survey was made to determine the density and distribution pattern of an aphid on white oak leaves along a decreasing radiation gradient. Pines were checked monthly to determine the intensity of bark beetle infestation. Later, squares of the bark were removed and the developmental success was determined by estimating the per cent of cambial surface utilized. Trap logs were also used to provide *Ips* populations at very high radiation intensities. Radiation had extensive effects on the vegetation of the experimental forest. The abundance of the shrub insects was greatly depleted near the radiation source in the area of severe shrub damage. Omitting Psocoptera, insect abundance was 5% of normal at 10 m. Normal abundance for most species was reached at about 60 m. Near the source, the leaf feeding species and their parasites and predators were mostly absent; the insects present were fungivorous or vagile forms. The fungivorous Psocoptera were normal or above normal in abundance in the area of complete shrub mortality. In 1963, a species of aphid, Myzocallis discolor, was observed on the radiation-damaged white oaks. This aphid was not found in the unaffected forest but increased in abundance on the debilitated oaks to >25 winged aphids/leaf. This increase amounted to as much as 350 000 aphids/m<sup>2</sup> of forest floor area. A possible increase in the soluble amino acid content in damaged leaves was a likely causal factor for the aphid increase. Bark beetles attacked dead and dying trees and the area of infestation increased as pines further from the source died. Trees at high radiation levels were attacked by *Ips* where the exposure level proved lethal. Several zones of effect on *Ips* developmental success were recognized at different intensities of exposure. Developmental success was greater on the self-shielded side than on the exposed side of trees. Trap logs were used for studies of developmental success at high radiation intensities. In 1962 development in them was subnormal reaching ~60%, in 1963 total utilization at low radiation intensities approached 100%. The zones of effect were comparable to those in the standing trees. The per cent of cambial surface utilized by *Ips* increased from 9% at 2300 R/d to ~80% at 300 R/d. The difference between sides of the same log was as great as 30% because of the shielding factor. Ants are the only insects reported to have a radiation avoidance response. The habits of a colony of Formica integra changed so that ants were no longer exposed to high radiation levels. The ants constructed a 12.5 m sunken runway from the nest away from the

radiation source and they no longer appeared on the exposed nest snag. — The insect community in the irradiated area was divided into two parts on the basis of food requirements, one ecologically sensitive and the other ecologically resistant. The former was composed of herbivorous populations and their parasites and predators while the latter contained fungivorous, xylophagous, and saprophagous populations, insects favouring debilitated plants, and the parasites and predators of these groups. (From auth. summary)

- 959 Erdman, H.E. EFFECTS OF RADIATION ON COMPETITIVE INSECTS. p.277 of "Research and Development in Progress. Biology and Medicine. No.3". Abstr. TID-4203, Division of Technical Information Extension, (AEC), Oak Ridge, Tenn. Apr.1964, 290p.
- 960 Woodwell, G.M., Sparrow, A.H. EFFECTS OF IONIZING RADIATION ON ECOLOGICAL SYSTEMS. p.26-27 of "Ecological Effects of Nuclear War". BNL-917, Brookhaven National Lab., Upton, N.Y. Aug.1965, 76p.

Field experiments with small, open, irradiated ecosystems have shown no clear tendency for devastating population explosions of insects after radiation damage, but experience is limited. Principal changes in insect population (cf. Brower) followed changes in abundance of food. Thus bark lice (Psicoptera) and certain beetles (*Ips*) increased in abundance in the zone of tree mortality. In certain instances there was a clear increase in the amount of damage by herbivorous insects (e.g. aphids). Three categories of radiation effects on ecosystems were established for predicting potential fallout effects.

See also:

- 310 Transport of radioactive materials by mud-dauber wasps. (Shinn, A.F. et al., 1964)
- 916 Changes in the insect populations of the low shrub synusia in a natural forest community exposed to chronic gamma radiation stress. (Brower, J.H., 1964)
- 930 Chromosomal aberrations in a natural population of *Chironomus tentans* exposed to chronic low-level radiation. (Blaylock, B.G., 1965)
- 940 Clinch River and related aquatic studies. (Nelson, D.J. et al., 1964)

## D. APPLICATIONS

### 1. General Articles. Surveys. Books

- 961 Bailey, P.J., Baines, B.D. IRRADIATION: PRESENT AND FUTURE APPLICATIONS. Nucl. Engng 9 (1964) 213-6.

Insect elimination by release of sterile males is discussed and conditions for successful application of the technique are listed. Using radiation to kill or sterilize insects in infected grains to reduce grain losses is also discussed. Food irradiation to kill fruit flies, to improve storage properties, to complete sterilization, and to eliminate salmonella is described. The designs of typical chemical irradiation plants are described, in which radiation is used to promote chemical reactions. Radio-induced sterilization of surgical products is also discussed. Control and measurement of dose is described. (NSA 18:1964,30080)

- 962 Ericson, L.-E. FOOD SUPPLY AND ATOMIC ENERGY RESEARCH. TJV 35 (1964) 245-51. (In Swedish)

The importance of atomic energy research to the world food supply is discussed. Ionizing radiation methods are analysed, with special reference to extermination of insects and parasites, disinfection of animal products, food preservation, industrial application, plant breeding, production of vaccines, etc. (Auth.)

- 963 Jefferson, S., Ed. **MASSIVE RADIATION TECHNIQUES**. London, George Newnes Ltd, 1964, 324p.  
Commercial applications of  $\gamma$ -radiation and high energy electrons are reviewed. The book is divided into sections on the interaction of radiation with matter, biological effects of massive radiation doses in relation to agricultural problems, plant breeding, the sterilization of medical equipment and pharmaceutical products, food irradiation, insect control (see ref. 1062), the use of radiation in the chemical industry, radiation sources, and dosimetry.
- 964<sup>(2)</sup> Knipling, E.F. **DIE SELBSTVERNICHTUNGSMETHODE DER SCHÄDLINGSBEKÄMPFUNG**. (The autocidal method in pest control). Umschau **63**, 20 (1963) 632-36. (In German)  
General article on the principle of the method and achievements to date.

See also:

- 824 The protection of the olive tree at the present time. (Melis, A., 1962)

## 2. Population Control

### (a) Sterile Male Technique

- 965 Butt, B.A., Hathaway, D.O. **INSECT CONTROL BY THE STERILE MALE TECHNIQUE**. (Bag 29: 1965, 52591). Wash. St. Hort. Ass. Proc., 60th A. Meet. **83** (1964) 86.
- 966 Diffidenti, G.A. **INSETTI STERILIZZATI CON L'ENERGIA ATOMICA**. (Insects sterilized with atomic energy). Agr. d'Ital. **10**, 2 (1964) 17-29. (In Italian)  
Review article.
- 967 Gibbons, H.L., Dille, J.R., Cowley, R.G. **INHALANT ALLERGY TO THE SCREW-WORM FLY: PRELIMINARY REPORT**. Archs envir. Hlth **10** (1965) 424-30.

Following the emergency landing of three light aircraft being used for the aerial dispersal of radio-sterilized screw-worm flies (*Cochliomyia hominivorax*) eradication programme, a preliminary survey revealed that ~ 70% of the flight crew members reported developing mild to severe allergic symptoms, after spending from 2 weeks - 6 months in the programme. The radio-sterilized screw-worm flies are being released in the Southwestern United States to combat multimillion dollar losses to the cattle industry. Up to 100 000 000 flies per week are raised in a plant near Mission, Texas. Fertile adult flies lay eggs which hatch into larvae and then transform into the pupal stage. Sexual sterilization is accomplished 5½ d after entering this stage when canisters containing 25 000 pupae are given a dose of about 8000 R of  $\gamma$ -radiation from a <sup>60</sup>Co source. The pupae are packaged in boxes of about 400 and placed in holding rooms until they emerge as adults. They are then loaded into aircraft at the plant or trucked in refrigerated vans to other distribution centres. Dispersal is made from 20 light aircraft. Plans for release vary from 200 - 1000 flies/square mile, depending upon the presence or absence of reported infestations in the area. Persons involved in aerial dissemination of irradiated flies experienced significant allergic manifestations, with near disastrous results in some cases. Symptoms consist of eye irritation, nasal congestion, coughing, wheezing, and shortness of breath. The results of a survey of symptoms, dust analysis, skin testing, and case histories are presented. (NSA 19:1965, 43652)

- 968 Katiyar, K.P. **CONTROL DE INSECTOS POR MEDIO DE LA TECNICA DE MACHOS ESTERILIZADOS POR RADIACIONES GAMMA**. Boln Jta Control Energia Atómica **9**, 48 (1964) 25-8. (In Spanish)  
The control of insects by  $\gamma$ -sterilization of the males is briefly described, and the advantages of this method are tabulated. The principal studies now in progress on its practical utilization are summarized. (NSA 19:1965, 3910)

- 969 Knipling, E.F. THE POTENTIAL ROLE OF THE STERILITY METHOD FOR INSECT POPULATION CONTROL WITH SPECIAL REFERENCE TO COMBINING THIS METHOD WITH CONVENTIONAL METHODS. ARS-33-98, USDA series. Nov.1964, 54p.
- 970 Knipling, E.F. THE STERILITY PRINCIPLE OF INSECT POPULATION CONTROL. p.251-2 of "Proceedings of the 12th International Congress of Entomology, London, 8-16 July 1964". Freeman, P., Ed. London, Royal Entomological Society of London, 1965.
- Review of various problems involved in the genetic control of insects. A table shows the relative trends of hypothetical insect populations subjected to different systems of control. By means of hypothetical models attempts had been made to appraise the potential role of sterile-insect release in the elimination of various important insects. Two ways of employing sterile-male releases have been considered for controlling populations of tsetse flies. One way involves the use of such releases only to eliminate a low density population. The other method involves the application of a single insecticide mist spray treatment to reduce the natural adult population followed by the sustained release of sterile males. Thus, 1700 fully competitive sterile male tsetse flies/square mile for about one year should eliminate a population that initially averages about 200 flies/square mile. For a population of about 1000 tsetse flies/square mile complete elimination should result from a single insecticide application, followed by the release of about 1500 sterile males during the following 6-12 months.
- 971 LaBrecque, G.C., Keller, J.C. ADVANCES IN INSECT POPULATION CONTROL BY THE STERILE-MALE TECHNIQUE. Report of a Panel held in Vienna, 20-24 Jul.1964. STI/DOC/10/44. International Atomic Energy Agency, Vienna (Austria), Jun.1965, 81p.
- Recent progress in inducing sexual sterility in insects is reviewed. Emphasis is placed on fruit flies and tsetse flies but data are included on 39 species of economic or medical significance. The utilization of radioisotopes for labelling insects for use in ecological studies is also discussed. Dosage and rearing problems for large scale production of the various species (in particular, Dacus oleae and Ceratitis capitata) are discussed. The "flushing technique" of overloading natural resources with a sterile population has been tried out in the field in Australia. Other field studies are reported from Costa Rica, Israel, Tunisia (also using <sup>32</sup>P), and USA. Increasing attention is being paid to the tsetse fly (Glossina palpalis) in Central Africa (chemosterilants proving very promising). The screw-worm eradication programme in Texas is discussed. Several other species have been studied, with a view to eventual radiation-induced sterilization (the horn fly Haematobia irritans, Drosophila melanogaster, the codling moth Carpocapsa pomonella, the mallow moth Pectinophora gossypiella, the European cornborer Ostrinia nubilalis, Aedes aegypti, Calandra granaria, the cutworm moth Laphygma exigua, Acanthoscelides obtectus, the cotton bollworm Chloridea obsoleta, the Colorado beetle Leptinotarsa decemlineata, Culex fatigans, Aedes aegypti, Anopheles quadrimaculatus). The status of chemosterilants is reviewed in some detail (p.48-52), work being reported on numerous species. The toxicology of chemosterilants is also discussed. Other topics considered are genetic manipulations (incompatibility, hybrid sterility, deleterious genes, gene propagation), adjuncts to the sterility approach, major pitfalls in release programmes, a proposed approach to the study of radiation sterilization and chemical sterilization (including a partial list of insects on which sexual-sterility research has been initiated), the integration of the sterile-insect-release method with other means of control, and finally the theory of dominant lethality. Panel recommendations are summarized.
- 972 Ramos, V.P. O METODO DOS MACHOS ESTERILIZADOS DE INSETOS NA LUTA CONTRA AS PRAGAS. (The sterile-male technique in the fight against pests). "Colloquium held at the National Agronomical Station, Oeiras, Portugal, 8 Feb.1964", 25p. (In Portuguese)
- Review article. The principles of the method, radiation effects at the cellular level, and the radiosensitivity of the female and the male reproductive systems are discussed, also the results of trials carried out on various species to date, and the conditions under which the technique can be applied with success.
- 973 Ramos, V.P. THE USE OF STERILIZED MALE INSECTS IN PEST CONTROL. Gazeta Agric. Moçamb. 16, 177 (1964) 47-53. (In Portuguese)

- 974 Weidhaas, D.E. RESEARCH ON RADIOISOTOPES AND RADIATION IN INSECT CONTROL RELATED TO THE DEVELOPMENT OF THE STERILE-MALE TECHNIQUE. p.189-95 of "5th Inter-American Symposium on the Peaceful Application of Nuclear Energy". Washington, D.C., Pan American Union, 1965.

The use of the sterility principle for the control or eradication of insect pests or vectors of disease offers a new technique in pest control operations. One means of using this new technique is the mass production and release of insects sterilized by  $\gamma$ -radiation into natural populations. The effectiveness of the method has been demonstrated in the successful eradication of the screw-worm fly, Cochliomyia hominivorax, from the island of Curacao and the Southeastern United States. A current programme in the Southwestern United States has demonstrated that a high degree of control of this same fly in a non-isolated area can be achieved by the method. A recent pilot experiment has also demonstrated that the sustained release of sterilized melon flies resulted in the eradication of this pest of vegetables from the island of Rota in the Pacific Ocean. Over the past several years encouraging results have been obtained in preliminary research on the sterile-insect method for controlling several other important insect pests. Results are summarized from research to date and ways are considered whereby the sterile-insect method might be used alone or integrated with other methods to achieve control or eradication of certain insects. The role of radioisotopes in fundamental studies relating to the development of sterile-male techniques is summarized. (Auth.)

See also:

- 555 Insect gametogenesis as a target. (Virkki, N., 1965)

#### (i) Coleoptera

- 975<sup>(2)</sup> Horber, E. MAIKÄFER GEGEN MAIKÄFER? EIN VERSUCH ZUR VERTILGUNG VON ENGERLINGEN DES FELDMAIKÄFERS (Melolontha vulgaris Fabr.) MIT RÖNTGENESTRAHLEN MÄNNCHEN. (Cockchafer against cockchafer? An attempt at eradicating larvae of the field cockchafer Melolontha vulgaris Fabr. by means of x-rayed males). Mitt. Schweiz. Landw. 11, 10 (1963) 145-55. (In German)

For maturation feeding and mating cockchafers choose a particular area and return to the original emergence sites for oviposition. Short of overpopulation or exhausted food supplies, the beetles will continue to follow the same pattern of behaviour. These foci of breeding activity and development therefore have the same practical effect as if island populations were to be investigated. From 1955-1962 samples were obtained in three different areas, dug up during a flight year prior to emergence and flight. Subsequently, males were x-rayed with various doses (1000, 2000, 4000, 5000, 6000, 10000, and 20000 R) and then mated with non-irradiated females. The minimal dose for temporary sterilization was 3000 R. No marked alteration in behaviour or life span was observed even after 20000 R. Field trials were made with males irradiated with 3000 - 5000 R (average dose of 3325 R). Test regions were defined, and details of the operation given (marking, irradiation, and release). 3109 Cockchafers were released from an open crate in 1959, 8594 in 1962. The subsequent drop in population was very marked, and the method shows great promise as preventive treatment, even under conditions where mass rearing is not possible, females copulate several times, and the population density in the area considered is low and cannot be dealt with effectively by other means.

See also:

- 659 The potential application of  $\gamma$ -radiation for the sterilization of Chloridea obsoleta for the purpose of reducing its population. (Andreev, S.V. et al., 1964)  
971 Advances in insect population control by the sterile-male technique. (LaBrecque, G.C., Keller, J.C., 1965)

#### (ii) Diptera

- 976 Anonymous. CONTROL OF MEDITERRANEAN FRUIT FLY IN CENTRAL AMERICA. Pl. Prot. Bull. F.A.O. 13, 2 (1965) 47-8.

A project to eradicate *Ceratitis capitata* (Wied.) from Costa Rica by the release of sterile males is in progress. Between July 1963 and September 1964, over 110 million pupae of the fruit fly were reared from about 190 million eggs, over 63 million pupae were irradiated from a  $^{60}\text{Co}$  source and over 60 million adults from the irradiated pupae were released over an area of about 2-5 square miles on the Puntarenas peninsula, where the principal host-fruit of the fly (available all the year) is *Terminalia catappa*. Monthly releases were begun in July 1963 and increased from January 1964, irradiated pupae being set out in cages from which the adults (which emerged 12-24 h later) were able to escape. The releases were sufficient to outnumber the existing fly population by 40:1, and the percentage of *Terminalia* fruits infested, which was 38-52 in Aug. - Dec. 1963 and 49.5 in Jan. 1964, fell progressively until it was only 3 in Sep. 1964. It is considered that more laboratory work and larger releases over greater areas will be required if the technique is to be improved. (RAE-A 53:1965, 545)

- 977 Anonymous. ORIENTAL FRUIT FLIES ..... GONE FROM GUAM. *Agric. Res.*, Wash. 13, 11 (1965) 12-13.

The sterile male technique was applied to the control of *Dacus dorsalis* on the island of Guam. Large numbers ( $20 \times 10^6$ ) of sterile males were released in 1963, at a cost of 4 cents/acre. This is of particular interest when compared with the cost of conventional chemical control measures.

- 978 Cohen, I. INSECT CONTROL BY THE STERILE MALE TECHNIQUE. *Haklauth Israel* 10, 4 (1965) 45-46.

The article is mostly concerned with *Ceratitis capitata*.

- 979 Donnelly, J. POSSIBLE CAUSES OF FAILURE IN A FIELD TEST OF THE "STERILE MALES" METHOD OF CONTROL. p. 253 of "Proceedings of the 12th International Congress of Entomology, London, 8-16 Jul. 1964". Freeman, P., Ed. London, Royal Entomological Society of London. 1965.

After release of large numbers of  $\gamma$ -radiation-sterilized *Lucilia sericata* into a small, apparently isolated, population for two seasons, reliable estimates showed that the population had not even been reduced. Various aspects of the test are examined for any evidence of possible causes of failure. No clear-cut cause could be demonstrated. Serious impediments to the success of the method may have existed in the sector of release and maintenance of adequate numbers of adequately viable, sterile individuals. Both males and females are sterilized by doses of 4500 rep and above. Material for release was treated with 6000 or 7000 rep, at which dose adult longevity was reduced to 60% of normal. There was evidence that the sterile male was not as effective as the normal in achieving a second copulation, and was incapable of a third. Normal males, on the other hand, average at least six and are sometimes capable of up to twelve copulations. Due to the fact that neither sex can mate within their first three adult days, thus allowing for some dispersal, the danger of absorption of the total potency of a sterile male by a single sterile female is reduced. An unknown and possibly serious loss of effective sterile population may have occurred due to: (a) serious depredation at emergence while large numbers of newly emerged flies were aggregated at the release sites; (b) loss of viability inherent in laboratory strains under field conditions; (c) very low emergence rates in released material during the first season especially; (d) vulnerability of young material to extreme weather conditions.

- 980 Feron, M. STERILISATION DE *Ceratitis capitata* PAR LES IRRADIATIONS. Interim Report, received July 20, 1964, 5p. (mimeographed)

En conclusion d'une première série d'essais, il apparaît à l'échelle du Laboratoire que les meilleures conditions, pour obtenir une stérilité presque totale des mâles, soient faites d'une dose de 8 à 10 kR appliquées à des pupes de 8 jours. Pour être efficaces, les mélanges de population doivent être de l'ordre de 90 insectes stériles pour 1 fertile.

- 981 Hightower, B.G., Adams, A.L., Alley, D.A. DISPERSAL OF RELEASED IRRADIATED LABORATORY-REARED SCREW-WORM FLIES. *J. econ. Ent.* 58, 2 (1965) 373-4.

The initial release point was on the Colorado River about 15 miles NE of Llano, Texas. About 200 000 flies, marked with red or blue dye, were released at weekly intervals from 25 Apr. - 15 Nov. 1964. In late July, the release point was moved 120 miles up the Colorado River. All traps were



placed along the Colorado and Concho Rivers. A maximum dispersal range of 180 miles for individual flies was obtained.

- 982 Hightower, B.G., Alley, D.A. OBSERVATIONS ON THE EFFECTS OF RELEASING STERILE SCREW-WORM FLIES IN NORTHWESTERN VERACRUZ, MEXICO. *Bull. ent. Soc. Am.* 11, 3 (1965) 173. Abstr. 376. Presented at the "Annual Meeting of the Entomological Society of America, New Orleans, 29 Nov. - 2 Dec. 1965".

The feasibility of controlling screw-worm flies over large areas by releasing sterile flies on flight lanes 8 miles apart was tested in northern Veracruz, Mexico. Promising results were obtained in areas with low populations of native flies, but increasing populations in favourable environments were not controlled. (Abstr.)

- 983 Husman, C.N. USE OF AIRCRAFT IN THE ERADICATION OF SCREW-WORMS IN THE SOUTH-EASTERN UNITED STATES. *Int. agric. Aviat. Conf.* (1964) 56-57. (4th International Agricultural Aviation Conference, 1962).

Use of sterile-fly technique for controlling *Cochliomyia hominivorax*. (BAg 30:1966,4784)

- 984 International Atomic Energy Agency, Vienna (Austria). APLICACIONES DE ENERGIA NUCLEAR EN ENTOMOLOGIA. *Boln Jta Control Energía Atómica* 9, 48 (1964) 103-6. (In Spanish). Translation of Circular Letter SC/822-2.

Four possible projects for the eradication of insects using male sterilization by  $\gamma$ -radiation and supported by the IAEA are described. The insects to be eradicated are the Mediterranean fruit fly, the olive fly, locusts, and the tsetse fly. The cost of a coordinated investigation to determine the feasibility of the projects is estimated.

- 985 Katiyar, K.P., Valerio, J. EFECTO CAUSADO POR LA INTRODUCCION DE MACHOS ESTERILIZADOS POR RADIACION GAMMA, EN UNA POBLACION NORMAL DE MOSCAS DEL MEDITERRANEO (*Ceratitis capitata*). (Effect of introducing males sterilized by  $\gamma$ -radiation into a normal population of Mediterranean fruit fly (*Ceratitis capitata*). *Turrialba* 14, 4 (1964) 211-12. (In Spanish, with English summary)

The males were exposed to 10 kR of  $\gamma$ -radiation from a  $^{60}\text{Co}$  source, at 1600 R/min. A reduction in sexual vigour and fertility was observed.

- 986 Katiyar, K.P., Valerio, J. FURTHER STUDIES ON THE POSSIBLE USE OF STERILE-MALE RELEASE TECHNIQUE IN CONTROLLING OR ERADICATING THE MEDITERRANEAN FRUIT FLY, *Ceratitis capitata* Wied., FROM CENTRAL AMERICA. p.197-202 of "5th Inter-American Symposium on the Peaceful Application of Nuclear Energy". Washington, D.C., Pan American Union, 1965.

Since its recent appearance (1955) in Costa Rica, the Medfly has produced a highly adverse effect on the local fruit industries. In spite of strict quarantine regulations observed on the country's two frontiers, the fly has managed to cross the borders. It has already spread into Nicaragua and is reported recently to have entered Panama. The Medfly meets all the basic requirements for control by the sterile male technique. A cooperative project between the Inter-American Institute of Agricultural Sciences and the Organismo Internacional Regional de Sanidad Agropecuaria (OIRSA) has been under way for the past two years to explore the feasibility of this method of control under Central American conditions. Irradiation tests carried out with a  $^{60}\text{Co}$  pool irradiator have shown that males irradiated with 10 000 or 12 500 R at a 7-, 8- or 9-d-old pupal stage produce sperms with almost 100% dominant lethal factors. Females treated at similar stages do not lay eggs beyond 7500 R. Such pupal treatment inhibits neither the adult's emergence nor decreases its subsequent survival rate. Contrariwise, a slight increase in the longevity of the adults, especially females, was noticed when flies were treated with 10 000 or 12 500 R at the 7-d-old pupal stage. Irradiated males do not seem to compete equally with normal males in insemination. In a laboratory test in small cages, overflooding of the normal population by 39-times with sterile flies reduced the fertility of normal females by 89%. To test the laboratory findings in the field, weekly releases of more than half a million irradiated flies have been under way since May 1963 in a small semi-isolated test area of  $\sim 4 \text{ km}^2$ . (Auth.)

- 987 Moh, C.C. STERILIZATION OF MEDITERRANEAN FRUIT FLY. p.419 of "Research and Development in Progress. Biology and Medicine, No.3". Abstr. TID-4203, Division of Technical Information Extension, (AEC), Oak Ridge, Tenn. Apr.1964, 290p.
- 988 Moh, C.C. THE APPLICATION OF NUCLEAR ENERGY TO AGRICULTURE. Annual Report. TID-20708, Inter-American Inst. of Agricultural Sciences, Turrialba, Costa Rica. 1 July 1964, 76p.  
 Section D (p.51-67) deals with the sterilization of the Mediterranean fruit fly and its application to fly eradication. Studies include work on mating behaviour; single- and multi-mating effects on egg hatch; effects of alternate matings of normal and sterile males on fertility; effect of cage size on fertility; field test with sterile releases (release of ~120 000 <sup>32</sup>P-labelled adults at Chacarita in April 1964 showed that allowances must be made for the constant migration of released flies). The study of the ecology of the tropical warble fly, *Dermatobia hominis* Linn., and a method of control, with a view to applying the sterile male technique are considered on p.67-8.
- 989 Morales, E. ACTIVITIES OF THE MEDFLY INVESTIGATION SECTION DURING JULY 10, 1963 - JUNE 30, 1964 ON INSECT CONTROL BY RADIATION. OIRSA, SAN SALVADOR, EL SALVADOR. NP-15348, Organismo Internacional Regional de Sanidad Agropecuaria, San Salvador (El Salvador). nd, 19p.  
 Procedures used for the rearing and radiation exposure of massive numbers of Mediterranean fruit flies are discussed. Adult flies were exposed to 10 000 R  $\gamma$ -radiation and pupae were exposed to 2500 R. Several hundred thousand adult flies were released in a test area to study the effects of sterile adults on population control. Preliminary results are reported. Studies were also conducted on the biological control of the Mediterranean fruit fly by parasites and the behaviour of the flies, in which flies marked with radioisotopes or colour points were released. (NSA 20:1966,12633)
- 990 Morales, E. SUMMARY OF THE MEDFLY INVESTIGATION SECTION'S ACTIVITIES DURING THE PERIOD JUNE 1964 - MARCH 1965 ON INSECT CONTROL BY RADIATION. NP-15349, Organismo Internacional Regional de Sanidad Agropecuaria, San Salvador (El Salvador). nd., 13p.  
 Procedures for the rearing of mass numbers of Mediterranean fruit flies, exposed to <sup>60</sup>Co  $\gamma$ -radiation during various developmental stages, and the marking of irradiated flies with fluorescent powders are described. Preliminary results are reported from studies on the effects of the release of radiation sterilized flies on populations of the insects in Nicaragua and Panama. (NSA 20:1966,12634)
- 991 Organismo Internacional Regional de Sanidad Agropecuaria, San Salvador (El Salvador). SUMMARY OF THE MEDITERRANEAN FRUIT FLY INVESTIGATION PROGRAM JUNE 1964 THROUGH MAY 1965. OIRSA-AID-USDA-AIEA-IICA, 1965, 81p.  
 A number of tests were made, in the laboratory as well as in the field, to obtain information to improve the massive reproduction technique and release of sterile *Ceratitis capitata*. Techniques of mass rearing, sterility determinations for flies after <sup>60</sup>Co irradiation, mortality of sterile flies released in the field, a technique for marking adults of sterile flies, and optimum temperature conditions during rearing, just prior to emergence, and prior to release are among the problems studied. Numerous tables are given. The preliminary aspect of the work is stressed.
- 992 Smith, C.L. THE STERILE SCREWORM FLY PRODUCTION PLANT. "Proceedings of the 14th Annual Meeting. Texas Agricultural Aviation Conference and Short Course Pest Control, B1-B8, 1965".
- 993 Soria, F. PERSPECTIVES DE LUTTE BIOPHYSIQUE CONTRE *Ceratitis capitata* Wied. EN TUNISIE. Documents Techniques 8 (1965) 9p. Tunisia, Institut National de la Recherche Agronomique, Ariana.
- 994 Steiner, L.F., Harris, E.J., Mitchell, W.C., Fujimoto, M.S., Christenson, L.D. MELON FLY ERADICATION BY OVERFLOODING WITH STERILE FLIES. J. econ. Ent. 58, 3 (1965) 519-22.  
 The melon fly, *Dacus cucurbitae* Coquillett, was eradicated from the 33 square mile island of Rota, M.I., by the release of 257 million flies irradiated as pupae with 9.5 kR from a <sup>60</sup>Co source.

Pupae were produced in Hawaii and air shipped 3800 miles. Releases were made from both air and ground at weekly intervals between Sep. 1962 and July 1963. They were preceded by low-cost applications of concentrated protein hydrolyzate-malathion bait sprays, limited to about 20 of the principal fly-producing sites. Predators, off-island drift, and shorter life of boxed flies reduced the efficiency of the releases. Fruit infestations disappeared late in December 1962 and none occurred in 1963. Sterile eggs were found until the end of February 1963. Sterile flies of both sexes congregated in host plantings, the same as wild flies, but sting damage by females was far less per female than by wild individuals. Some sterile flies of each sex lived 4 months after the last release. (Auth.)

See also:

- 632 How far a fly can fly. (Anonymous, 1965)
- 637 The effect of cobalt 60 gamma rays on the biology of the eye gnat, Hippelates pusio Loew. (Flint, H.M., 1965)
- 907 Field behavior of sexually sterile Anopheles quadrimaculatus males. (Dame, D.A. et al., 1964)

### (iii) Lepidoptera

- 994-a Bulyginskaya, M.A. THE POSSIBILITY OF UTILIZING GAMMA RAYS FOR SEXUAL STERILIZATION OF THE MALLOW MOTH (Pectinophora malvella Hb.). Dokl. Akad. Nauk SSSR (1963) 76-78. R. Zh. Biol. No. 1E180. 1964. Presented at: "Fifth Conference of the All-Union Entomological Society, 1963".

- 995 Graham, H.M., Glick, P.A., Ouye, M.T., Martin, D.F. MATING FREQUENCY OF FEMALE PINK BOLLWORMS COLLECTED FROM LIGHT TRAPS. Ann. ent. Soc. Am. 58, 4 (1965) 595-6.

Studies on the possibility of controlling Pectinophora gossypiella (Saund.) on cotton by the release of sterile males created interest in the frequency of mating of the females in the field. Dissection of females taken in light traps in Texas in 1962-63 indicated that, although multiple mating occurred, single mating was by far the commonest. During the early part of the season, while the population was still low, there was a high proportion of unmated individuals, and in view of this and the high mortality of young larvae during this period releases of sterile males would best be made at this time. (RAE-A 53:1965,514)

- 996 Hussein, M.M., Madsen, H.F. STERILIZATION OF THE NAVEL ORANGEWORM, Paramyelois transitella (Walker), BY GAMMA RADIATION (LEPIDOPTERA: PHYCITIDAE). Hilgardia 36, 3 (1964) 113-37.

The studies described were directed towards the control of P. transitella (Wlk.) on almonds and walnuts in California by the release of insects sterilized after  $\gamma$ -irradiation (from a  $^{60}\text{Co}$  source). Laboratory culture required a high relative humidity and good indirect air circulation. Successful mating was obtained at temperatures between 10° and 16°C, with a light intensity similar to that of the early-morning hours. Temperatures of about 28°C favoured growth and development. Irradiating eggs or larvae did not give complete sterility without injurious effects and high mortality. Common injuries were failure to pass a critical stage of development, delayed metamorphosis and deformation of pupae or adults. Mature pupae about 8-d-old best tolerated irradiation and also were convenient to handle. Both sexes were sterilized completely by exposure of the mature pupae to a dose of 50 000 rad, and this treatment did not seem to affect mating habits, egg-laying or length of adult life. A dose of 40 000 rad very nearly sterilized most of the pupae treated, but not with sufficient certainty for use in a control project. Multiple matings were fairly common but would not interfere with the success of a control programme. At least one female mated 5 times, and some males mated 3 times and probably more. The most important result of the work was the demonstration that sterile females of P. transitella can be used for autocidal control as successfully as sterile males. Adding both sterile males and sterile females to a normal population gives two-way competition for the normal mates and does not simply add but actually multiplies the probabilities of sterile matings by the normal males and the normal females. (Based on auth. summary)

- 997 Katiyar, K.P., Ferrer, F. STERILIZATION OF THE MEDITERRANEAN FRUIT FLY AND ITS APPLICATION TO FLY ERADICATION. p.69-94 of "The Application of Nuclear Energy to Agriculture. Annual Report". NYO-2043-108, Inter-American Inst. of Agricultural Sciences, Turrialba, Costa Rica. 1 Jul.1965, 107p.

Experiments were carried out to obtain detailed information on the fertility of females which first mate with a normal and later with an irradiated (sterile) male, or vice versa (p.69-73). The sterile males were obtained by irradiating pupae with a dose of 10 000 R 24 h prior to adult emergence. First mating of virgin females and males was permitted when the adults were 5 d old. Eggs were collected daily. A second mating with appropriate males was permitted a week later. The results which are tabulated indicate that the effect of matings with normal males subsequent to sterile matings is almost twice as great (as far as the fertility of the females is concerned) as when sterile matings follow the normal ones. - The effect of humidity on egg-hatch of the Medfly is described on p.74-84. An evaluation of the performance of four different types of yeasts in the larval diet is given on p.94-93, and the report finishes with a brief note on the progress of the cooperative project with OIRSA (Organismo Internacional Regional de Sanidad Agropecuaria (Central American Phytosanitary Organization)) on the Medfly (p.94).

- 998 Proverbs, M.D. THE STERILE MALE TECHNIQUE AND ITS POSSIBLE USE FOR CODLING MOTH ERADICATION. Can. Ent. 96 (1964) 143.

When mature male pupae of the codling moth, Carpocapsa pomonella (L.), were subjected to 40 000 rad of  $\gamma$ -radiation, dominant lethals were induced in at least 98% of the sperm without affecting adult emergence, mating, or adult longevity. Higher exposures reduced the frequency of mating. The female codling moth was more radiosensitive than the male. In general, radiosensitivity of both sexes decreased as development progressed from the egg to the adult stage. The progeny that survived from normal females  $\times$  irradiated (30 000 rad) males were at least 89% male; female progeny were completely sterile, males mostly so. When irradiated males (exposed as mature pupae to 40 000 rad) were confined over dwarf apple trees with normal males and normal females in the proportion of 10:1:1 the reproductive potential, based on the numbers of mature larval progeny, was reduced 85%. When the ratio was 20:1:1 the reproductive potential was reduced 98%. The sterile male technique is now being tested for codling moth eradication in an isolated apple orchard in the Okanagan Valley of British Columbia.

- 999 Proverbs, M.D., Newton, J.R., Logan, D.M. PROGRESS REPORT ON CODLING MOTH CONTROL BY THE STERILE MALE TECHNIQUE. WP/31/7. p.31. 1964-1965. Unpublished work.

- 1000 Katiyar, K.P., Ferrer, F. EVALUATION OF THE STERILE MALE TECHNIQUE FOR CONTROLLING THE COFFEE LEAF MINER, Leucoptera coffeella Guer. p.97-102 of "The Application of Nuclear Energy to Agriculture. Annual Report". NYO-2043-108, Inter-American Inst. of Agricultural Sciences, Turrialba, Costa Rica. 1 Jul.1965, 112p.

After discussing the damage due to the leaf miner and its biology, the authors consider the theoretical suitability of the sterile male technique to control measures against the pest. With regard to possible rearing, larval duration is short (~3 weeks) and the amount of food consumed by an individual larva very little. Although no leaf miner has so far been reared on an artificial diet, several leaf-feeding Lepidoptera have been reared successfully. The dispersion of the (winged) moth should present no problems following release. The miner population fluctuates greatly, reaching some very low seasonal levels when release of irradiated males would be very effective. The adults of the leaf miner are non-destructive to man, animals, and plants. The only stage damaging to plants is the larva, so that sterile males would not cause any additional damage on release. Insecticides used so far did not affect the pupa in its silken cocoon but did affect beneficial insects. The sterile male technique therefore appears to be very promising for controlling the coffee leaf miner.

See also:

- 633 Effect of gamma radiation on the sterilization of Corcyra cephalonica Stanton (Lep.: Pyralidae). (Atwal, A.S., Sethi, S.L., 1964)
- 635 Suppression of the reproductive potential of the potato tuberworm, Gnortmoschema operculella by gamma irradiation. (Elbadry, E., 1964)
- 647 Lethal and sterilising effects of cobalt-60 gamma rays on Argyroplotea leucotreta. (Myburgh, A.C., 1963)

#### (iv) Hemiptera

See:

- 639 Gamma radiation and the reproductive behavior of male Rhodnius prolixus. (Gomez-Nunez, J.C., 1964)

#### (b) Overloading Resources

See:

- 971 Advances in insect population control by the sterile-male technique. (LaBrecque, G.C., Keller, J.C., 1965)

### 3. Infestation and Countermeasures

#### (a) Stored Products

- 1001 Cornwell, P.B., Bull, J.O., Pendlebury, J.B. CONTROL OF WEEVIL POPULATIONS (Sitophilus granarius (L.)) WITH STERILISING AND SUBSTERILISING DOSES OF GAMMA RADIATION.\* p.71-95 of "Entomology of Radiation Disinfestation of Grain". Cornwell, P.B., Ed. Oxford, Pergamon Press, 1966\*\*, 236p.

The efficacy of 16 000 rad, recommended for industrial applications of  $\gamma$ -radiation for the control of insects in grain, is substantiated by the complete sterilization and death of 10 million insects of a wild strain of grain weevil under conditions simulating bulk storage. Substerilizing doses of 10 000 - 14 500 rad suppress weevil populations to a very low level and prevent their increase for 4-8 months; this period of "short-term" control is related to the size of the population and oxygen tension at irradiation. The reproductive potential of fertile and subfertile grain weevils is depressed when added to large irradiated populations; partial protection to the grain against reinfestation is afforded by the insemination of contaminants with sterile sperm, which remains competitive within the female and with fertile sperm subsequently inseminated, for periods greater than 4 months. A reduction in reproductive potential of weevils which may be underdosed at irradiation gives considerable flexibility to the requirement of dose uniformity in plant design for disinfestation of grain. (Auth.)

\* For an earlier report of the same title, AERE-R-3892, see II/1479.

\*\* Since the work reported in this volume was carried out by the Entomology Group of the Wantage Research Laboratory, U.K.A.E.A., during the period 1955-61, individual papers are included in the present bibliography although they were actually not published in book form until 1966.

- 1002 Laudani, H., Tilton, E.W., Brower, J.H. USDA RESEARCH PROGRAM AND FACILITIES FOR THE USE OF GAMMA IRRADIATION IN THE CONTROL OF STORED-PRODUCT INSECTS. Fd Irrad. 6 (1965) A6-A9.

A  $^{60}\text{Co}$  irradiator for grain disinfestation to be located at Savannah, Georgia, is described. The pilot plant, which will be operated by the USDA, will be located near to a railroad spur in an arrangement such as to permit continuous grain flow. Total activity of the  $^{60}\text{Co}$  source will be about 26 000 Ci and capacity of the irradiator will be from 2500 - 10 000 lb of grain/h. In addition to bulk grain irradiation, packages and bags of a large range of processed agricultural commodities, including various cereals and grain products, dried fruit and nuts, and legumes may be processed in a separate section of the irradiator designed for package handling. Research will be oriented toward establishing: the minimum effective lethal dose for use in packaging plants where complete and immediate mortality of the insects is required; and the minimum effective dose to induce dominant lethal genes, thereby breaking the reproductive cycle of the insects. (NSA 20:1966,19124)

- 1003 Marzke, F.O. IRRADIATION STUDIES WITH INSECTS INFESTING BULK GRAIN AND PACKAGED COMMODITIES. p. 53-55 of "Radiation Pasteurization of Foods. Summaries of Accomplishment". Presented at the "5th Annual Contractors Meeting, 20-21 Oct. 1965". CONF-651024, nd, 210p.
- Construction of a bulk grain and packaged commodity irradiator at Savannah, Ga., is reported to be almost completed. Results are reported from preliminary studies on the radiosensitivity of insects infesting stored products. Insects were exposed to doses of 10, 20, 30, 50, or 100 krad  $\gamma$ -radiation during the egg, larva, pupa, and adult stage. The merchant grain beetle and the almond moth, Cadra cautella, were both found to be very radiosensitive. (NSA 20:1966, 9324)
- 1004 Ross, E. DOSIMETRY, TOLERANCE, AND SHELF-LIFE EXTENSION RELATED TO DISINFESTATION OF FRUITS AND VEGETABLES BY GAMMA IRRADIATION. p. 49-52 of "Radiation Pasteurization of Foods. Summaries of Accomplishment". Presented at the "4th Annual Contractors Meeting, 21-22 Oct. 1964". CONF-641002, Division of Isotopes Development, AEC and Division of Biology and Medicine, AEC. 216p.
- Practically all fruits and vegetables, and some flowers, are subject to rigid plant quarantine restrictions for out-shipment to the Mainland USA from Hawaii. The present commercial variety of pineapple, which does not carry fruit fly infestation, is permitted for shipment without restrictions. Fumigation by ethylene dibromide is required prior to shipment for papaya fruits. Since 1954 the Hawaii Fruit Fly Investigations Laboratory, USDA, has been developing information on ionizing radiation dosage requirements to obtain disinfestation. A 416-Ci  $^{60}\text{Co}$ -facility was installed at that time for this purpose. Experiments to date have indicated that low dosages of 20-25 krad can effectively disinfest papaya, cucumber, lychee, and tomato. Insect species were found to vary in susceptibility and fruit varieties to vary in tolerance. Mango fruits present a special problem by reason of seed weevil infestation. Although naked weevils can be sterilized or killed with 25 krad, those in the seeds inside the fruit resist external dosages up to 100 krad. Present evidence indicates that  $\gamma$ -irradiation dosages to prolong the shelf-life would be sufficiently high to ensure disinfestation.
- See also:
- 641 Susceptibility of the saw-toothed grain beetle, Oryzaephilus surinamensis (L.) to gamma radiation. (Jefferies, D.J., 1966)
- 647 Lethal and sterilizing effects of cobalt-60 gamma rays on Argyroprocta leucotreta. (Myburgh, A.C., 1963)
- 651 Some effects of gamma radiation on Rhizopertha dominica (F.), Cadra cautella (Wlk.), Plodia interpunctella (Hübner) and Lasioderma serricorne (F.). (Pendlebury, J.B. et al., 1966)
- 653 Susceptibility of Australian strains of Sitophilus and Tribolium species to gamma radiation. (Shipp, E., 1966)
- 656 Sterilizing effects of gamma radiation on eight insect and one mite species that infest stored products. (Tilton, E.W. et al., 1964)
- 811 Susceptibility of the grain and rice weevils, Sitophilus granarius (L.) and Sitophilus zeamais Mots. to gamma radiation. (Cornwell, P.B., 1966)
- 846 Irradiation studies with insects infesting bulk-grain and packaged commodities. (Tilton, E.W., Brower, J.H., 1965)
- 877 Effects of ionizing radiation on pests in cereals. II. Effects of cobalt-60 radiation on Tyroglyphus farinae mites. (Szyszko, E. et al., 1962)
- 883 The effect of culture environment on the susceptibility of Sitophilus granarius (L.) to gamma radiation. (Bull, J.O., Cornwell, P.B., 1966)
- 1009 The possibility of using the  $^{60}\text{Co}$  radioisotope against grain storage insects. (Blazek, J. et al., 1964)
- 1010 The entomology of radiation disinfestation of grain. (Cornwell, P.B., 1966)
- 1012 Application of ionizing radiation to grain disinfestation. (Goresline, H.E., 1965)
- 1014 Effects of continuous and fractionated doses of gamma radiation on the survival and fertility of Sitophilus granarius (L.). (Jefferies, D.J., 1966)
- 1018 Dosimetry, tolerance, and shelf life extension related to disinfestation of fruits and vegetables by gamma irradiation. (Ross, E., Brewbaker, J.L., 1965)
- 1019 Disinfestation of dried fruits. (Shchegoleva, G.I., 1963)

(b) Disinfestation Measures (Sources. Conveyor Systems. Etc.)

- 1005 Cornwell, P.B. RADIATION DISINFESTATION OF GRAIN - THE LAST 5 YEARS. Fd Irrad. 6 (1965) A2-A5.

Development of the programme for radiation disinfestation of grain is reviewed. The events that have taken place over the past five years are surveyed as a background to the joint action now being taken by the IAEA and FAO to establish a pilot plant for evaluating radiation disinfestation of grain as an industrial process in Turkey. It is concluded that at best radiation disinfestation is an additional insecticide technique, which is never likely to replace present practices, but may be considered as an alternative where conditions are favourable for its application. (NSA 20: 1966,19123)

- 1006 Anonymous. THE UNIVERSITY OF HAWAII IS AWAITING DELIVERY OF A 30 000-CURIE  $^{60}\text{Co}$  IRRADIATOR. Nucleonics Week 5, 48 (1964) 4.

The pool-type facility - Mark IV of a model designed at Brookhaven National Labs and already in use at several US universities - will be used in experimental irradiation treatment of papayas, pineapple and mangos. The food container, which is manipulated inside the 12 ft deep tank by a hoist, can be temperature-controlled from 20-150°F. Additional tubes holding small canisters can be used for small batch tests. (From citation)

- 1007 Anonymous. AGRICULTURE DEPARTMENT (THE) HAS AWARDED TWO COBALT CONTRACTS .... Nucleonics Week 6, 17 (1965) 5.

(Agriculture Dept. has awarded two cobalt contracts) "to American Nuclear Corp., Oak Ridge. One involves encapsulation of 30 000 Ci for a new and versatile research irradiator at North Carolina State Univ. USDA's Entomology Research Div. is supplying the Co, and a grant from the State's Board of Science & Technology will finance the facility, on which AMF Atomics (in its first irradiator proposal) is apparent low bidder. The second USDA order is for 2800 Ci of  $^{60}\text{Co}$ , its encapsulation and construction of five insect sterilization units. These will be scattered from Mexico to Oregon for experiments in the eradication of a variety of fruit and crop pests. The North Carolina State-irradiator, designed by Martin Weit, university director of nuclear science & engineering, will feature a second, higher specific-activity  $^{60}\text{Co}$  source (5000 Ci at 50 Ci/g) in a variable-intensity irradiator, which Weit says will permit very precise dosages. The second source will be ordered soon". (Direct citation)

- 1008 Boisor, M., Henrion, B. PROCEDE ET INSTALLATION POUR LA DESTRUCTION D'INSECTES PAR RAYONNEMENTS NUCLEAIRES. Prop. ind. nucl. 7, 18 (1964) 76.

Procédé de stérilisation d'insectes par radiations nucléaires comportant deux stades: 1) attraction des insectes par émanations d'un produit chimique contenu dans des coupelles, par exemple: -1,2-sec-butyl 6-méthyl 3-cyclohexène 1-carboxylate, ou l'essence d'angélique, ou analogue pour la mouche des fruits; -1,2-sec-acétoxy 1-hydroxy-cis-9-octadécène pour le bombyx; 2) stérilisation par une source radio-active (émetteur  $\beta$  ou  $\gamma$ ) disposée dans un container à l'intérieur d'un logement de béton, et fermé par un bouchon solidaire d'un couvercle amovible sur lequel sont fixées les coupelles. (Res.)

- 1009 Blazek, J., Dockal, J., Kolín, J. THE POSSIBILITY OF USING THE  $^{60}\text{Co}$  RADIOISOTOPE AGAINST GRAIN STORAGE INSECTS. Mlynsko-Pekarský Průmysl 10 (1964) 636-9. (In Czech)

Containers with grain, to which were added 30 live grain beetles (*Calandra granaria* L.) and grain that had beetle eggs, were exposed to various doses of  $^{60}\text{Co}$   $\gamma$ -radiation. A 5000-rad dose was sufficient to exterminate the beetles, their eggs, and larvae. Three arrangements for irradiation of grain are described. In two cases, the grain would be irradiated as it passed slowly into the silo. The third, and recommended arrangement, involved the placement of a metal tube along the shaft of the silo. The source would be suspended inside the tube on a cord, which could be unwound and wound by a motor at the top of the tube or pipe. The radiation source could be raised or lowered to obtain the desired exposure. (NSA 19:1965,32830)

- 1010 Cornwell, P.B., Ed. "The Entomology of Radiation Disinfestation of Grain". Oxford, Pergamon Press, 1966, 236p.

The work had been carried out by the Entomology Group of the Wantage Research Laboratory in 1955-61. This group was established as part of the contribution of the United Kingdom Atomic Energy Authority to the finding of possible industrial applications of the new sources of radiation now available. The book contains a foreword by H. Seligman, an introduction by the Editor (pp. xi-xx), who reviews the necessity for the treatment of stored grain to free it from insect pests and the development of the use of ionizing radiation for this purpose, and a final discussion by him (pp. 187-227, 2 pages of references), in which he surveys the various problems that may arise in the application of radiation for the disinfection of grain as an industrial process. The bulk of the book consists of 13 scientific papers, with summarized findings and conclusions.

- 1011<sup>(2)</sup> Farkas, H., Kiss, I., Razga, Z., Vas, K. EXPERIMENTS ON THE INFLUENCE OF IONIZING RADIATIONS ON THE GROWTH OF BREWING BARLEY. Brauwissenschaft 16 (1963) 483-91. (In German)

The effects of 250-kV x-rays in doses varying from 1.5 - 50 krad on the sprouting of barley to be used in brewing were investigated. The x-rays were applied during steeping or at different points during germination to study the development of root growth in barley. It was found that radiation doses of over 12 krad exert an inhibitory action on the development of the roots but do not arrest the growth of tips and tendrils. The radiation could be used conveniently during storage of the barley since it also has a lethal action on insect pests which normally contaminate the grain, and thus prevents damage by them. The action of radiation doses of 25-800 krad was therefore investigated on air-dried barley (moisture content 11.1%). On the basis of a 4-d growth test, it was established that steeped barley of moisture content of 35 - 45% is 5 times more sensitive to radiation than air-dried barley. Radiation sensitivity is increased both with increasing moisture content above 16.3% and when it is lowered from 13.7 - 9.5%. During storage of the irradiated air-dried barley for 7 months, no regeneration was observed. A close relation was found between the increase in malt yield and the reduction of the growth of roots obtained after irradiating the grain. After treating the air-dried barley with doses of 60 - 100 krad, the malting loss was reduced by 1 - 2%. All qualitative characteristics of the malts prepared from the irradiated barleys were satisfactory. The increase in malt yield obtained by irradiation occurred without disturbance of the enzymic processes which occur during germination. (From NSA 20:1966,10619)

- 1012 Goresline, H.E. APPLICATION OF IONIZING RADIATION TO GRAIN DISINFESTATION. Fd Irrad. 6 (1965) A10-A12.

Genesis of a pilot plant in Turkey for the radiation disinfection of grain is discussed. The installation will consist of a <sup>60</sup>Co irradiation unit of approximately 150 000 Ci located in an operating grain terminal as an independent unit that will not interfere with the normal operation of the terminal. The pilot plant will be used to study the effectiveness of grain radiosterilization under actual commercial conditions and to identify the problems that would be encountered in applying the method to all grain taken into a large operating terminal. (NSA 20:1966,19125)

- 1013 Henderson, L.P. RADIATION TREATMENT OF GRAIN AND GRAIN PRODUCTS. p.8-9 of "Radiation Pasteurization of Foods. Summaries of Accomplishment". Presented at the "4th Annual Contractors Meeting, 21-22 Oct. 1964". CONF-641002, Division of Isotopes Development, AEC and Division of Biology and Medicine, AEC. 216p.

An extensive study was conducted to determine the gross effects of  $\gamma$ -radiation on the Indian meal-moth, Plodia interpunctella; the Angoumois grain moth, Sitotroga cerealella; the lesser grain borer, Rhyzopertha dominica, the confused flour beetle, Tribolium confusum; the rice weevil, Sitophilus oryzae; the cigarette beetle, Lasioderma serricorne; the black carpet beetle, Attagenus piceus; Trogoderma glabrum; and the grain mite, Acarus siro. Dosages included 13.2 kR, 17.5 kR, 25 kR, 45 kR, and 100 kR. Three of the species of beetles were also treated at a fractionated dosage of 13.2 kR  $\pm$  10% repeated 5 times at hourly intervals. All metamorphic stages of the test insects were used in tests. In all species of beetles, the adults were the most tolerant of radiation, followed by the pupae, then the larvae, while the eggs were the most susceptible. No dosage used was sufficiently high to produce immediate complete mortality of all species. Sterility occurred following  $\gamma$ -radiation of a single continuous dose of 25 kR or more. The results of the fractionated dosage indicate that the total effect is not cumulative. (NSA 19:1965,15947)



- 1014 Jefferies, D.J. EFFECTS OF CONTINUOUS AND FRACTIONATED DOSES OF GAMMA RADIATION ON THE SURVIVAL AND FERTILITY OF *Sitophilus granarius* (L.)\* p.41-56 of "The Entomology of Radiation Disinfestation of Grain". Cornwell, P.B., Ed. Oxford, Pergamon Press. 1966\*\*, 236p.

Megacurie sources of  $^{60}\text{Co}$  are required to disinfest grain at 16 500 rep ( $\approx 16\,000$  rad), the dose level evaluated for commercial treatment, at conveyor rates normally encountered in grain handling. Maximum efficiency in the use of irradiation plant might be obtained with sources of lower curie strength to ensure continuous operation if the full dose for sterilization could be given in a process of repeated passes. The question arises as to whether many sublethal and substerilizing doses would provide the same measure of control as continuous treatment. A study of dose fractionation on the grain weevil shows differences in survival and fertility which may be attributed to "recovery" of somatic and reproductive cells between treatments. Differences in survival were obtained in all developmental stages; recovery was obtained with intervals of 10 min and longer, the process being governed by the number of fractions, the fractional dose, interval time and interval temperature. Recovery in reproductive capacity was obtained in irradiated eggs, larvae and pupae, but not in adults. Whilst these effects are manifest at low doses, fractionated treatment does not adversely affect the degree of control achieved at the commercial dose level. (Auth.)

\* For an earlier paper of the same title see II/1363.

\*\* Since the work reported in this volume was carried out by the Entomology Group of the Wantage Research Laboratory, U.K.A.E.A., during the period 1955-61, individual papers are included in the present bibliography although they were actually not published in book form until 1966.

- 1015 Leggo, D., Gellatley, J.G., Seberry, J.A., Peggis, L.D., Long, J.K., Hall, E.G. POST-HARVEST STERILIZATION OF ORANGES AGAINST QUEENSLAND FRUIT FLY. Fd Preserv. Q. 24, 1 (1964) 15-9.

For quarantine purposes, New Zealand has recently officially recognized ethylene dibromide fumigation of packed oranges as an acceptable measure against Queensland fruit fly. Irradiation as a possible method of post-harvest sterilization of fruit against fruit fly is also being studied. In conjunction with the Australian Atomic Energy Commission the Division of Food Preservation of CSIRO is carrying out studies in this field. So far it has been found that Queensland fruit fly in oranges can be killed by low doses of  $\gamma$ -radiation, but it is not certain whether rind injury can be avoided. It is thought that when suitable commercial irradiation facilities become available, irradiation may prove a useful method of quarantine treatment.

- 1016 Lowenberg, H., Morton, M.R. BULK GRAIN IRRADIATOR (BGI) AND MOBILE GAMMA IRRADIATOR (MGI). p.70-72 of "Radiation Pasteurization of Foods. Summaries of Accomplishment". Presented at the "5th Annual Contractors Meeting, 20-21 Oct. 1965". CONF-651024, nd, 210p.

The design features are described of a bulk grain irradiator under construction at Savannah, Ga. The facility has the capability of supplying a disinfestation dose of 25 000 rad  $^{60}\text{Co}$   $\gamma$ -radiation at a grain flow rate of 5000 lb/h, with a dose max./min. ratio of less than 1.65. It also has a package handling capability for irradiating such packaged products as cake mixes, flour, and raisins. Design features are also described of a mobile  $\gamma$ -irradiator capable of being transported by road from one harvesting area to another. It is designed to process 1000 lb/h of a product, such as strawberries, at a radiopasteurization dose between 175 000 and 225 000 rad or it can process large quantities of a product, such as potatoes or onions, at a desprouting dose of between 5000 and 15 000 rad. (NSA 20:1966, 9326)

- 1017 Menhinick, E.F. DESIGN OF  $^{90}\text{Sr}$  SOURCES FOR ECOLOGICAL STUDIES INVOLVING BETA IRRADIATION. ORNL-TM-997, Oak Ridge National Lab., Tenn. 11 Nov. 1964, 17p.

Three  $^{90}\text{Sr}$  -  $^{90}\text{Y}$  sources containing 0.08, 0.8, and 8.0 Ci respectively, giving surface dose rates of approximately 100, 1000, and 10 000 R/h, respectively were designed for ecological studies. These sources will consist of  $^{90}\text{SrCl}_2$  mixed with sodium silicate and painted on transite plaques which will then be placed in leak-tested aluminium source holders. These sources will be used for acute and chronic  $\beta$ -irradiations of insects, studies in radiation detection by insects, glass rod dosimetry research, and tissue absorption studies. (Auth.)

- 1018 Ross, E., Brewbaker, J.L. DOSIMETRY, TOLERANCE, AND SHELF LIFE EXTENSION RELATED TO DISINFESTATION OF FRUITS AND VEGETABLES BY GAMMA IRRADIATION. p.43-48 of "Radiation Pasteurization of Foods, Summaries of Accomplishment". Presented at the "5th Annual Contractors Meeting, 20-21 Oct. 1965". CONF-651024, nd, 210p.
- Results of a study of the effects of low dose  $\gamma$ -radiation on the control of decay microorganisms, insect disinfestation, fruit ripening, and extension of refrigerated storage life of tropical fruits showed good results for papayas and mangoes. Mangoes are attacked by the seed weevil, Sternonchus mangiferae. A dose of > 75 krad proved lethal within 2 weeks, whereas 20 krad caused sterility. The studies encourage shipping and marketing tests of these fruits. Studies on pineapple and lychee fruits showed that radiation processing extended the shelf life of whole pineapple by 7 - 10 d but produced colour and flavour changes in pureed pulp. No significant differences were found in the aroma, flavour, or texture of radiative processed lychee, but highly significant colour changes were found in whole, unpeeled fruits treated with 25 - 200 krad  $\gamma$ -radiation and stored at 35°F for 4 - 5 weeks. Data are included on the effects of  $\gamma$ -radiation on enzyme and pectin content of the fruits.
- 1019<sup>(2)</sup> Shchegoleva, G.I. DISINFESTATION OF DRIED FRUITS. Zashch. Rast. Pt. 9 (1963) 14-15, (In Russian)
- Insects and mites infesting dried fruits in factories in Fergana (Uzbekistan) and Kanibadam (Tadjikistan), in Soviet Central Asia, and work on their control are reviewed. The most important pests are Plodia interpunctella (Hb.), Ephestia elutella (Hb.), Oryzaephilus surinamensis (L.), Tribolium confusum Duv. and Tenebroides mauritanicus (L.). In 1951-53, effective programmes of control with fumigants were developed using ethylene dichloride alone or mixed 3:1 with ethylene dibromide, or 3:2 with carbon tetrachloride. In 1954-55, a system of control by heat was applied commercially in one factory, in which a variety of infested dried fruits were exposed for 25-30 min to a temperature of 60-85°C [140-185°F]; complete control resulted. In tests on control by  $\gamma$ -radiation from a <sup>60</sup>Co source applied at a rate of 2000 R/min, a dose of 70 000 rad was sufficient to kill most pests within 2 weeks, but one of 300 000 rad was necessary for satisfactory control of Dermestids and mites. (RAE-A 53:1965,389)
- 1020 Smith, T.L. A SERVICEABLE IRRADIATOR-SHIELD DEVICE. Ann. ent. Soc. Am. 58, 2 (1965) 245-7.
- The author describes the design of a device in which a radioactive isotope (<sup>60</sup>Co) can be stored and which can also be used for irradiating insects or other small objects. The device was made up at the local workshop at very low cost. By inserting a small, electrostatic-ionization-chamber type of dosimeter into the empty, troughlike space in the servicing shaft, and calibrating the emission rate of the isotope, a rate of R/s values is established.
- 1021 Vitro Engineering Co., New York, N.Y. PRELIMINARY DESIGN REPORT - TITLE I ON BULK GRAIN IRRADIATOR. KLX-1869. 27 Jan. 1965, 68p.
- The Bulk Grain Irradiator will be capable of delivering  $\gamma$ -radiation doses in the disinfestation range (approximately 25 000 rad) to handle 5000 lb/h of grain at this dose. The bulk grain will be loaded into a hopper outside the irradiator from whence it will be carried by conveying equipment through the irradiation section. The grain will leave the irradiation cell by means of a pressurized air system. The bulk grain may be stored in any of the bins provided by the USDA located either inside or outside of the building. It also may be delivered directly into railway cars located at the nearby spur. In addition, packages and bags of a large range of products, including dried fruit, peanuts, cereals, grains and flour, may be processed in the section of the irradiator designed for package handling. The packaged products will be arranged in aluminium carriers and loaded automatically into the package handling section of the irradiator from the interior of the building. Work space and storage space for the packaged product are provided in that vicinity. It is expected that initially packaged products will be irradiated. Bulk grain irradiation is not likely to occur in substantial volume until approximately a year after the completion of the facility. The same source material will be used for both the bulk grain and the package handling part of the irradiator. (Auth.)

See also:

- 641 Susceptibility of the saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.) to gamma radiation. (Jefferies, D.J., 1966)
- 651 Some effects of gamma radiation on *Rhizopertha dominica* (F.), *Cadra cautella* (Wlk.), *Plodia interpunctella* (Hüb.) and *Lasioderma serricorne* (F.). (Pendlebury, J.B. et al., 1966)
- 653 Susceptibility of Australian strains of *Sitophilus* and *Tribolium* species to gamma radiation. (Shipp, E., 1966)
- 759 Strontium-90 - Yttrium-90 beta source. (Menhinick, E.F., 1964)
- 811 Susceptibility of the grain and rice weevils, *Sitophilus granarius* (L.) and *Sitophilus zeamais* Mots. to gamma radiation. (Cornwell, P.B., 1966)
- 870 Susceptibility of laboratory and wild strains of the grain weevil *Sitophilus granarius* (L.) to gamma radiation. (Cornwell, P.B., 1966)
- 872 The effect of dose rate on the response of *Tribolium confusum* Duv., *Oryzaephilus surinamensis* (L.) and *Sitophilus granarius* (L.) to  $\text{Co}^{60}$  gamma radiation. (Jefferies, D.J., Banham, E.J., 1966)
- 877 Effects of ionizing radiation on pests in cereals. II. Effects of cobalt-60 radiation on *Tyroglyphus farinae* mites. (Szyszko, E. et al., 1962)
- 883 The effect of culture environment on the susceptibility of *Sitophilus granarius* (L.) to gamma radiation. (Bull, J.O., Cornwell, P.B., 1966)
- 899 The influence of temperature upon the radiation susceptibility of *Sitophilus granarius* (L.). (Pendlebury, J.B., 1966)
- 1001 Control of weevil populations (*Sitophilus granarius* (L.)) with sterilising and substerilising doses of gamma radiation. (Cornwell, P.B. et al., 1966)
- 1002 USDA research program and facilities for the use of gamma irradiation in the control of stored-product insects. (Laudani, H. et al., 1965)
- 1003 Irradiation studies with insects infesting bulk grain and packaged commodities. (Marzke, F.O., 1965).
- 1004 Dosimetry, tolerance, and shelf-life extension related to disinfection of fruits and vegetables by gamma irradiation. (Ross, E., 1964).

### (c) Economics

See:

- 1007 Agriculture department (the) has awarded two cobalt contracts .... (Anonymous, 1965)
- 1010 The entomology of radiation disinfection of grain. (Cornwell, P.B., 1966)
- 1012 Application of ionizing radiation to grain disinfection. (Goresline, H.E., 1965)
- 1014 Effects of continuous and fractionated doses of gamma radiation on the survival and fertility of *Sitophilus granarius* (L.). (Jefferies, D.J., 1966)
- 1021 Preliminary design report - Title I on bulk grain irradiator. (Vitro Engineering Co., New York, N.Y., 1965)

### (d) Detection and Damage Assessment

- 1022 Aebensold, P.C., Rotariu, G.J., Weiss, F.J. WORLDWIDE STATUS OF NUCLEAR APPLICATIONS TO THE WOOD, PAPER AND PULP INDUSTRIES. p.27-47 of "Nuclear Application to the Wood, Paper, and Pulp Industries Conference". Pullman, Wash., Washington State University, 1964.

Review of the applications and uses of isotope and radiation technology in the major foreign countries of the world in their wood, paper and pulp industries. Some reference is made to non-destructive tests for determining decay resistance and insect damage of wood used in poles or in underwater constructions. Since decaying wood absorbs much faster than healthy wood, a simple and reliable decay test is possible using  $^{192}\text{Ir}$  salt solutions. Marine piling which supports many docks and other marine constructions is often infested with marine borers. Piling thus becomes weakened and may give way under stress. The Battelle Memorial Institute, Columbus, Ohio, has developed a

$\gamma$ -radiographic method using thulium-170 for the underwater inspection of 3.5 in. thick waterlogged marine piling.

- 1023 Berryman, A.A. IDENTIFICATION OF INSECT INCLUSIONS IN X-RAYS OF PONDEROSA PINE BARK INFESTED BY WESTERN PINE BEETLE, Dendroctonus brevicornis LeConte. Can. Ent. 96, 6 (1964) 883-8.

A guide to the interpretation of x-ray radiographs of samples of the bark of ponderosa pine (Pinus ponderosa) infested with D. brevicornis and its principal predators and parasites is presented. Diagrammatic and photographic illustrations of the radiographic images are given to enable analysts to gain experience more rapidly. (From auth.)

- 1024 DeMars, C.J., Jr. CORRECTION TO "A COMPARISON OF RADIOGRAPH ANALYSIS AND BARK DISSECTION IN ESTIMATING NUMBERS OF WESTERN PINE BEETLE". Can. Ent. 97, 2 (1965) 206.

Corrections applied to table I [see Can. Ent. 95:1963, 1112-6, and 11/1509]; the correlation coefficient for "Pupae plus Adults-Live" is changed from "poor" to "fair" ( $r = 0.7675$  instead of 0.5546).

- 1025 Fatzinger, C.W., Dixon, J.C. USE OF X-RAYS TO DETECT SOUTHERN PINE BEETLES IN SHORT-LEAF PINE BARK. J. For. 63 (1965) 451-5.

The larvae of Dendroctonus frontalis Zimm. mine away from the bark/wood intersurface as they mature, and complete their development in the outer bark. Late instar larvae, pupae, and adults are in the outer bark. To estimate population levels of the southern pine beetle, brood counts are made of a large number of bark samples which are removed and dissected, a tedious and time-consuming technique. A method of sampling by x-rays is described. Rectangular 3- x 6-in. bark samples,  $\frac{1}{4}$  -  $\frac{1}{2}$  in. thick were removed at 5 ft height intervals along the bole of felled infested pines. Bark samples were maintained in a portable cooler. Field-collected bark samples were x-rayed with a Kelket x-ray unit (300 mA, 125 kV power max.), eight samples being x-rayed simultaneously. Beetle images on radiographs were counted and the results compared with those obtained from dissection. Analysis of the data demonstrates approximately equal accuracy for both methods. The x-ray method, however, is more rapid and far less expensive.

- 1026 Graham, H.M., Robertson, O.T., Martin, D.F. RADIOGRAPHIC DETECTION OF PINK BOLL-WORM LARVAE IN COTTONSEED. J. econ. Ent. 57, 3 (1964) 419-20.

Soft x-rays were tested. The use of open cotton bolls had to be abandoned. Exposures of 17 kV and 800 mA-s were most favourable for 100-g samples of seed cotton and cottonseed ginned from 100- and 150-g samples of seed cotton. Exposures of 900 mA s were required for optimum darkening in 150-g samples of seed cotton. For the detection of bollworm larvae (Pectinophora gossypiella (Saunders)) the radiographic technique has considerable merit, particularly when many samples need to be examined and when detection of every larva is not necessary; when it is, however, careful dissection remains the best procedure.

- 1027 Howe, R.W., Currie, J.E. SOME LABORATORY OBSERVATIONS ON THE RATES OF DEVELOPMENT, MORTALITY AND OVIPOSITION OF SEVERAL SPECIES OF BRUCHIDAE BREEDING IN STORED PULSES. Bull. ent. Res. 55, 3 (1964) 437-77.

The rate of development of six species of Bruchidae including four species of Callosobruchus attacking stored pulses was studied over a wide range of constant temperature and humidity and the rate of oviposition of five of them investigated over a range of temperatures at 70% R.H. and a range of humidities at 30°C. Treatment with soft x-rays was restricted to times when identifiable incidents were expected to occur (e.g. the period of pupation, the appearance of windows to give warning of the event), since moulting could not be detected and larvae could not with certainty be assigned to instars. In order to divide the period of pupation into its two parts, pupa and quiescent adult in seed, about 1/5 of the windows were removed so that the transformation from pupae to adult could be observed. This also enabled a check to be made of the correctness of the timing of pupation as inferred from x-ray photographs of pupae of C. rhodesianus.

- II/1515 Hurlock, E. T. DETECTION OF INSECTS IN DRIED PEAS. x-RAYS SHOW MOST PROMISE AMONG 8 METHODS. Fd Mf. 38, 7 (1963) 367-9.\*

An investigation was carried out on dried peas to determine whether some of the methods used for grain could be extended to pulses and to compare the results obtained by the various methods for reliability and accuracy. The x-ray method was found to be accurate, reliable, and rapid.

\* No abstract available in Vol. II.

- 1028 Knight, F.B., Albertin, W. PORTABLE x-RAY EQUIPMENT IN FORESTRY RESEARCH. J. Forestry 63, 7 (1965) 543-4.

A Picker 50 kV x-ray unit, successfully adapted for field use was tested in studies of a variety of forest insects without destroying their habitat. They were the twig-boring insect Oberia schaumii Lec. (habits and developmental rate), the white-pine weevil Pissodes strobi (Peck), the poplar and willow weevil Sternonchus lapathi (L.), the pitch nodule borer Petrova albicapitana Busck on jack pine, the jackpine shoot borer Eucosma sonomana Kearfott on jack pine, conemoths, and other borers in aspen. Insects at various positions, up to 6-8 ft up the trees were photographed by adapting the equipment accordingly. Routine procedures (monitoring, transport, field conditions) are described.

- 1029 Soares de Gouveia, A.J., Moreira, M.I. USE OF x-RAYS TO EVALUATE THE EFFECTIVENESS OF INSECTICIDE TREATMENTS. Garcia de Orm 10, 4 (1962) 661-65. (In Portuguese)

The use of x-rays was compared with the usual process of examination of  $F_1$  or  $F_2$  (1st or 2nd generation). The efficacy of phytopharmacological products on immature forms of insects whose progenitors had been treated with insecticides was determined. The studies were carried out on one of the "cultivated types" of the common bean (Phaseolus vulgaris) from Angola, and Zabrotes subfasciatus and Acanthoscelides obtectus, which are the most important pests of beans in that territory. In the insecticide applications, inert dust (diatomite and kaolin) and lindane dusts, containing diatomite and kaolin, were used. A considerable economy of time is obtained by using the x-ray method. (CA 62:1965,12388)

- 1030 Wickman, B.E. A COMPARISON OF RADIOGRAPHIC AND DISSECTION METHODS FOR MEASURING SIRICID POPULATIONS IN WOOD. Can. Ent. 96, 3 (1964) 508-10.

Correlation coefficients were calculated for the estimates of insect density obtained by radiographs versus dissection, and for the estimates obtained by radiographs versus radiographic guided dissection. Estimates of numbers of siricids (Sirex longicauda Middl. (Hymenoptera: Siricidae)) in white fir obtained by the two methods were closely correlated. The radiographic methods are more accurate than dissection alone, and also faster and cheaper.

#### 4. Sericulture\*

- 1031<sup>(1)</sup> Kipiani, R. Ya., Tsetskhladze, T.V. THE KILLING OF SILKWORM PUPAE AND THE PRESERVATION OF SILKWORM COCOONS BY GAMMA RAYS. Soobshch. Akad. Nauk gruz. SSR (1967) 657-662. (In Russian)

- 1032<sup>(2)</sup> Molnar, I., Babos, L., Gubicza, A., Lukacsóvics, F. RADIOAKTIV SUGARAKKAL ELÖLT SELYEMGABOKKAL KAPCSOLATOS VIZSGÁLATOK. (The killing of cocoons by irradiation from radioactive sources). Magy. Text-Tech. 15 (1962) 196-99. (In Hungarian)

- 1033 Molnar, I., Gubicza, A., Babos, L. A STUDY OF SILK COCOONS FROM THE EGGS OF Bombyx mori L. IRRADIATED WITH  $Co^{60}$ . Magy. Text-Tech. 16 (1964) 449-51. (In Hungarian)

\* See also Bombyx mori silkworm.

Eggs of Varo silkworms at various stages of their development (10 h to the last embryonic stage) were exposed to 200 - 7000 and 100 000 R doses of  $^{60}\text{Co}$   $\gamma$ -radiation. The high dose was lethal. The quality of the cocoons exposed to 200 R was nearly identical to the control group. Increased irradiation (3000 - 5000 R) brought about an increased number of deformed and dead cocoons and decreased the silk content of the cocoons and the length of the spinnable fibres; these cocoons were also smaller than the controls. The characteristics of the next generation of each subgroup will be studied. Improvements are expected in these. (NSA 18:1965,24302)

- 1034 Tazima, Y. "The Genetics of the Silkworm". London, Logos Press, Prentice Hall, Inc. 1964, 253p.

This is a treatise on the development of the silkworm from mating to the spinning of raw silk. It explains the embryology, chromosomogenesis, heredity, sex determining factors and cocoon colours produced by carotinoids in detail. Other factors such as voltinism, moulting, natural mutations, hormones, artificial parthenogenesis and radiation induced mutations are discussed less completely. The appendix contains a list of silkworm genes issued by the Science Council of Japan in 1953. This is a useful book for the scientist engaged in scientific work, but it is too technical for most practical sericulturists. (BA 45:1964,102888)

## 5. Biological Control

- 1035 Balock, J.W. DIFFERENTIAL EFFECT OF GAMMA RADIATION ON FRUIT FLIES AND FRUIT FLY PARASITES. J. econ. Ent. 58, 6 (1965) 1169.

In conducting experiments in Hawaii to determine the use of gamma radiation as a quarantine treatment for destroying infestations of the oriental fruit fly, Dacus dorsalis Hendel, and the Mediterranean fruit fly, Ceratitis capitata (Wiedemann), in fresh fruits and vegetables, the author observed that parasitization was quite high in many of the wild fruits treated. Flies and parasites were counted in treated and non-treated false kamani (Terminalia catappa L.), T. chebula Retz., ball kamani (Calophyllum inophyllum L.), hog plum (Spondias mombin L.), guava (Psidium guajava L.), strawberry guava (Psidium cattleianum Sabine), and acerola or Barbados cherry (Malpighia glabra L.). Parasites appeared to be more resistant to  $\gamma$ -radiation than their fruit fly hosts. Higher parasite survival occurred at all dosages tested but differences were most apparent at the lowest dosages of 1000 or 2000 R. At these dosages higher parasite survival than in non-irradiated controls suggested a beneficial rather than harmful effect, although the effect may have been due to errors in estimating populations. (Auth.)

See also:

- 890 Synergistic action of radiation and of Bacillus thuringiensis toxin in protozoan diseases of insects. (Jafri, R.H., 1963)  
891 Influence of pathogens on the life span of irradiated insects. (Jafri, R.H., 1964)  
892 Influence of pathogens on the life span of irradiated insects. (Jafri, R.H., 1965)  
893 Prospects of integrated radiation and microbial control of harmful insects. (Jafri, R.H., 1965)

## 6. Disease Control

- 1036 Ayuzawa, C., Yusa, F. ON THE INACTIVATION OF THE VIRUSES OF THE SILKWORM, Bombyx mori L., BY  $^{60}\text{Co}$ -GAMMA RAY IRRADIATION. Nippon Sanshigaku Zasshi (J. seric. Sci., Tokyo) 33, 2 (1964) 130-33. (In Japanese)

See also:

- 896 The treatment with x-rays of eggs of Bombyx mori L. parasitized by Nosema bombycis Naeg. (Masera, E., 1965)

## 7. Miscellaneous

- 1037<sup>(2)</sup> Kurir, A. MÖGLICHKEIT DER BEKÄMPFUNG DER TERMITEN MIT ATOMMÜLL. (Possibility of controlling termites with atomic waste). Holzforsch. Holzverwert. 15, 4 (1963) 67-70. (In German)

In connection with the finding of Reticulitermes flavipes (Koll.) in Austria, the author suggests that atomic waste might be used for the control of termites in open country. Such waste is available from nuclear reactors. Waste containing <sup>60</sup>Co giving off relatively low doses of  $\gamma$ -radiation could be lowered into the soil in probes of lead or refined steel surrounded by concrete in close proximity to queens and replacement queens, the object being to affect the gonads of both sexes and bring about negative gene mutations in the heterochromosomes resulting in progressive reduction in reproductive capacity over several years. <sup>90</sup>Sr could also be used, but is less suitable. The limitations of such a method, the necessary precautions, and the details of application and the periodic monitoring of the level of radioactivity round the probes are discussed. (RAE-A 53:1965,519)

- 1038 Popa, A., Mihalache, G. A CONTRIBUTION TO THE UTILIZATION OF RADIOACTIVE TRACERS IN THE PROTECTION OF FORESTS. Rev. Padurilor 87, 2 (1965) 59-62. (In Rumanian)

See also:

- 1041 The development of a gamma radiographic method for the underwater inspection of marine piling. (Battelle Memorial Institute, 1956)

# ADDENDUM

## A. TECHNIQUES

### 1. Autoradiography

See:

- 53 Sites of fibroin formation in the silk gland in Bombyx mori. (Akai, H., Kobayashi, M., 1965)
- 82 Autoradiographic study of protein-producing cells. (Makarov, P. V., 1965)
- 100 Acetylcholinesterase in motor end-plates evaluated by electron microscope autoradiography. (Salpeter, M. M., O'Connor, A., 1965)
- 161 An autoradiographic study of RNA synthesis in isolated salivary glands of Drosophila hydei. II. Interferometric studies. (Pollister, A. W., 1965)
- 237 Incorporation of labelled thymidine into the silk gland of the silkworm. (Akai, H., Kobayashi, M., 1965)
- 248 Application of the autoradiographic technique to the study of the excretion in the coleopterous insect Tenebrio molitor L. (Marcuzzi, G., Degasperis, P., 1964)

### 2. Dosimetry

See:

- 1005 Radiation disinfection of grain—The last 5 years. (Cornwell, R. B., 1965)

### 3. Isotope Dilution

See:

- 334 Determination of the content of  $\gamma$ -hexachlorocyclohexane in technical samples by using isotope dilution with  $^{36}\text{Cl}$ . (Sieber, K. et al., 1964)
- 1023 Identification of insect inclusion in x-rays of ponderosa pine bark infested by western pine beetle, Dendroctonus brevicornis LeConte. (Berryman, A. A., 1964)

### 4. Labelled Pool Technique

See:

- 79 Amino acid requirements for the wheat stem sawfly determined with glucose- $\text{U-}^{14}\text{C}$  after vacuum-infiltration. (Kasting, R., McGinnis, A. J., 1964)
- 83 Glycine catabolism in Blattella germanica (L.). (Mansingh, A., 1965)
- 88 Rate of incorporation of amino acids into the web proteins of the spider Araneus diadematus Cl. (Peakall, D. B., 1963)
- 91 Nutritionally essential amino acids of Rhodnius prolixus (Stål) determined with glucose- $\text{U-}^{14}\text{C}$ . (Pickett, C., Friend, W. G., 1965)
- 95 The incorporation in vitro of l-valine into the fat-body protein of the larva of the blowfly, Calliphora erythrocephala. (Price, G. M., 1965)
- 101 Free amino acids of the virginia pine sawfly, Neodiprion pratti Dyar: their chromatographic determination and biosynthesis. (Schaefer, C. H., 1964)



## 5. Neutron Activation Analysis

- 1039<sup>(2)</sup> Guinn, V. P., Schmitt, R. A. DETERMINATION OF PESTICIDE RESIDUES BY NEUTRON-ACTIVATION ANALYSIS. Residue Rev. 5 (1963) 148-74.

Samples and standards were activated at the same flux, time, and counting conditions to detect the following pesticide residues: Br from nematocides at  $10^8$  neutrons/cm<sup>2</sup> sec from a Van de Graaff accelerator and  $\gamma$ -ray detection of 18 min <sup>86</sup>Br; also from a TRIGA reactor, a flux of  $10^{12}$  neutrons/cm<sup>2</sup> sec to determine 1 ppm Br with sensitivities of 0.005  $\gamma$  <sup>86</sup>Br and 0.01  $\gamma$  <sup>82</sup>Br; detection of 0.1  $\gamma$  <sup>36</sup>Cl; <sup>197</sup>Hg down to 0.1 ppm and with radiochemical separation sensitivities to 0.001 ppm were possible. Various neutron sources and radiation-detection instruments were described in detail. (CA 61:1964,11239h)

- 1040<sup>(2)</sup> Riebartsh, K. INAKTIVE MARKIERUNG VON INSEKTEN MIT DYSPROSIUM. (Inactive labelling of insects with dysprosium). NachrBl. dt. PflSchutzdienst, Stuttg. 15, 10 (1963) 154-7. (In German)

Insects can be labelled with inactive dysprosium, which is subsequently rendered radioactive in a nuclear reactor and measured in a scintillation counter. The procedure has all the advantages of conventional radiotracer techniques without the danger of contaminating the experimental environment with radioactivity and the necessity of restricting the duration of the experiment because of the short half-life of most of the conventional radiotracers so far used. Activation and measurement can take place at any time after labelling. The rareness of dysprosium ensures that the insects contain none except that administered to them, and the period required for activation is so short that other insect elements are not significantly affected and chemical recovery of the dysprosium before measurement is unnecessary. The half-life of radioactive dysprosium (<sup>165</sup>Dy) is 2.32 h, so that measurement can be carried out several hours after activation and, since only about a millionth of the original activity persists after 48 h, the whole process repeated if necessary after 2 d. An account is given of investigations carried out to develop an acceptable labelling technique. Adults of Ceratitis capitata (Wied.) were fed on solutions of dysprosium chloride, the preparation of which from the commercial oxide is described; 0.1% solutions caused little harm to them, but 1% solutions proved toxic, the insects dying within 3 d. A 0.02% dysprosium concentration was therefore selected. In one experiment, the insects were allowed to feed on the solution of 24 h and then received a normal diet during the next 10 d. Every 3rd day during this period, insects were removed for activation. In another, the insects received the solution for 10 d, at the end of which they were dissected and the various parts, and also the eggs laid by the females, investigated for their dysprosium content. Quantities of dysprosium amounting to  $10^{-8}$  g were determinable with a margin of error of about 5%. At  $10^{-6}$  g, the margin was about 1.3%. During 24 h of feeding, about  $10^{-6}$  g dysprosium was ingested per individual, and about 5% of that amount was still present after a further 10 d. Feeding for up to 10 d resulted in no greater content of dysprosium in the flies than was present after 1 d, and there was no difference in dysprosium content between males and females or between individuals that were washed with hydrochloric acid to eliminate external traces of dysprosium and those that were not. The content of dysprosium amounted to  $0.83 \times 10^{-6}$  g in the abdomen,  $0.16 \times 10^{-6}$  g in the head,  $0.03 \times 10^{-6}$  g in the legs and  $0.003 \times 10^{-6}$  g in the wings. The amount in the eggs was between  $0.02 \times 10^{-6}$  and  $0.15 \times 10^{-6}$  g. (Essentially RAE-A 53:1965,381)

See also:

- 243 The estimation of adenosine triphosphate and related compounds in insect tissue. (Heslop, J. P., 1964)

## 6. Miscellaneous (including Radiography)

- 1041<sup>(1)</sup> Battelle Memorial Inst., Columbus, Ohio. THE DEVELOPMENT OF A GAMMA RADIOGRAPHIC METHOD FOR THE UNDERWATER INSPECTION OF MARINE PILING. Summary Report, 15 Apr. 1956.

Thulium-170 is used for the underwater inspection of 3.5 in. -thick waterlogged marine piling. The damaging effects of infestation with marine borers can thus be detected in time for replacement.

- 1042(2) Carvalho, J. P. de. CONTRIBUTION OF THE RADIOGRAPHIC METHOD FOR THE STUDY OF Sitotroga cerealella (Oliv.). Agricultura, Ls. 19 (1963) 22-25. (In Portuguese)

1043 Deleted

- 1044 Gupta vanij, P., Venard, C. E. A RADIOGRAPHIC STUDY OF THE OESOPHAGEAL DIVERTICULA AND STOMACH OF Aedes aegypti (L.). Mosquito News 25, 3 (1965) 288-83.

The study was undertaken to determine the location of a meal and to observe the shape and position of the organs containing it. Foods used were glucose solution, citrated rabbit blood, heparinized fresh rabbit blood, and direct blood meals from mice. Various contrast media were used, the most suitable being Hypaque (sodium 3,5-diacetamido-2,4,6-triiodobenzoate), at 0.60 g/ml. An industrial x-ray unit (150 kV tube with Be-window and a focal spot of 0.7 and 2.5 mm) was employed. The shape, size, and positions of the diverticula became clearly visible. Two similar diverticula are located dorsal to the oesophagus which occupy 1/3-1/2 of the anterior portion of the thorax dorsal to the alimentary canal. The diverticula are separated at the midline by longitudinal flight muscles. The ventral diverticulum varies tremendously in size depending on the quantity inside it. The oesophagus puts the three diverticula in communication with each other in such a way that portions of their content can freely pass from one diverticulum to another by way of the common chamber formed by the oesophagus. After a blood meal the stomach (a narrow tube along most of its length) fills first from the posterior end. The ventral diverticulum is forced forward, forming a chamber of air under pressure anterior to the stomach. The duct, the oesophagus, and the dorsal diverticula all become inflated.

- 1045 Kirkpatrick, R. L., Wilbur, R. A. THE DEVELOPMENT AND HABITS OF THE GRANARY WEEVIL Sitophilus granarius WITHIN THE KERNEL OF WHEAT. J. econ. Ent. 58, 5 (1965) 979-85.

Radiographs were made with a General Electric x-ray Grain Inspection Unit using 20 kV and 5 mA and a 2 1/2 min exposure to Type M Industrial film (Eastman Kodak Co. 1960). Radiographs of wheat infested by granary weevil, S. granarius (L.), were made daily from egg to emerged adult. Enlarged prints of the radiographs were mounted consecutively on illustration boards to facilitate study of development and habits of the weevils within kernels. Measurements of tunnel widths were used to determine instars. A series of four increases in tunnel width occurred, each of which was followed by one or more days of static tunnel width. Each period of increased width paralleled feeding activity; the static width formulated the following instar.

- 1046(2) Lal, H., Ginocchio, S., Hawrylewicz, E. J. PROCEDURE FOR BIOASSAYING MOSQUITO REPELLENTS IN LABORATORY ANIMALS. Proc. Soc. exp. Biol. Med. 113 (1963) 770-2.

Mice were injected intravenously with 0.005 ml/g of mouse weight of an indicator solution containing 20 mg of Blancophore (SVT-400, General Dyestuff Co., N. Y.) dye and 20  $\mu$ Ci of  $^{131}\text{I}$ -serum albumin. Mosquitoes were admitted for 30 min. They were subsequently radioassayed and also counted under ultraviolet, when insects which had fed on mice appeared bright green while the others remained black. The prospective repellent was administered to the mouse at a pre-determined time prior to testing. In the experiments on Aedes aegypti N,N-diethyl toluamide, Indalone, N,N-propylacetanilide, ronnel and thiamine hydrochloride were tested. The procedure is successful for testing the effects of repellents on living mice, because of uniform mixing of the radio-iodinated serum albumin within a very short period and because it remains restricted to the vascular compartments. The technique can also be used with other small lab animals. Experiments with urea- $^{14}\text{C}$  did not give reproducible results.

- 1047 Levenbook, L., Dinamarca, M. L. A SIMPLIFIED IONIZATION CHAMBER PROCEDURE FOR THE CONTINUOUS MEASUREMENT OF RESPIRATORY  $\text{C}^{14}\text{O}_2$  OF INSECTS. Analyt. Biochem. 11, 2 (1965) 391-4.

A vibrating-reed electrometer for continuously measuring the  $^{14}\text{CO}_2$  expired by insects which had been injected with radioactive glucose has been described (see Robinson and Chefurka: 1048). A simplified and improved procedure is proposed here, in which the experimental insect or other small animal injected with an oxidizable  $^{14}\text{C}$ -tracer is placed directly in the ionization chamber. Living Phormia regina Meig. behaved very differently from dead insects with respect to ionization in the chamber. Alanine-U- $^{14}\text{C}$  was very rapidly ionized to  $^{14}\text{CO}_2$ , lysine-U- $^{14}\text{C}$  very slowly. For small insects weighing ~100 mg (or less) the Cary-Toibert chamber requires no modification.

- 1048 Robinson, J.R., Chefurka, W. CONTINUOUS MEASUREMENT OF  $C^{14}O_2$  RESPIRED BY INSECTS. AN IONIZATION CHAMBER METHOD. *Analyt. Biochem.* 9 (1964) 197-203.
- Details of a method and apparatus for continuous assay and recording of  $^{14}CO_2$  respired by insects treated with  $^{14}C$ -labelled materials are described. The technique, based upon an ionization flow chamber and vibrating-reed electrometer, is sensitive to less than  $10^{-8}$   $\mu Ci$  of  $^{14}C$  as  $^{14}CO_2$  in the system and allows very economical use of labelled materials in the study of normal and poisoned metabolic pathways in vivo. (Auth.)
- 1049 Porter, N.S., Sheen, E.M. AN AUTOMATIC ENTOMOLOGICAL SPECIES COUNTER. p. 5. 22-4 of "Hanford Radiological Sciences Research and Development Annual Report for 1963". Gamertsfelder, C.C., Green, J.K., Eds. HW-81746, General Electric Co. Hanford Atomic Products Operation, Richland Wash. Jan. 1964.
- During the study of radiation effects on entomological species such as the *Tribolium castaneum* and *confusum*, it is necessary periodically to count colony populations. By hand, such counts are tedious and time consuming; similarly, photographic methods require laborious techniques. An automatic counter for performing such tasks was developed. The instrument counts whole colonies of the species being investigated. (Auth.)
- 1050 Smith G.N., Ludwig, P.D., Wright, K.C., Bauriedel, W.R. SIMPLE APPARATUS FOR COMBUSTION OF SAMPLES CONTAINING  $^{14}C$ -LABELED PESTICIDES FOR RESIDUE ANALYSIS. *J. agric. Fd Chem.* 12, 2 (1964) 172-5.
- A simple apparatus is described for the combustion of biological samples containing  $^{14}C$ -labelled pesticides. The apparatus can be used to trap the liberated radioactive  $CO_2$  as  $BaCO_3$  or in ethanolamine for scintillation counting. The apparatus is rapid, simple, safe to operate, and can be used with any type of biological sample. (Auth.)
- See also:
- 580 Grasshopper neuroblast techniques. (Carlson, J.G., Gauden, M.E., 1964)
- 765 The control of spontaneous locomotor activity in *Phormia regina* Meigen. - II. Experiments to determine the mechanism involved. (Green, G.W., 1964)
- 1017 Design of  $^{90}Sr$  sources for ecological studies involving beta irradiation. (Menhinick, E.F., 1964)
- 1027 Some laboratory observations on the rates of development, mortality and oviposition of several species of Bruchidae breeding in stored pulses. (Howe, R.W., Currie, J.E., 1964)

## B. BIBLIOGRAPHIES AND GENERAL SURVEYS

### 1. Bibliographies

- 1051 Binggeli, M.-H. RADIOISOTOPES AND IONIZING RADIATIONS IN ENTOMOLOGY (1961-1963). Bibliographical Series No. 15. STI/PUB/21/15, International Atomic Energy Agency, Vienna (Austria). 1965, 576p.
- Fully annotated bibliography for the 3-year period 1961-1963, a follow-up of the first volume (Bibl. Series No. 9) which covered the 11-year period 1950-1960. Approximately 1600 references on radioisotopes and radiations in entomology from reports and articles in journals and books are given, complete with abstracts. Author, subject, and insecticide indexes are included. A special feature of the subject index is the citation, alongside each reference, of the relevant radioisotope or radiation employed in the study. Tabulated data are given on dispersal, sterilization, and insecticides (synthesis, metabolism, residues).
- 1052 International Atomic Energy Agency, Vienna (Austria). INFORMATION CIRCULAR ON RADIATION TECHNIQUES AND THEIR APPLICATION TO INSECT PESTS. No. 5. WP/31/5. Sep. 1964, 22p.

The circular is aimed at disseminating research information to workers in the field. This circular contains abstracts from seven papers presented at an agency panel on advances in insect population control by the sterile male technique, an ecological study, five studies each on ionizing radiation and on rearing techniques, and 17 on chemosterilants.

- 1053 International Atomic Energy Agency, Vienna (Austria). INFORMATION CIRCULAR ON RADIATION TECHNIQUES AND THEIR APPLICATION TO INSECT PESTS. No. 6. WP/31/6. June 1965, 14p.  
The circular lists 7 ecological studies, 2 on the effects of ionizing radiation, 9 on rearing techniques, 4 on radiation sterilization theory, and 8 on chemosterilants.
- 1054(a) Franz, J. M., Laux, W. BIBLIOGRAPHIE ÜBER BIOLOGISCHE BEKÄMPFUNG. (Bibliography on biological control). *Entomophaga* 8, 4 (1963) 263-334.  
Bibliographical listing without abstracts, in alphabetical order within a particular section. Section 9 deals with autocidal measures (p. 315-7); 43 references are cited, including work with chemosterilants. The following bibliographical lists have already appeared: Part I: *Entomophaga*, 1: 1956, 107-112; II: *ibid.*, 2: 1957, 293-311; III: *ibid.*, 3: 1958, 333-364; IV: *ibid.*, 4: 1959, 315-348; V: *ibid.*, 5: 1960, 295-335; VI: *ibid.*, 6: 1961, 277-329; VII: *ibid.*, 8: 1963, 89-161.
- 1055 Franz, J. M., Laux, W. BIBLIOGRAPHIE ÜBER BIOLOGISCHE BEKÄMPFUNG. (Bibliography on biological control). *Entomophaga* 9, 4 (1964) 311-89.  
Continuation of bibliography. Section 9 on autocidal measures (p. 376-80) contains 87 references, including chemosterilants, which represents a 50% increase over the preceding year.
- 1056 Klement, A. W., Jr., Schultz, V. TERRESTRIAL AND FRESHWATER RADIOECOLOGY. A Selected Bibliography - Supplement 2. TID-3910, Suppl. 2. March 1964, 123p.  
This is the second supplement to the bibliography issued in March 1962, with a supplement in February 1963. References are taken from the open literature, listed alphabetically by first author. When obtained from NSA, the abstract number is given. No indexes are supplied. Numerous entomological studies are included.
- 1057 Scharffenberg, R. S., Pollard, J. K., Jr. CARBON-14. A COMPREHENSIVE ANNUAL BIBLIOGRAPHY OF APPLICATIONS IN CHEMISTRY, BIOLOGY AND MEDICINE. Jan. - Dec. 1963. Los Angeles, Calbiochem. 1964, 126p. Vol. 2.  
2956 References are given to US and foreign publications on <sup>14</sup>C-tracer techniques in biology, chemistry, and medicine, published from 1962 through 1963. An index of <sup>14</sup>C-labelled compounds is included. A list of <sup>14</sup>C, deuterium, <sup>35</sup>S, tritium, and <sup>15</sup>N-labelled compounds available through Calbiochem is also included. Some work relevant to entomology is included.
- 1058 Ward, H. L. RADIOISOTOPES IN AGRICULTURE: ANALYTICAL PROCEDURES, ANIMAL HUSBANDRY, ENTOMOLOGY, FERTILIZER UPTAKE, GENERAL STUDIES, PHOTOSYNTHESIS, PLANT GENETICS, AND PLANT PHYSIOLOGY. A selected bibliography. TID-3078, Suppl. 1, Division of Technical Information Extension, AEC. May 1964, 24p.  
A very general survey containing a total of 229 selected references are presented from literature published from 1958 - 1962 on uses of radioisotopes in agricultural sciences.
- 1059 Ward, H. L. INSECT CONTROL BY RADIATION AND RADIOISOTOPES. TID-3579, Technical Information Service Extension, AEC, Nov. 1964, 32p.  
101 References selected from the scientific literature published since 1961 are presented. An insect index is included.

## 2. Surveys

- 1060 Brown, A. W. A. TACTICS OF INSECT CONTROL, PARTICULARLY IN MEDICAL ENTOMOLOGY. *Can. Ent.* 96, 1-2 (1964) 172-82.

Overall review of control measures against insect pests, especially mosquitoes. Resistance phenomena have been studied in numerous species. Countermeasures against resistance include the use of synergists, non-detoxicable analogues, and negatively-correlated compounds. Resistance usually dictates a shift from the chlorinated hydrocarbon to the organophosphorus insecticides, thus reducing the residue problem, particularly for wildlife. Alternative methods of control include the sterile-male technique, with two successful examples (*Callitroga hominivorax*, *Anastrepha ludens*) but no success yet with mosquitoes, and the use of chemosterilants, with an example of imminent success against houseflies on islands. Chemosterilants however, like bacterial toxins, are not free from the possible development of resistance by detoxication.

- 1061 Chant, D. A. STRATEGY AND TACTICS OF INSECT CONTROL. Can. Ent. 96, 1-2 (1964) 182-201.

The background against which decisions on control strategy are made is explained and general approaches to pest control are discussed in detail. Canadian work on population dynamics that involves research on the processes regulating numbers is reviewed. Conventional and unconventional methods of control, including insect sterilization, are considered and the need for an adequate understanding of insect ecology is stressed.

- 1062 Cornwell, P. B. INSECT CONTROL. p. 141-98 of "Massive Radiation Techniques". Jefferson, S., Ed. London, George Newnes Ltd. 1964, 324p.

Comprehensive review article of research and applications of ionizing radiations for insect control. The effects of radiation on developmental stages of insects are considered, also reports on stimulating effects. Delayed growth and the production of deformities as well as modifications in mobility and feeding are among the effects involved. Radiation disinfection of stored products is discussed together with its associated practical problems, and also insect control by sterile male release. 272 references.

- 1063<sup>(2)</sup> Day, M. F., Bailey, S. W., Norris, N. R. USES OF RADIOACTIVITY IN ENTOMOLOGY AND INSECT-PEST CONTROL. Aust. Mus. Mag. 13, 9 (1961) 291-3.

Survey.

- 1064<sup>(2)</sup> Figura, V. PRESENT KNOWLEDGE ON THE USE OF RADIOISOTOPES AND IONIZING RADIATION IN ENTOMOLOGY. Nuovi Annali Ig. Microbiol. 12, 12 (1961) 156-70. (In Italian)

- 1065 Freeman, P., Ed. INTERNATIONAL CONGRESS OF ENTOMOLOGY, 12, 1964. "Proceedings of the 12th International Congress of Entomology. London, 8-16 Jul. 1964". London, 12th International Congress of Entomology\*. 1965, 842p.

\* c/o Royal Entomological Society of London, 41 Queen's Gate, London, S. W. 7.

- 1066 Grobman, A. APPLICATIONS OF NUCLEAR ENERGY IN AGRICULTURE. Boln Jta Control Energia Atómica 9, 48 (1964) 73-84. (In Spanish)

The uses of radioisotopes and radiation in agriculture are tabulated. The more important progress made in studies on soil, physiology and vegetable autoecology, radioactive precipitation, and entomology is summarized. (NSA 19:1965,4554)

- 1067<sup>(2)</sup> Huque, H. ROLE OF ATOMIC ENERGY IN INSECT STUDY AND CONTROL. Agriculture Pakist. 13, 4 (1962) 77-80.

Brief, general survey of applications.

- 1068 Impens, R., François, E., Riga, A. L'UTILISATION DES RADIOISOTOPES ET DES RAYONNEMENTS EN ENTOMOLOGIE APPLIQUEE. Annls Gembloux 70 (1964) 45-63.

Review article. The advantages and limitations of the methods are described. 13 references (to 1963) are cited, including two IAEA Proceedings of Symposia.

- 1069 Książek, J. ATOMIC ENERGY IN RADIATION DAMAGE TO LIVING ORGANISMS. Postepy Nauk roln. 12 (1965) 131-5. (In Polish).

The useful effects of sterilizing and pasteurizing doses of radiation are reviewed. Topics discussed include: the physical properties of ionizing radiation; radiation-dose damage; disinfection of grains, retardation of sprouting and germination of seed-type foods; sterilization of insects (males) and insect population control; changes in susceptibility to disease due to induced mutations; and use of radioisotopes in biological research. (NSA 19:1965, 32631)

- 1070 Mercer, W. A., Ralls, J. W. USE OF ISOTOPES IN THE FOOD-CANNING INDUSTRY. Isotopes Radiat. Technol. 1, 3 (1964) 245-55.  
Applications of isotopes in food processing research and quality control are reviewed. Applications discussed in detail include research on raw food and containers, quality control, autoradiography of crop samples treated with radioactive insecticides, research on food washing, and in the radiation processing of foods, with emphasis on the radio-sensitivity of spores of Clostridium botulinum (19 references). (NSA 18:1964, 22384)
- 1071<sup>(2)</sup> Nardon, P. A COLLOQUIUM ON THE USE OF RADIOISOTOPES AND RADIATION IN THE CONTROL OF INSECTS. Phytoma 15, 151 (1963) 20-22.
- 1072 O'Brien, R. D., Wolfe, L. S. "RADIATION, RADIOACTIVITY, AND INSECTS". New York, Academic Press. 1964, 211p.  
Invaluable as a condensed introduction to the impressive range of applications of radioisotopes and ionizing radiations in entomology. The book is planned to give an account of academic and utilitarian radiation studies on insects. Various uses of radioisotopes in entomology, both for labelling insects and for elucidating biochemical, physiological and toxicological mechanisms are considered. The book contains chapters on the non-genetic effects of radiation, tagging, insect control by irradiation, biochemistry, physiology, insects and light, organophosphorus insecticides, chlorinated hydrocarbons, and miscellaneous other insecticides. Author and subject indexes are supplied.
- 1073 Robredo, F. THE USE OF RADIOACTIVE ISOTOPES AND IONIZING RADIATIONS IN ENTOMOLOGY. Spain. Serv. Plagas Forest. B. 7, 13 (1964) 42-51. (In Spanish)  
General article.
- 1074<sup>(2)</sup> Taimr, L., Diabola, J. UTILIZATION OF RADIOACTIVE TRACERS IN AGRICULTURAL ENTOMOLOGY. Za vys. Úrodu 11, 2 (1963) 471-. (In Czech)



### III

## TABLES AND INDEXES





TABLE 1

SYSTEMATIC LISTING OF INSECTS  
AND RELATED ARTHROPODS

Table 1

Class	Order	Family	Systematic Code	Scientific Name
ARACHNIDA				
	Araneida		Ar	
		Agelenidae	Ar. 1	
				Agelena
				Tegenaria
		Argiopidae	Ar. 1a	
				Araneus diadematus Cl.
				Araneus sericatus
		Epeiridae	Ar. 2	
				Epeira (Araneris)
		Theridiidae	Ar. 11	
				Latrodectus tredecimguttatus
	Acarina		Ac	
		Acaridae	Ac. 1	
				Acarus siro Linnaeus
		Dermanyssidae (?)	Ac. 4	
				Echinolaelaps echidninus
		Ixodidae	Ac. 8	
				Boophilus
				Dermacentor andersoni Stiles
				Hyalomma asiaticum
		Tetranychidae	Ac. 14	
				Tetranychus telarius (L.)
				Tetranychus urticae (Koch)
		Tyroglyphidae	Ac. 16a	Tyroglyphus farinae

Table 1

Common Name(s)	Reference No.	AF	V	P	B	E
spiders	305, 311					
funnel-web weavers						
	227					+
	227					+
	88					+
	89, 90					+
orb weavers						
	227					+
comb-footed spiders						
	315					+
mites and ticks						
acarid mites						
grain mite	656, 1013	+				
dermanyssid mites						
	255					
hard-backed ticks						
	227		+			
Rocky Mountain wood tick	255			+		
	839			+		
spider mites						
} two-spotted spider mite	766	+				
	98, 284, 410-1	+				
	877	+				

AF = Insects of agricultural or forestry importance  
 V = Insects of veterinary interest  
 P = Pests of public health or household significance  
 B = Beneficial insects  
 E = Insects chosen for experimental purposes.

Table 1 (cont.)

Class	Order	Family	Systematic Code	Scientific Name
INSECTA				
	Ephemeroptera		E	
		Baetidae	E. 1	
				Cloëon dipterum L.
	Odonata		F	
		Aeschnidae	F. 1	
				Aeschna grandis L.
				Aeschna mixta (Latr.)
		Agrionidae	F. 2	
				Pyrrhosoma nymphula (Sulz.)
		Calopterygidae	F. 2a	
				Calopteryx splendens Haar
				Calopteryx virgo (L.)
		Cordulegastridae	F. 4	
				Cordulegaster boltonii (Donov.)
		Lestidae	F. 7	
				Lestes sponsa Hans.
		Libellulidae	F. 8	
				Leucorrhinia rubicunda L.
				Plathemis lydia
				Sympetrum vulgatum (L.)
	Orthoptera		H	
		Acrididae	H. 1	
				Chorthippus brunneus
				Chortophaga viridifasciata (DeG.)

Table 1 (cont.)

Common Name(s)	Reference No.	AF	V	P	B	E
mayflies						
	34					+
damselflies and dragonflies						
	34					+
	249					+
	249					+
	513					+
	249					+
	249					+
	249					+
	249					+
	34					+
	36					+
	249					+
cockroaches, grasshoppers and allies	521, 530					
grasshoppers						
	129	+				
green-striped grasshopper	57, 134-5, 169, 170, 520, 540-1, 552	+				

Table 1 (cont.)

Class	Order	Family	Systematic Code	Scientific Name
INSECTA	Orthoptera	Acrididae		Cyrtacanthacris tartarica
				Locusta migratoria
				Melanoplus differentialis (Thos.)
				Podisma sapporensis
				Romalea microptera (P. de B.)
				Schistocerca gregaria Forak.
				Schistocerca vaga
		Blattidae	H. 2	
				Blaberus craniifer
				Blaberus giganteus
				Blattella germanica (L.)
				Eurycotis floridana
				Leucophaea maderae (F.)
				Nauphoeta cinerea
				Parcoblatta spp.
				Periplaneta americana (L.)
		Gryllidae	H. 4	
				Acheta domesticus (L.)
				Gryllus bimaculatus
				Gryllus domesticus L.
				Oecanthus domesticus
		Phasmatidae	H. 7	
				Carausius morosus Br.
		Tettigoniidae	H. 9	
				Orchelimum
	Isoptera		K	
		Rhinotermitidae	K. 3	
				Reticulitermes flavipes (Kollar)

Table 1 (cont.)

Common Name(s)	Reference No.	AF	V	P	B	E
	129	+				
	60, 73, 220, 535, 795, 984	+				
differential grasshopper	59, 143-4, 148, 181, 186, 192, 263, 567	+				
	754	+				
eastern lubber grasshopper	177, 251	+				
desert locust	50, 70, 75, 102, 124, 129, 244-5, 818	+				
	59	+				
cockroaches						
	796-8	+				+
	790	+				+
German cockroach	69, 83-4, 193, 195, 321, 241-b, 350, 408, 445, 457-8, 500, 860			+		
	136, 190, 193-6			+		
Madeira roach	224			+		
	809			+		
wood cockroach	41, 858			+		
American cockroach	49, 186, 201, 218, 221-2, 235, 253-4, 258, 260, 356, 398, 417, 434, 454, 457-8, 788, 850			+		
crickets	935					
European brown or home cricket	417, 777, 858-9, 860	+				
	37	+				
domestic cricket	802, 850	+				
green cricket	311	+				
walkingsticks						
stick insect	252	+				
longhorn grasshoppers and katydids						
	311	+				
termites	1037					
eastern subterranean termite	1037	+				



Table 1 (cont.)

Class	Order	Family	Systematic Code	Scientific Name
INSECTA	Psocoptera		L	
		Psocidae	L, 2	
				Psocoptera
	Anoplura		O	
		Pediculidae	O, 4	
				Pediculus humanus humanus L.
	Hemiptera (Heteroptera)		Q	
		Lygaeidae	Q, 10	
				Oncopeltus fasciatus (Dall. )
		Myridae	Q, 11	
				Lygus hesperus
				Orthotylus virescens (Douglas and Scott)
				Trygonotylus fulgoris (Prokelisia)
		Pentatomidae	Q, 15	
				Eurygaster integriceps Put.
		Reduviidae	Q, 18	
				Rhodnius prolixus (Stål)
				Triatoma infestans
	Hemiptera (Homoptera)		QQ	
		Aphididae	QQ, 2	
				Aphis fabae Scop.
				Hyperomyzus staphyleae Koch
				Myzocalis discolor Monell
				Myzus persicae
		Cercopidae	QQ, 4	
				Closoptera proteus

Table 1 (cont.)

Common Name(s)	Reference No.	AF	V	P	B	E
booklice and psocids						
psocids						
bark louse	960	+				
sucking lice						
human lice						
body louse	40, 366			+		
true bugs						
lygaeid bugs						
large milkweed bug	33, 118, 241, 417, 429, 434, 812, 820, 858					+
plant bugs						
	285	+				
	297	+				
	311					
stink bugs						
grain bug	1	+				
	91, 179, 639, 806					+
	351, 368			+		
aphids, leafhoppers, planthoppers, scale insects and allies	275					
aphids or plant lice						
bean aphid	33, 295, 319	+				
	319	+				
	957-8	+				
green peach aphid	295, 319	+				
spittlebugs						
dogwood spittlebug	916, 958	+				

Table 1 (cont.)

Class	Order	Family	Systematic Code	Scientific Name
INSECTA	Hemiptera (Homoptera)	Chermidae	QQ. 5	
				Phylloxera
		Cicadellidae	QQ. 6	
				Caligypona pellucida F.
				Dalbulus maidis
				Javesella pellucida F.
		(Jassidae)		Limotettix striola
				Scaphytopius magdalensis
		Pseudococcidae	QQ. 18	
				Planococcoides njalensis (Laing)
				Planococcus citri (Risso)
		Psyllidae	QQ. 19	
				Psylla pyricola Foerst.
	Mecoptera		S	
		Panorpidae	S. 3	
				Panorpa communis
	Trichoptera		T	
		Limnephilidae	T. 2	
				Glyphotaelius puntatolineatus Retz.
				Halesus interpunctatus Zett.
	Lepidoptera		U	
		*	*	
		Arctiidae	U. 2	
				Arctia caja
				Rhyparia purpurata

\* Available information was not sufficient to permit the assignment of families.

Table 1 (cont.)

Common Name(s)	Reference No.	AF	V	P	B	E
bark-, gall-aphids and phylloxera						
	786	+				
leafhoppers						
	304	+				
corn leafhopper	283	+				
	292	+				
	561	+				
	958	+				
mealybugs						
	280	+				
citrus mealybug	592	+				
jumping plantlice or psyllids						
pear psylla	317	+				
scorpionflies						
scorpionflies						
	96, 118, 162					+
caddisflies						
	34					+
	34					+
butterflies, moths, skippers	740				+	+
silkworms	64, 86, 151, 163, 176, 507, 509, 518, 542-3, 549, 550-1, 624, 652, 654-5, 681, 686, 699, 702-3, 719, 727-33, 755				+	+
tiger moths and allies						
	262					
	262					

Table 1 (cont.)

Class	Order	Family	Systematic Code	Scientific Name
INSECTA	Lepidoptera	Bombycidae	U. 3	
				Bombyx mori (L.)
		Crambidae	U. 8	
				Chilo partellus(zonellus) Swinhoe
				Chilo suppressalis (Wlk.)
		Galleriidae	U. 12	
				Galleria mellonella (L.)
		Gelechiidae	U. 13	
				Gnorimoschema operculella (Zell.)
				Pectinophora gossypiella (Saund.)
				Pectinophora malvella Hbst.
				Sitotroga cerealella (Oliv.)
		Hesperiidae	U. 19	
				Calpodex erilius (Stoll)
		Leucopteridae	U. 22a	
				Leucoptera coffeella Guer.
		Lymantriidae	U. 25	
				Porthetria dispar (L.)
		Noctuidae	U. 29	
				Agrotis orthogonia Morr.
				Agrotis ypsilon (Rottemburg)
				Chloridea obsoleta
				Hadena basilinea
				Heliothis virescens (F.)

Table 1 (cont.)

Common Name(s)	Reference No.	AF	V	P	B	E
<b>silkworm moths</b>						
<b>silkworm</b>	45, 51, 53, 80, 106-8, 111, 131-2, 136, 142, 153-4, 175, 215-7, 226, 237, 312-3, 518, 726, 754, 774-5, 817, 821, 844-5, 896, 936, 1033, 1036, II/320				+	+
<b>grass moths</b>						
<b>maize and jowar stalk borer</b>	2	+				
<b>Asiatic rice borer</b>	136, 422, 428	+				
<b>wax moths</b>						
<b>greater wax moth</b>	268-9	+				+
<b>gelechiid moths</b>						
<b>potato tuberworm</b>	635, 763-4, 794, 813	+				
<b>pink bollworm</b>	649, 971, 995, 1026	+				
<b>mallow moth</b>	994-a	+				
<b>Anguimoid grain moth</b>	830-2, 1013, 1042	+				
<b>skippers</b>						
<b>large canna leaf roller</b>	236	+				
<b>coffee leaf miner</b>	1000	+				
<b>tussock moths</b>						
<b>gypsy moth</b>	816, 838	+				
<b>owlet moths and underwings</b>						
<b>pale western cutworm</b>	281	+				
	803	+				
	659, 971	+				
<b>grain moth</b>	1	+				
<b>tobacco budworm</b>	263	+				

Table 1 (cont.)

Class	Order	Family	Systematic Code	Scientific Name
INSECTA	Lepidoptera	Noctuidae		<i>Heliothis zea</i> (Boddie)
				<i>Laphygma exigua</i>
				<i>Laphygma frugiperda</i> (J. E. Smith)
				<i>Prodenia eridania</i> (Cram. )
				<i>Prodenia litura</i>
				<i>Pseudaletia unipuncta</i> (Haw. )
				<i>Trichoplusia ni</i> (Hbn. )
		Nymphalidae	U. 31	
				<i>Aglais urticae</i>
				<i>Araschnia levana</i>
				<i>Inachis io</i>
		Olethreutidae	U. 33	
				<i>Carpocapsa pomonella</i> (L. )
				<i>Eucosma sonomana</i> Kearfort
				<i>Grapholita molesta</i> (Busck)
				<i>Petrova albicapitana</i> Busck
		Papilionidae	U. 34	
				<i>Papilio demodocus</i>
		Phycitidae	U. 36	
				<i>Cadra cautella</i> (Wlk. )
				<i>Ephestia</i> (= <i>Anagasta</i> )
				<i>Ephestia cautella</i>
				<i>Ephestia elutella</i> (Hbn. )
				<i>Ephestia kühniella</i> Z.
				<i>Paramyelois transitella</i> (Wlk. )
		Psychidae	U. 39	
				<i>Thyridopteryx ephemeraeformis</i>

Table 1 (cont.)

Common Name(s)	Reference No.	AF	V	P	B	E
bollworm, corn earworm, tomato fruitworm	393, 401-2	+				
	971	+				
fall armyworm	348	+				
southern armyworm	83	+				
cotton leaf worm	383, 386-7	+				
	303	+				
cabbage looper	263	+				
brush-footed butterflies						
	262	+				+
	262					+
	262					+
olethreutid moth						
codling moth	971, 998-9	+				
jackpine shoot borer	1028	+				
oriental fruit moth	293	+				
pitch nodule borer	1028	+				
	262	+				
almond moth	651, 1003	+				
	741-2	+				
almond moth	846	+				
tobacco moth	1019	+				
Mediterranean flour moth	791, 959	+				
navel orangeworm	996	+				
bagworm moths						
evergreen bagworm	834	+				



Table 1 (cont.)

Class	Order	Family	Systematic Code	Scientific Name
INSECTA	Lepidoptera	Pyrallidae	U.41	
				<i>Corcyra cephalonica</i> Stanton
				<i>Diatraea saccharalis</i> (F.)
				<i>Ectomyelois ceratoniae</i> (Zell.)
				<i>Plodia interpunctella</i> (Hbn.)
		Pyraustidae	U.42	
				<i>Ostrinia nubilalis</i> (Hbn.)
		Saturniidae	U.43	
				<i>Antheraea pernyi</i>
				<i>Antheraea polyphemus</i>
				<i>Attacus ricini</i>
				<i>Hyalophora cecropia</i> (L.)
				<i>Samia cynthia</i> (Drury)
				<i>Samia ricini</i>
		Sphingidae	U.46	
				<i>Celerio euphorbiae</i>
				<i>Protoparce* sexta</i> (Johan.)
		Tortricidae	U.49	
				<i>Argyroplote leucotreta</i> Meyr
				<i>Argyrotaenia velutinana</i> (Wlk.)
				<i>Platynota stultana</i> (Wlshn)
	Coleoptera		V	
		Anobiidae	V.1	
				<i>Lasioderma serricorne</i> (F.)
		Bostrichidae	V.5	
				<i>Rhyzopertha dominica</i> (F.)

\* Approved generic name: *Manduca*

Table 1 (cont.)

Common Name(s)	Reference No.	AR	V	P	B	E
pyralid moths						
	633	+				
	658					
carob moth	9	+				
Indian meal-moth	651, 1013, 1019	+				
pyraustid moths						
European corn borer	804, 971	+				
giant silkworm moths						
oak silkworm	82, 113, 139	+				
polyphemus moth	150	+				+
	138, 142	+				
cecropia moth	46, 120, 171, 182, 186, 192, 198-9, 201	+				+
cynthia moth	120, 150, 234	+				+
	137	+				
sphinx moths						
	781	+				
tobacco hornworm	218, 263, 356, 486	+				
leaf roller moths						
	647	+				
red-banded leaf roller	356	+				
omnivorous leaf roller	871	+				
deathwatch and drugstore beetles						
cigarette beetle	651, 1013	+				
false powder-post beetles						
lesser grain borer	1013	+				

Table 1 (cont.)

Class	Order	Family	Systematic Code	Scientific Name
INSECTA	Coleoptera	Bruchidae	V. 7	
				<i>Acanthoscelides obrectus</i> (Say)
				<i>Callosobruchus maculatus</i> (F.)
				<i>Callosobruchus rhodesianus</i>
				<i>Callosobruchus subinnotatus</i> Pic
		Cerambycidae	V. 12	<i>Oberea schaumii</i> Lec.
		Chrysomelidae	V. 13	
				<i>Chrysomela knabi</i> Brown
				<i>Diabrotica virgifera</i> Lec.
				<i>Galeruca tanacetii</i> (L.)
				<i>Leptinotarsa decemlineata</i> (Say)
				<i>Oulema melanopa</i> (L.)
		Coccinellidae	V. 18	
				<i>Chilocorus bipostulatus</i> L.
				<i>Epilachna philippinensis</i>
				<i>Epilachna varivestis</i> Muls.
				<i>Prototheca zopfi</i>
		Cucujidae	V. 18	
				<i>Oryzaephilus mercator</i> (Fauvel)
				<i>Oryzaephilus surinamensis</i> (L.)
		Curculionidae	V. 19	
				<i>Anthonomus grandis</i> Boh.
				<i>Calandra granaria</i> (L.)
				<i>Conotrachelus nenuphar</i>
				<i>Cryptorhynchus lapathi</i> L.
				<i>Pissodes strobi</i> (Peck)

Table 1 (cont.)

Common Name(s)	Reference No.	AF	V	P	B	E
seed beetles						
bean weevil	971	+				
cowpea weevil	874	+				
	1027	+				
	819	+				
long-horned beetles or roundheaded wood borers	1028					
leaf beetles						
willow leaf beetle	32, 33	+				
western corn rootworm	338	+				
	264-5	+				
Colorado (potato) beetle	3, 417, 971	+				
cereal leaf beetle	767, 924	+				
lady beetles						
	10					
	760	+				
Mexican beanbeetle	748, 760	+				
	271					
cucufid or flat bark beetles						
merchant grain beetle	846, 1003	+				
saw-toothed grain beetle	641, 872, 1019	+				
snout beetles or weevils						
boll weevil	38, 48, 200, 204-7, 261, 345, 360, 363, 393-4, 401, 500, 823	+				
granary weevil	668, 884-5, 971, 1009	+				
plum curculio	820	+				
	5					
white-pine weevil	1028	+				

Table 1 (cont. )

Class	Order	Family	Systematic Code	Scientific Name
INSECTA	Coleoptera	Curculionidae		Sitophilus granarius (L. )
				Sitophilus oryzae (L. )
				Sitophilus sasaldi (Tak. )
				Sitophilus zeamais Mots.
				Sternochetus lapathi (L. )
				Sternochetus mangiferae (F. )
		Dermestidae	V. 20	
				Anthrenus flaviceps Lec. (vorax Waterh. )
				Attagenus piceus (Oliv. )
				Trogoderma glabrum Hbst.
		Dytiscidae	V. 21	
				Dytiscus marginalis
		Elateridae	V. 22	
				Conoderus vesperinus (F. )
		Nitidulidae	V. 35	
				Meligethes aeneus F.
		Scarabaeidae	V. 41	
				Amphimallon majalis (Raz. )
				Melolontha vulgaris F.
		Scolytidae	V. 42	
				Dendroctonus brevicornis Lec.
				Dendroctonus frontalis Zimm.
				Ips confusus (Lec. )

Table 1 (cont.)

Common Name(s)	Reference No.	AF	V	P	B	E
granary weevil	653, 872, 883-7, 899, 900, 971, 1001, 1009, 1014, 1045	+				
rice weevil	653, 760, 768, 1013	+				
	768	+				
rice weevil	653, 768, 811	+				
poplar and willow weevil	1028	+				
mango weevil	879, 1018	+				
dermestid beetles						
	825	+				
black carpet beetle	1013	+				
	656, 1013					
predaceous diving beetles	314					+
	178					
click beetles, wireworms						
tobacco wireworm	263	+				
sap beetles						
	292	+				
scarabs						
European chafer	820	+				
cockchafer	975, II/1270	+				
bark beetles						
western-southwestern pine beetle	1023	+				
southern-, Arizona-, smaller Mexican pine beetle	1025	+				
California five-spined ips	840-1, 843, 958, 960	+				

Table 1 (cont. )

Class	Order	Family	Systematic Code	Scientific Name
INSECTA	Coleoptera	Tenebrionidae	V. 46	
				Ocnera hispida (Forsk. )
				Pelecyporus densicollis Horn
				Pimelia
				Pimelia angulata expiata (Peyer. )
				Pimelia angulata lesnei (Peyer. )
				Stenomorpha puncticollis Lec.
				Tenebrio molitor L.
				Tenebroides mauritanicus (L. )
				Tribolium
				Tribolium castaneum Hbst
				Tribolium confusum Duv.
	Hymenoptera		W	
		Apidae	W. 3	
				Apis mellifera L.
				Apis mellifica
		Braconidae	W. 5	
				Habrobracon juglandis
				Habrobracon seriopae
				Macrocentrus ancyliivorus Roh.
				Phanerotoma flavitestacea Fischer
		Cephidae	W. 6	
				Cephus cinctus Nort.
		Chalcididae	W. 7	
				Copidosoma koehleri Blanch.
		(Pteromalidae?)		Mormoniella
				Mormoniella vitripennis (Wlk. )

Table 1 (cont.)

Common Name(s)	Reference No.	AF	V	P	B	E
darkling beetles						
	762					
	308					
	779					
	762					
	762					
	308					
yellow mealworm	55, 63, 248, 256, 776, 778, 782-3, 858-9, 860	+				+
	1019					
	901	+				+
red flour beetle	512, 636, 653, 675-7, 760, 814, 888, 890-3, 913-4, 919-23, 929, 959, 1049	+				+
confused flour beetle	636, 653, 657, 673, 675-6, 769, 779, 846-7, 851, 872, 880-1, 890-3, 900, 902-4, 918, 922-3, 959, 1013, 1019, 1049	+				+
bumble, carpenter, honey, and stingless bees						
honey bee	43-b, 211-2, 223, 282, 606, 873, 912				+	
	65, 240, 242				+	
braconids						
	35, 533, 857, 959					+
	35					+
	763-4				+	
	11				+	
stem sawflies						
wheat stem sawflies	79	+				
chalcids						
	763-4				+	
	613, 712				+	
	619, 628-9, 815				+	



Table 1 (cont. )

Class	Order	Family	Systematic Code	Scientific Name
INSECTA	Hymenoptera	Cynipidae	W. 11	
				<i>Dryocosmus kurtiphilus</i> Yasumatsu
		Diprionidae	W. 12	
				<i>Neodiprion fulvipes</i>
				<i>Neodiprion pratti</i> Roh.
		Formicidae	W. 14	
				<i>Acanthomyops claviger</i> Roger
				<i>Camponotus castaneus</i> Latr.
				<i>Camponotus herculeanus</i> L.
				<i>Camponotus ligniperda</i> Latr.
				<i>Crematogaster</i>
				<i>Dorymyrmex</i>
				<i>Formica integra</i>
				<i>Formica polycetena</i>
				<i>Lasius umbratus</i> (Nyl. )
				<i>Pogonomyrmex occidentalis</i> (Cress.)
				<i>Tetramorium caespitum</i> (L. )
		Siricidae	W. 23	
				<i>Sirex longicauda</i> Middlk.
		Sphecidae	W. 24	
				<i>Dahlbominus</i>
				<i>Dahlbominus fuliginosus</i>
				<i>Dahlbominus fuscipennis</i> (Zett.)
				<i>Sceliphron cementarium</i>
				<i>Trypoxylon politum</i>
		Trichogrammatidae	W. 28	
				<i>Trichogramma semifumatum</i> (Perkins)

Table 1 (cont.)

Common Name(s)	Reference No.	AF	V	P	B	E
cynipids or gall wasps						
chestnut gall wasp	335	+				
conifer sawflies						
	840-3	+				
Virginia pine sawfly	101, 202, 213-4	+				
ants						
smaller yellow ant	71	+				
	894	+				
carpenter ants	287-9	+				
	287, 289	+				
	311	+				
common ant	311					
	906, 958	+				
	277, 287	+				
	894	+				
	894	+				
	894	+				
horntails						
	1030	+				
cicada killers, mud-daubers, and sand wasps						
	504					+
	590					+
	591, 805, 835, 925					+
mud-dauber wasp	309, 310					+
mud-dauber wasp	309, 310					+
minute egg parasites						
	303, 763				+	

Table 1 (cont.)

Class	Order	Family	Systematic Code	Scientific Name
INSECTA	Hymenoptera	Vespidae	W. 29	
				Paravespula germanica
				Paravespula vulgaris
	Diptera		X	
		Calliphoridae	X. 5	
				Calliphora erythrocephala (Meig.)
				Callitroga hominivorax (Coq.)
				Cochliomyia hominivorax (Coq.)
				Lucilia
				Lucilia cuprina
				Lucilia sericata
				Phaenicia cuprina
				Phaenicia sericata
				Phormia regina
				Protophormia terrae-novae (Rob. -Desv.)
		Chironomidae	X. 9	
				Acricotopus lucidus
				Chironomus tentans
				Chironomus thummi
				Culicoides barbosi Wirth & Blanton
				Culicoides furens Poey
				Smittia
				Smittia parthenogenetica
		Chloropidae	X. 10	
				Hippelates pustio Loew
		Culicidae	X. 11	
				Aedes aegypti (L.)
				Aedes atropalpus (Coq.)

Table 1 (cont.)

Common Name(s)	Reference No.	AF	V	P	B	E
hornets, yellow jackets, and porter wasps						
	290					+
	290-1					+
flies						
blowflies	272					
blowfly	54, 72, 74, 76-8, 94-5, 103-5, 116, 118, 159, 172-4, 209, 238-9, 247, 643, 800		+			
screw-worm fly	642, 905, 1060		+			
	495, 905, 967, 974, 981-3, 992		+			
blowfly	632		+	+		
blowfly	68		+			
sheep maggot fly	390, 979		+			
blowfly	752		+			
sheep maggot fly	270		+			
black blowfly	136, 189, 208, 219, 266, 765		+			
northern blowfly, carrion fly	361, 771, 827-8			+		
	56, 74, 123, 306			+		
	229			+		
	61, 114, 122, 158, 930, 940, 950, 954-5			+		
	167, 180, 519, 750			+		
	6			+		
	6			+		
	119, 233			+		
	130			+		
chloropid flies						
eye gnat	637, 854			+		
mosquitoes						
yellow fever mosquito	13, 25, 42, 99, 276, 279, 286, 337, 349, 372, 377, 498, 557, 927-8, 949, 971, 1044, 1048			+		
	314			+		

Table 1 (cont.)

Class	Order	Family	Systematic Code	Scientific Name
INSECTA	Diptera	Culicidae	X. 11	<i>Aedes cataphylla</i> Dyar
				<i>Aedes nigromaculis</i> (Ludlow)
				<i>Anopheles albimanus</i>
				<i>Anopheles atroparvus</i>
				<i>Anopheles punctipennis</i> (Say)
				<i>Anopheles quadrimaculatus</i> Say
				<i>Anopheles sergenti</i>
				<i>Anopheles stephensi</i>
				<i>Culex pipiens fatigans</i> Wied.
				<i>Culex pipiens quinquefasciatus</i> Say
				<i>Culex quinquefasciatus</i> Say
				<i>Culex restuans</i> Theob.
				<i>Culex tarsalis</i>
				<i>Culex territans</i> Wlk.
		Cuterebridae	X. 12	
				<i>Dermatobia hominis</i>
		Drosophilidae	X. 14	
				<i>Drosophila</i>
				<i>Drosophila busckii</i>
				<i>Drosophila hydei</i>
				<i>Drosophila melanogaster</i>

Table 1 (cont.)

Common Name(s)	Reference No.	AF	V	P	B	E
	145			+		
	424			+		
	464			+		
	506, 638			+		
	314			+		
common malaria mosquito	286, 498, 630, 756, 907, 971			+		
	273-4			+		
	299, 318			+		
	362, 630, 971			+		
southern house mosquito	294, 464, 630			+		
	343			+		
	314			+		
	362, 373			+		
	314			+		
rabbit bots, rodent bots						
human bot fly	988			+		
	15, 22, 81, 118, 149, 165, 321, 505, 507, 511, 514, 519, 524, 526, 534, 545, 548, 553, 556, 564, 569, 575, 581-2, 584, 586, 589, 595, 598, 600, 611, 614, 645, 664, 670, 689, 696, 708, 712, 736, 738, 744, 755, 780, 878, 882, 908, 933, 945-6					+
	97, 164, 166					+
	112, 161, 230, 515					+
	14, 16, 17, 18, 21, 23, 24, 26, 27, 58, 62, 66-7, 87, 92, 97b, 109, 126-8, 140, 146-7, 152, 160, 225, 508-10, 516-7, 523, 525, 527-9, 531-2, 536-8, 544, 546-7, 554, 556, 558-9, 560, 562-3, 565-6, 568, 570-9, 580-9, 593-7, 599, 601-5, 608-9, 610, 612, 616-8, 620-3, 625-7, 631, 640, 660-3, 665-7, 669, 671-2, 674, 678-9, 680, 682-5, 687-8, 690-5, 697-8, 700, 704-7, 709-18, 720-5, 734-5, 737, 739, 743, 745-7, 751, 753, 757, 761, 773, 779, 784, 787, 789, 822, 833, 848, 862, 865, 867-8, 875-6, 882, 889, 895, 909, 910, 911, 915, 917, 926, 931, 934, 938-9, 941-4, 947, 971					+

Table 1 (cont.)

Class	Order	Family	Systematic Code	Scientific Name
INSECTA	Diptera	Drosophilidae	X. 14	<i>Drosophila pseudoobscura</i>
				<i>Drosophila simulans</i>
				<i>Drosophila subobscura</i>
				<i>Drosophila virilis</i>
				<i>Drosophila willistoni</i>
		Muscidae	X. 19	
				<i>Haemaphys irritans</i> (L. )
				<i>Musca domestica</i> L.
				<i>Stomoxys calcitrans</i> (L. )
		Mycetophilidae	X. 20	
				<i>Sciara coprophila</i> Lint.
		Oestridae	X. 21	
				<i>Hypoderma lineatum</i> (De Vill. )
		Otitidae	X. 22	
				<i>Euxesta notata</i> (Wied. )
		Psilidae	X. 26	
				<i>Psila rosae</i> (F. )
		Sarcophagidae	X. 29	
				<i>Sarcophaga bullata</i>
				<i>Sarcophaga peregrina</i>
		Sciaridae	X. 29a	
				<i>Rhynchosciara angelae</i>
		Simuliidae	X. 30	
		Syrphidae	X. 32	<i>Eristalis tenax</i> (L. )

Table 1 (cont.)

Common Name(s)	Reference No.	AF	V	P	B	E
	866, 932, 937, 948					+
	126, 598					+
	855					+
	141, 810					+
	607, 615, 935					+
house flies, stable flies, and allies						
horn fly	644, 971		+			
house fly	19, 47, 110, 116-8, 155, 188, 191, 197, 203, 210, 239, 243, 267, 278, 321, 329, 336-7, 344, 347, 350, 354, 358, 385, 396, 398, 409, 417, 423, 447, 454, 457-8, 460-5, 468, 496, 499, 500, 504, 756, 785, 792-3, 808, 836-7, 849, 852-3	+		+		+
stable fly	321, 395, 460, 496, 500		+			
fungus gnats						
house plant gnat	121, 156, 231-2	+				
bot and warble flies			+			
common cattle grub	634		+			
otitid flies						
spotted root maggot	359	+				
carrot rust fly	646	+				
flesh flies			+			
	85		+		+	
	863-4		+			
fungus gnats						
	133, 156-7, 250, 522					+
black flies	301					
flower flies						
drone fly	34	+			+	



Table 1(cont.)

Class	Order	Family	Systematic Code	Scientific Name
INSECTA	Diptera	Tephritidae	X.35	
				Anastrepha ludens (Loew)
				Ceratitis capitata (Wied.)
				Dacus cucurbitae Coq.
				Dacus dorsalis Hendel
				Dacus oleae (Gmel.)
				Dacus tryoni
				Rhagoletis cerasi
				Rhagoletis pomonella (Walsh)
	Syphonaptera		Y	
		Pulicidae	Y.2	
				Xenopsylla cheopis (Rothsch.)

Table 1 (cont.)

Common Name(s)	Reference No.	AF	V	P	B	E
fruit flies	650, 861, 1004					
Mexican fruit fly	807, 1060	+				
Mediterranean fruit fly	12, 302, 749, 971, 976, 978, 980, 984-9, 990-1, 993, 997, 1035, 1040	+				
melon fly	749, 994	+				
oriental fruit fly	749, 977, 1035	+				
olive fruit fly	824, 971, 984	+				
Queensland fruit fly	799	+				
cherry fruit fly	296	+				
apple maggot	8	+				
fleas						
pulicid fleas						
oriental rat flea	20			+		



TABLE 2

LETHAL RADIATION EFFECTS

Table 2

Order	Family	Systematic Code	Insect	Life Cycle Stage [e = egg l = larva p = pupa a = adult]
Acarina	Tyroglyphidae	Ac 16a	Tyroglyphus farinae	e
				a
Orthoptera	Acrididae	H 1	Schistocerca gregaria (Forsk.) [desert locust]	e
				l (2-5) *
				a "young"
Lepidoptera	Tortricidae	U 49	Platynota stultana (Wishm) [omnivorous leaf roller]	a ♀
				a ♂
Coleoptera	Bostrichidae	V 5	Rhyzopertha dominica (F.) [lesser grain borer]	p, a }
	Bruchidae	V 7	Callosobruchus maculatus (F.) [cowpea weevil]	e }
				l
				p
				a
	Cucujidae	V 18	Oryzaephilus surinamensis (L.) [saw-toothed grain beetle]	e
				l
				Pearly
				Plate
				a
	Curculionidae	V 19	Sitophilus granarius (L.) [granary weevil]	e
				l
				p
				a

\* Instar may be indicated  
in parentheses.

Table 2

Table 2

Age [ days]	Temperature [ °C]	Radiation	Dose	Lethal dose (LD)/days	Ref. No.
		γ	12 000 R	100	877
		γ	18 000 - 20 000 R	100/30, 40	
		γ	90 000 - 120 000 R	100	818
		γ	2 500 - 7 000 R	100	
		γ	15 000 - 120 000 R	100/4	
0-1		γ	16 000 R	> 99 (e)	871
0-1		γ	32 000 R	> 99 (e)	
	30	γ	7 000 rad	50/63	651
	30	γ	25 000 rad	99, 9/63	
3	27	γ	1 000 rad	50	874
3	27	γ	3 000 rad	100	
14	27	γ	2 500 rad 6 000 rad	50 100	
27	27	γ	5 000 rad > 10 000 < 20 000 rad	50 100	
0-1	27	γ	100 000 rad 176 000 rad	50/2 100/2	
1-2	30	γ	9 600 rad	99, 9/21	
10-11	30	γ	8 600 rad	99, 9/21	641
20-21	30	γ	14 500 rad	99, 9/21	
22-23	30	γ	30 800 rad	99, 9/21	
0-14	30	γ	20 600 rad	99, 21	
0-6	26	γ	4 000 rep	100/28(a)	811
6-26	26	γ			
26-32	26	γ	11 200 rep		
32-36	26	γ			

Table 2 (cont.)

Order	Family	Systematic Code	Insect	Life Cycle Stage [e = egg l = larva p = pupa a = adult]
Coleoptera	Curculionidae	V 19	Sitophilus granarius (L.) [granary weevil]	e
				l
				p
				a
				e, l, a
				a
				a (6 strains)
				a (6 strains)
				a
				a (7 strains)
				a (7 strains)
			Sitophilus zeamais Mots.	a (3 strains)
				a (3 strains)
				e
				l
				p
				a
			Stemochetus mangiferae (F.) [mango weevil]	a
				immature
	Scolytidae	V 42	Ips confusus (Lec.)	a ♂
	Tenebrionidae	V 46	Tribolium castaneum Hbst. [red flour beetle]	a

Table 2 (cont.)

Age [days]	Temperature [°C]	Radiation	Dose	Lethal dose (LD)/days	Ref. No.
0- 4	26	$\gamma$	4 000 rep	99. 9/60	1014
7-11	26	$\gamma$			
28-32	26	$\gamma$			
7-11	26	$\gamma$	9 000 rep		
		$\gamma$	5 000 rad	100	1009
	26-31	$\gamma$	10 700 rad	99. 9/56	883
0- 1	15	$\gamma$	15 300 - 20 500 rad	100/56	899
	30	$\gamma$		100/14	
21	24-25	$\gamma$	12 000 rad	100/210	1001
21	24-25	$\gamma$	16 000 rad	100/21	
9-14	26	$\gamma$	5 000 - 7 500 rad	50/21	653
9-14	26	$\gamma$	7 800-14 500 rad	99. 9/21	
		x	8 000 R	100/50	884
		x (hypoxia)	14 000 R	100/50	
7-11	26	$\gamma$	5 000 - 5 500 rad	50/16	653
7-11	26	$\gamma$	7 400 - 8 300 rad	99. 9/16	
7-11	26	$\gamma$	3 700 - 4 300 rad	50/21	653
7-11	26	$\gamma$	6 600 - 13 700 rad	99. 9/21	
0- 5	26	$\gamma$	4 000 rep	100/21 (a)	811
5-20	26	$\gamma$			
22-24	26	$\gamma$	11 200 rep		
28-29	26	$\gamma$			
		$\gamma$	30 000 - 60 000 rad	100	879
		$\gamma$	> 75 000 rad	100/14	1018
		$\gamma$	7 500 R	50/11. 5	848
4-11	26	$\gamma$	11 900 - 15 900 rad 21 200 - 34 500 rad	50/21 99. 9/21	653



Table 2 (cont.)

Order	Family	Systematic Code	Insect	Life Cycle Stage [ e = egg l = larva p = pupa a = adult]
Coleoptera	Tenebrionidae	V 46	Tribolium castaneum Hbst. [red flour beetle]	e
				l
				p
				a
			Tribolium confusum Duv. [confused flour beetle]	a (4 strains)
				e
				l
				p
				a
				a
Diptera	Chloropidae	X 10	Hippelates pusio Loew [eye gnat]	p
				a ♀
				a ♂
				a ♀
				a ♂
				a
	Drosophilidae	X 14	Drosophila melanogaster (Meig.)	a ♀
				a ♂
	Tephritidae	X 35	Anastrepha ludens (Loew)	e
				l
				p
				a ♀, ♂
			Ceratitis capitata (Wied.) [Mediterranean fruit fly]	p
				p

Table 2 (cont.)

Age [days]	Temperature [°C]	Radiation	Dose	Lethal dose (LD)/days	Ref. No.
2-3	30	$\gamma$	10 900 rad	99, 9/28	869
14-15	30	$\gamma$	10 500 rad	99, 9/28	
26-27	30	$\gamma$	25 800 rad	99, 9/28	
0-14	30	$\gamma$	21 500 rad	99, 9/28	
4-11	26	$\gamma$	8 350 - 10 800 rad 12 300 - 22 200 rad	50/24 99, 9/24	653
2- 3	30	$\gamma$	4 400 rad	99, 9/28	869
14-15	30	$\gamma$	5 200 rad	99, 9/28	
30-31	30	$\gamma$	14 500 rad	99, 9/28	
0-14	30	$\gamma$	12 800 rad	99, 9/28	
random	27	$\gamma$	30 000 - 60 000 rad	100/30	881
2 d pre-emergence	21	$\gamma$	15 000 R	50	854
2-3	24	$\gamma$	>15 000 R	100/54	
		$\gamma$		100/41	
		$\gamma$	75 000 R	100/8	
		$\gamma$		100/7	
		$\gamma$	135 000 R	100/3	
1	25	x	96 000 R	50	862
1	25	x	46 000 R	50	
1	25	$\gamma$	2 000 R	99, 9/7	807
10	26	$\gamma$	1 500 R	99, 5 (a)	
5-7		$\gamma$	25 000 R	100 (a)	
1		$\gamma$	50 000 R	50/21	
2-4	26	$\gamma$	5 000 - 15 000 R	100	971
7	26	$\gamma$	70 000 R	100	



TABLE 3

STERILIZATION DATA

Table 3

Order	Family	Systematic Code	Insect	Life Cycle Stage [e = egg l = larva p = pupa a = adult]
Acarina	Acaridae	Ac 1	Acarus siro L. [grain mite]	
	Ixodidae	Ac 8	Hyalomma asiaticum	a♀
	Tetranychidae	Ac 14	Tetranychus telarius L. [two-spotted spider mite]	a♂ ♀ deutonymph
Lepidoptera	Gelechiidae	U 13	Gnorimoschema operculella (Zell.) [potato tuberworm]	p♀  p♂ p a
			Pectinophora gossypiella (Saund.) [pink boll worm]	p  p p p♀ p♂
	Noctuidae	U 29	Chloridea obsoleta	p♂
	Olethreutidae	U 33	Carpocapsa pomonella (L.) [codling moth]	p♂
	Phycitidae	U 36	Paramyelois transitella (Wlk.) [navel orangeworm]	p♀, ♂
			Cadra cautella (Wlk.) [almond moth]	p, a  p, a
	Tortricidae	U 49	Argyroplote leucotreta Meyr	e to a*)
Coleoptera	Anobiidae	V 1	Lastoderma serricorne [cigarette beetle]	p, a

\*) Original not available

Table 3

Age [h = hour(s) d = day(s)]	Temper- ature [°C]	Radiation	Dose	Sterility [%]	Ref. No.
		$\gamma$	> 25 000 R		656
		x	3 000 R	100	839
	24	$\gamma$	> 32 000 R		} 766
	24	$\gamma$	32 000 R	100	
8 d	21	$\gamma$	18 000 rad	100	} 635
8 d		$\gamma$	15 000 rad	100	
5, 8 d		$\gamma$	} 24 000 R	} 100	} 813
shortly after emergency		$\gamma$			
1 d	} 30	$\gamma$	6 000 R	100	} 649
3 d		$\gamma$	8 000 R	100	
5 d		$\gamma$	22 000 R	100	
7 d		$\gamma$	40 000 R	100	
7 d		$\gamma$	55 000 R	100	
post cocoon	23-25	$\gamma$	8 000 - 10 000 R		659
mature		$\gamma$	40 000 rad	98	998
~ 8 d	28	$\gamma$	50 000 rad	"complete"	996
mostly pupae	} 28	$\gamma$	2 700 rad	50	} 651
		$\gamma$	23 500 rad	99	
		$\gamma$	5 000 - 70 000 R (♀ more susceptible)		647
	25	$\gamma$	10 000 rad	99, 9	651

Table 3 (cont.)

Order	Family	Systematic Code	Insect	Life Cycle Stage [ e = egg l = larva p = pupa a = adult ]
Coleoptera	Bostrichidae	V 5	Rhyzopertha dominica (F.) [lesser grain borer]	p + a  p+a p+a
	Bruchidae	V 7	Callosobruchus maculatus (F.) [cowpea weevil]	a ♀, ♂
	Coccinellidae	V 16	Epilachna varivestis Muls. [Mexican bean beetle]	p ♀  p ♂ a ♀, ♂
	Cucujidae	V 18	Oryzaephilus surinamensis (L.) [saw-toothed grain beetle]	e  l  Pearly Plate a
	Curculionidae	V 19	Sitophilus granarius (L.) [granary weevil]	a (6 strains)  e  l  p a a
			Sitophilus oryzae (L.) [rice weevil]	a (3 strains)

Table 3 (cont.)

Age [h=hour(s) d=day(s)]	Temperature [°C]	Radiation	Dose	Sterility [%]	Ref. No.
32-35 d  4-7 d	30	γ	2 200 rad	50	651
		γ	11 000 rad	99.9	
		γ	16 000 rad	100	
0-1 d		γ	10 000 rad	100	874
3 d  2- 3 d		γ	1000 - 16 000 R	100	748
		γ	4000 - 16 000 R	100	
		γ	8000 - 16 000 R	100	
1- 2 d  10-11 d 20-21 d 22-23 d 0-14 d	30	γ	8000 rad	99.9	641
		γ	6500 rad		
		γ	7700 rad		
		γ	12 000 rad		
		γ	15 300 rad		
9-14 d  0- 3 d 3- 6 d 6-10 d 10-17 d 17-26 d  26-32 d 32-36 d  21 d	26	γ	~ 10 000 rad	99.9	653
		γ	2000 rep	98	
		γ	2000 rep	79	
		γ	2800 rep	78	
		γ	2800 rep	84	
	26	γ	2800 rep	97	811
		γ	4000 rep	lethal and/or sterilizing	
		γ	4000 rep	98	
		γ	4000 rep	97	
		γ	6000 rad	99.4	
	25-28	γ	16 000 rad	100	1001
7-11 d	26	γ	7000 rad	99.9	653



Table 3 (cont.)

Order	Family	Systematic Code	Insect	Life Cycle Stage [e = egg f = larva p = pupa a = adult]
Coleoptera	Curculionidae	V 19	Sitophilus zeamais Mots.	a (3 strains)  e  e  f  p a a
			Sternochetus mangiferae (F.) [mango weevil]	a
	Dermestidae	V 20	Anthonomus grandis Boh. [boll weevil]	a♂
			Trogoderma glabrum	a
	Scolytidae	V 42	Ips confusus (Lec.)	a♀ a♂
	Tenebrionidae	V 46	Tribolium castaneum Hbst. [red flour beetle]	a (5 strains)
			Tribolium confusum Duv. [confused flour beetle]	a (4 strains)  a
Diptera	Calliphoridae	X 5	Lucilia sericata [sheep maggot fly]	p♀  p♂
	Chloropidae	X 10	Hippelates pusio Loew [eye gnat]	p♀  p♂  p♀, p♂*

Table 3 (cont.)

Age [h = hour(s) d = day(s)]	Temper- ature [°C]	Radiation	Dose	Sterility [%]	Ref. No.
7-11 d	26	$\gamma$	8000 rad	99.9	653
{ 0- 3 d	{ 26	$\gamma$	1000 rep	99	{ 811
		$\gamma$	1400 rep	100	
$\gamma$		1400 rep	71		
$\gamma$		2000 rep	99		
$\gamma$		2000 rep	95		
$\gamma$		2000 rep	85		
$\gamma$		2000 rep	98		
$\gamma$		4000 rep	99.9		
$\gamma$		2800 rep	97		
$\gamma$		4000 rep	100		
		$\gamma$	20 000 rad		1018
12-36 h		$\gamma$	8000 R	100	823
		$\gamma$	25 000 R	100	656
{ newly emerged		$\gamma$	10 000 R	"almost complete"	{ 843
		$\gamma$	7500 R	"almost complete"	
4-11 d	26	$\gamma$	9500 rad	99.9	653
4-11 d	26	$\gamma$	8000 rad	99.9	653
30 d	27	$\gamma$	4000 rad	> 99.9	657
		$\gamma$	$\geq$ 4500 rep	100 (?)	{ 979
		$\gamma$	> 6000 rep	100 (?)	
{ 2 d before emergence	{ 27	$\gamma$	4700 R	*) partial recovery after 21 d	{ 637
		$\gamma$	3750 R		
		$\gamma$	4500 R		854

Table 3 (cont.)

Order	Family	Systematic Code	Insect	Life Cycle Stage [e = egg l = larva p = pupa a = adult]
Diptera	Chloropidae	X 10	Hippelates pusio Loew	a ♀ a ♂ a ♀, ♂
	Culicidae	X 11	Anopheles atroparvus	
			Anopheles quadrimaculatus Say [common malaria mosquito]	p P♂
	Muscidae	X 19	Haematobia irritans (L.) [horn fly]	P♀, ♂
			Musca domestica L. [house fly]	p
	Oestridae	X 21	Hypoderma lineatum (de Vill.) [common cattle grub]	P♀ P♂
	Tephritidae	X 35	Ceratitis capitata [Mediterranean fruit fly]	P♀ p
			Dacus cucurbitae Coq. [melon fly]	p

Table 3 (cont.)

Age [h = hour(s) d = day(s)]	Temperature [°C]	Radiation	Dose	Sterility [%]	Ref. No.
24-36 h	27	$\gamma$	4900 R	> 99	637 854
		$\gamma$	4550 R		
		$\gamma$	5000 R		
		x	6000 R	100	638
> 24 h	27	$\gamma$	10 000 - 12 000 R		756
0-24 h		$\gamma$	12 000 R		907
10 d from e	27	$\gamma$	5 000 R	100	644
31-54 h before eclosion	27	$\gamma$	2 850 R		756
	30-33	$\gamma$	2 500 R	100	634
	30-35	$\gamma$	5 000 R	100	
2- 4 d	26	$\gamma$	$\geq 5 000$ R		971
8	26	$\gamma$	8000 - 10 000 R		971, 980
	field conditions	$\gamma$	9 500 R	100	994



## TABLE 4

### RADIOTRACER STUDIES ON INSECTICIDES <sup>1, 2)</sup>

Data have been assembled in the following categories:

- B. BOTANICALS AND DERIVATIVES
- C. CHLORINATED ARYL HYDROCARBONS (containing 6 or more chlorines)
- D. DDT RELATIVES (diphenyl aliphatics)
- F. FUMIGANTS
- N. NICOTINE ALKALOIDS (including ANABASINE and related compounds)
- P. PHOSPHORUS-CONTAINING COMPOUNDS
  - A. ALIPHATIC DERIVATIVES
  - C. ARYL (PHENYL) DERIVATIVES
  - H. HETEROCYCLIC DERIVATIVES
- R. CHEMOSTERILANTS
- X. CARBAMATES
- Y. SYNERGISTS

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<sup>1)</sup> Chemical names and "other designations" for compounds cited in the bibliography have been compiled after consulting E. E. Kenaga's "Commercial and Experimental Organic Insecticides" (1963 Revision) in Bull. ent. Soc. Am. 9: 2, 1963, 67-103 and (1966 Revision) in 12: 2, 1966, 161-217. The chemical categories have been maintained, apart from slight modifications. Two indexes (i) Common and Manufacturers' Names Index, and (ii) Letter-and-Number Index (the latter differing somewhat from the separate Number and Letter Indexes of the article) have also been prepared.

<sup>2)</sup> The chemical name used in accordance with the principles of Chemical Abstracts nomenclature is generally marked with an asterisk, \*.

Table 4

	Chemical name	Other designations for chemical and its compositions	Synthesis **	Metabolism	Residue determination
BOTANICALS AND DERIVATIVES					
B. 1	rotenone (from plant species Derris and Lonchocarpus)	rotenone powder and resins derris cubé	<sup>14</sup> C (494)	rat liver <sup>14</sup> C (493)	
B. 2	* pyrethrum (principally from plant species Chrysanthemum cinerariifolium)	pyrethrum pyrethrin I pyrethrin II		Musca domestica <sup>14</sup> C (468, 501)	
B. 3	d-trans-chrysanthemic acid		<sup>14</sup> C (469)		
CHLORINATED ARYL HYDROCARBONS (containing 6 or more chlorines)					
C. 1/2	benzene hexachloride * 1, 2, 3, 4, 5, 6-hexachlorocyclohexane, mixed isomers hexachlorocyclohexane  1, 2, 3, 4, 5, 6-hexachlorocyclohexane, 99% or more gamma isomer * lindane	BHC HCH 666 gamma-hexachlorocyclohexane  lindane gamma BHC	Analysis (technical sample) * Cl (334)	rat <sup>14</sup> C (331) <sup>14</sup> Cl (332, 333)  plants (Castanea crenata) with insect galls <sup>14</sup> C (335)	

\*\* If no other indication

Table 4

C. 3	<p>1, 2, 4, 5, 6, 7, 8, 8-octachloro-3a, 4, 7, 7a-tetrahydro-4, 7-methanoindane</p> <p>* chlordane</p> <p>1, 2, 4, 5, 6, 7, 8, 8-octachloro-2, 3, 3a, 4, 7, 7a-hexahydro-4, 7-methanoindene</p> <p>1, 2, 4, 5, 6, 7, 10, 10-octachloro-4, 7, 8, 9-tetrahydro-4, 7-endo-methyleneindane</p>	<p>chlordane</p> <p>Octa-Klor</p> <p>Oetachlor</p> <p>Velicol 1068</p> <p>1068</p>	<p>rat</p> <p><math>^{14}\text{C}</math> (379)</p>	
C. 4	<p>not less than 95% of</p> <p>1, 2, 3, 4, 10, 10-hexachloro-1, 4, 4a, 5, 8, 8a-hexahydro-1, 4-endo-exo-5, 8-dimethanonaphthalene</p> <p>* aldrin</p>	<p>aldrin</p> <p>compound 118</p> <p>Ocialene</p> <p>HMDN</p>	<p>Diabrotica virgifera</p> <p><math>^{35}\text{Cl}</math> (338)</p> <p>Musca domestica</p> <p><math>^{14}\text{C}</math> (337, 344)</p> <p>rat</p> <p><math>^{14}\text{C}</math> (341-a)</p>	
C. 5	<p>not less than 85% of</p> <p>1, 2, 3, 4, 10, 10-hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro-1, 4-endo-exo-5, 8-dimethanonaphthalene</p> <p>* dieldrin</p>	<p>dieldrin</p> <p>compound 497</p> <p>Octalox</p> <p>HEOD</p>	<p>Anthonomus grandis</p> <p><math>^{14}\text{C}</math> (345, 360)</p> <p>Aedes aegypti</p> <p><math>^{14}\text{C}</math> (337)</p> <p>Culex pipiens</p> <p>quinquefasciatus</p> <p><math>^{14}\text{C}</math> (343)</p> <p>Blattella germanica</p> <p><math>^{14}\text{C}</math> (341-b)</p> <p>Diabrotica virgifera</p> <p><math>^{35}\text{Cl}</math> (338)</p> <p>Musca domestica</p> <p><math>^{14}\text{C}</math> (336, 337, 344)</p> <p>Mammals, toxicity to</p> <p><math>^{14}\text{C}</math> (339)</p> <p>mouse (pregnant)</p> <p><math>^{14}\text{C}</math> (353)</p>	<p>mouse (pregnant)</p> <p><math>^{14}\text{C}</math> (353)</p>



Table 4 (cont.)

	Chemical name	Other designations for chemical and its compositions	Synthesis	Metabolism	Residue determination
C. 6	* 6, 7, 8, 9, 10, 10-hexachloro-1, 5, 5a, 6, 9, 9a-hexahydro-6, 9-methano-2, 4, 3-benzodioxathiepin 3-oxide	endosulfan Thiodan BIO-5462 Hoe 2671 Malix Niagara 5462		rabbit <sup>14</sup> C (341) rat, metab. and toxicity <sup>35</sup> Cl (340) <sup>14</sup> C (341) penetration <sup>14</sup> C (436) wheat, uptake from soil <sup>14</sup> C (342)	
C. 7	* 1, 3, 4, 5, 6, 7, 8, 8-octachloro-3a, 4, 7, 7a-tetrahydro-4, 7-methanophthalan	Telodrin SD 4402 CP-14957		Aedes aegypti <sup>14</sup> C (349) Aspergillus niger <sup>14</sup> C (349) Aspergillus flavus <sup>14</sup> C (349) Penicillium chrysogenum <sup>14</sup> C (349) Penicillium notatum <sup>14</sup> C (349) Laphygna frugiperda <sup>14</sup> C (348)	

Table 4 (cont.)

DDT RELATIVES				
D. 1	dichloro diphenyl trichloroethane * 1, 1, 1-trichloro-2, 2-bis- (p-chlorophenyl) ethane	DDT Chlorophenothene		
			<i>Aedes aegypti</i> <sup>14</sup> C (372, 377) cockroach <sup>14</sup> C (370) <i>Culex fatigans</i> <sup>14</sup> C (362) <i>Culex tarsalis</i> <sup>14</sup> C (362) <i>Anthonomus grandis</i> <sup>14</sup> C (360, 363) <i>Blattella germanica</i> <sup>14</sup> C (350) <i>Euxoa notata</i> <sup>14</sup> C (359) <i>Musca domestica</i> <sup>14</sup> C (350, 354) <sup>36</sup> Cl (358) <i>Pediculus humanus</i> humanus <sup>14</sup> C (366) <i>Protophormia</i> <i>terraz-novae</i> <sup>14</sup> C (361) <i>Stomoxys calcitrans</i> <sup>14</sup> C (375) <i>Triatoma infestans</i> <sup>14</sup> C (351, 368) <i>Escherichia coli</i> <sup>14</sup> C (375) <i>Serratia marcescens</i> <sup>14</sup> C (375) cat <sup>14</sup> C (374)	fish <sup>14</sup> C (357) mouse (pregnant) <sup>14</sup> C (353) poultry <sup>14</sup> C (352) snails (Ampullaria) <sup>14</sup> C (357) lake water <sup>14</sup> C (367) mud <sup>14</sup> C (357) soil <sup>14</sup> C (357) vegetation <sup>14</sup> C (357)

Table 4 (cont.)

	Chemical name	Other designations for chemical and its compositions	Synthesis	Metabolism	Residue determination
				cattle (b.w're rumen fluid) <sup>14</sup> C (387) fish <sup>14</sup> C (357) mouse (pregnant) <sup>14</sup> C (353) rat (liver microsomes) <sup>14</sup> C (389) (skin) <sup>14</sup> C (435) snails (Ampullaria) <sup>14</sup> C (357) barley, susceptibility <sup>14</sup> C (376) porphyrins, reduced <sup>14</sup> C (387) marsh ecosystem <sup>14</sup> C (371)	
D.2	1,1-bis(p-chlorophenyl) 2,2-dichloroethane	TDE Rhotane® DDD		Argyrotaea velutinana <sup>14</sup> C (356) Blattella germanica <sup>14</sup> C (356) Periplaneta americana <sup>14</sup> C (356) Protoparce sexta <sup>14</sup> C (356)	lake water <sup>14</sup> C (387)

Table 4 (cont.)

				Stomoxys calcitrans <sup>14</sup> C (375) man <sup>14</sup> C (355) rabbit <sup>14</sup> C (355) rat <sup>14</sup> C (369)	
D.3	1, 1-bis(p-chlorophenyl) 2, 2-trichloroethanol *4, 4'-dichloro- $\alpha$ - (trichloromethyl) benzhydrol 1, 1, 1-trichloro-2-hydroxy- 2, 2-bis(p-chlorophenyl) ethane	Kelthane® FW-233		Triatoma infestans <sup>14</sup> C (351)	
D.4	2-nitro-1, 1-bis(p-chlorophenyl) propane *1, 1-bis(p-chlorophenyl)-2-nitropropane	Prolan CS645A		Aedes aegypti <sup>14</sup> C (372)	
FUMIGANTS					
F.1	sulfuryl fluoride	Vikane		wheat (graham) flour SS (330)	
F.2	naphthalene			Musca domestica <sup>14</sup> C (329)	
F.3	hydrogen cyanide *hydrocyanic acid	HCN prussic acid (in H <sub>2</sub> O)		basidiomycete (psychrophilic) <sup>14</sup> C (328)	
F.4	carbon tetrachloride	CCl <sub>4</sub>		rat, liver <sup>14</sup> C (323-7)	

Table 4 (cont.)

	Chemical name	Other designations for chemical and its compositions	Synthesis	Metabolism	Residue determination
NICOTINE ALKALOIDS (including ANABASINE and RELATED COMPOUNDS)					
N. 1	* nicotine 1-1-methyl-2-(3-pyridyl)-pyrrolidine 1-3-(1-methyl-2-pyrrolidyl)-pyridine	Black Leaf (40) nicotine (sulfate)	$^{14}\text{C}$ (470-2, 475-6, 482-4, 486, 492)	Conoderus vespertinus $^{14}\text{C}$ (263) Heliothis virescens $^{14}\text{C}$ (263) Melanoplus differentialis $^{14}\text{C}$ (263) Musca domestica $^{14}\text{C}$ (263) Protoparce sexta $^{14}\text{C}$ (263, 486) Trichoplusia ni $^{14}\text{C}$ (263) cat $^{14}\text{C}$ (472-3, 485) dog $^{14}\text{C}$ (485) mouse $^{14}\text{C}$ (472-3, 478-9) $^3\text{H}$ (474) rat $^{14}\text{C}$ (472, 478, 484) Nicotiana sp. $^{14}\text{C}$ (477, 483, 487, 490)	cat $^{14}\text{C}$ (473) mouse $^{14}\text{C}$ (473)

Table 4 (cont.)

N. 2	nicotiana alkaloids		<sup>14</sup> C (480-1, 487, 489) <sup>3</sup> H (491)		Nicotiana sp. <sup>14</sup> C (488)
	anabasine		<sup>14</sup> C (480-1, 489)		Nicotiana <sup>14</sup> C (487)
	cotinine				mouse <sup>3</sup> H (474)
	nicotinic acid				Nicotiana <sup>14</sup> C (487, 489) <sup>3</sup> H (491)

PHOSPHORUS-CONTAINING COMPOUNDS  
PHOSPHORUS ALIPHATIC DERIVATIVES

P/A. 1	* dimethyl (2, 2, 2-trichloro-1-hydroxyethyl) phosphonate	Dipterex Bayer L13/59 Dylox Neguvon chlorophos trichlorofon Tugon Dipterex	<sup>14</sup> C (380) <sup>32</sup> P (384, 388) Analogues <sup>32</sup> P (388)	Musca domestica <sup>32</sup> P (385) Prodenia litura <sup>14</sup> C (383) <sup>32</sup> P (383, 386-7) Aspergillus niger <sup>32</sup> P (389) Fusarium spp. <sup>32</sup> P (389) Penicillium notatum <sup>32</sup> P (389) cattle <sup>32</sup> P (II/674) rat <sup>14</sup> C (380) <sup>32</sup> P (381-2)
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Table 4 (cont.)

	Chemical name	Other designations for chemical and its compositions	Synthesis	Metabolism	Residue determination
P/A. 2	O, O-dimethyl 2, 2-dichlorovinyl phosphate * 2, 2-dichlorovinyl dimethyl phosphate	DDVP Herkol Vapona dichlorvos		cotton $^{32}\text{P}$ (384)	
P/A. 3	3-hydroxy-N-methyl crotonamide dimethyl phosphate	Azodrin SD 9129		<p><i>Lucilia sericata</i> <math>^{32}\text{P}</math> (390) <i>Oncopeltus fasciatus</i> <math>^{14}\text{C}</math> (429)</p> <p><i>Musca domestica</i> <math>^{14}\text{C}</math> (398) <math>^{32}\text{P}</math> (398) <i>Periplaneta americana</i> <math>^{14}\text{C}</math> (398) <math>^{32}\text{P}</math> (398) goat <math>^{14}\text{C}</math> (398) <math>^{32}\text{P}</math> (398) rat <math>^{32}\text{P}</math> (391) beans <math>^{32}\text{P}</math> (398) cotton <math>^{32}\text{P}</math> (391-2)</p>	<p>meat <math>^{32}\text{P}</math> (390)</p> <p>cotton <math>^{32}\text{P}</math> (392) soil <math>^{32}\text{P}</math> (392)</p>

Table 4 (cont.)

P/A. 4	* 3-(dimethoxyphosphinyl)- N, N-dimethyl- <u>cis</u> -crotonamide 2-dimethylcarbamoyl-1-methylvinyl dimethyl phosphate dimethyl phosphate of 3-hydroxy N, N-dimethyl- <u>cis</u> -crotonamide	Bidrin SD 3562			Anthrenus grandis 14 C (393-4) Σ P (393) Heliothis zea Σ P (393) Musca domestica 14 C (396) Periplaneta americana (toxicity to adults) Σ P (398) goat 14 C (398) Σ P (398) rat 14 C (393) Σ P (393) bean Σ P (398) cotton 14 C (393) Σ P (398, 397)	milk 14 C (398) Σ P (398) soil 14 C (395-6)
P/A. 5	O, O-diethyl O (and S)-2- (ethylthio) ethyl phosphorothioates * mixture of O, O-diethyl S- (and O) 2-(ethylthio) ethyl phosphorothioates mixture of O, O-diethyl S-ethyl- mercaptoethyl thiophosphate and O, O-diethyl O-ethylmercaptoethyl thiophosphate a trialkyl thiophosphate	demeton Systox E-1059 Bayer 8173 mercaptophos		Hydrolysis and isomerization Σ P (399)		



Table 4 (cont.)

	Chemical name	Other designations for chemical and its compositions	Synthesis	Metabolism	Residue determination
P/A. 6	* O, O-diethyl S-ethylthiomethyl phosphorodithioate O, O-diethyl S-ethylmercaptomethyl dithiophosphate	phorate Thimet L 11/8 AC 3911			millet #S (400)
P/A. 7	* O, O-diethyl S-2-(ethylthio)-ethyl phosphorodithioate	Bayer 19639 Di-Syston Ekatine dithiodemeton		Anthonomus grandis #P (401) Heliothis zea #P (401-2) rat #P (401-2) cotton #P (401, 403)	
P/A. 8	* O, O-dimethyl dithiophosphate of diethyl mercaptosuccinate O, O-dimethyl S-(1, 2-dicarboethoxyethyl) dithiophosphate S-[1, 2-bis(ethoxycarbonyl)-ethyl] O, O-dimethyl phosphorodithioate O, O-dimethyl phosphorodithioate ester with diethyl mercaptosuccinate	malathion Malathion 4049		Blattella germanica 14C (84, 408) Musca domestica 14C (336, 409) #P (409) Tetranychus urticae 14C (410-11) rat 14C (379, 435) #S (379) forest fauna (waterbed) #S (404, 407, 412)	gooseberries #P (405-6)

Table 4 (cont.)

P/A. 9	O, O-dimethyl thiophosphate of diethyl mercaptosuccinate	malaoxon		Musca domestica ΣP (408)
P/A. 10	<p>O, O-dimethyl S (N-methyl-carbamoylmethyl) phosphorodithioate</p> <p>* S-methylcarbamoylmethyl</p> <p>O, O-dimethyl phosphorodithioate</p> <p>O, O-dimethyl S-α-mercaptop-N-methylacetamido dithiophosphate</p> <p>methyl dimethyl dithiophosphoryl acetamide</p>	<p>dimethoate</p> <p>Cygon</p> <p>Rogor</p> <p>AC 12880</p> <p>ENT 24650</p> <p>NC-262</p>	<p>Properties ΣP (419)</p>	<p>Acheta domesticus ΣH (417)</p> <p>Leptinotarsa decemlineata ΣH (417)</p> <p>Musca domestica ΣH (417)</p> <p>Oncopeltus fasciatus ΣH (417)</p> <p>Periplaneta americana ΣH (417)</p> <p>dog ΣP (416)</p> <p>man ΣP (416)</p> <p>mouse ΣP (416)</p> <p>ΣH (418)</p> <p>pig ΣP (416)</p> <p>poultry ΣP (416)</p> <p>rabbit ΣP (416)</p> <p>rat ΣP (416)</p> <p>sheep ΣP (416)</p>

Table 4 (cont.)

	Chemical name	Other designations for chemical and its compositions	Syntheses	Metabolism	Residue determination
PHOSPHORUS PHENYL (CARBOCYCLIC) DERIVATIVES					
P/C. 1	* O, O-dimethyl O-p-nitrophenyl phosphorothioate O, O-dimethyl O-p-nitrophenyl thiophosphate dimethyl p-nitrophenyl thionophosphate dimethyl p-nitrophenyl phosphorothionate	methyl parathion methyl homologue of parathion Nitrox Bayer E-601 Metron		guinea pig $^{32}\text{P}$ (431) rat $^{14}\text{C}$ (420) $^{32}\text{P}$ (431)	
P/C. 2	O, O-diethyl O-p-nitrophenyl phosphorothioate * parathion O, O-diethyl O-p-nitrophenyl thiophosphate diethyl p-nitrophenyl thionophosphate diethyl p-nitrophenyl phosphorothionate	parathion Alkron Niran Thiophos Amer. Cyan. 3422 Bayer E-605	$^3\text{H}$ (425-7) $^{32}\text{P}$ (423) labelling $^3\text{H}$ (322)	Aedes nigromaculis $^{32}\text{P}$ (424) Chilo suppressalis $^{32}\text{P}$ (422, 428) Musca domestica $^{32}\text{P}$ (423) Oncomelanus fasciatus $^3\text{H}$ (429) Tetranychus urticae $^3\text{H}$ (410-11) frog $^3\text{H}$ (427) guinea pig $^3\text{H}$ (427) mouse $^3\text{H}$ (427)	

Table 4 (cont.)

					<p>pig <math>^3\text{H}</math> (427)</p> <p>pigeon <math>^3\text{H}</math> (427)</p> <p>rat <math>^3\text{H}</math> (427)</p> <p><math>^{32}\text{S}</math> (426)</p> <p>toad <math>^3\text{H}</math> (427)</p> <p>trout <math>^3\text{H}</math> (427)</p> <p>turtle <math>^3\text{H}</math> (427)</p> <p>poplar <math>^{32}\text{P}</math> (421)</p>			
P/C. 3	<p>O, O-diethyl O-p-nitrophenyl phosphate *diethyl p-nitrophenyl phosphate</p>	<p>paraoxon oxygen analogue of parathion Bayer E-800</p>	$^{32}\text{P}$ (423)		<p>Musca domestica <math>^{32}\text{P}</math> (423)</p> <p>cat <math>^{32}\text{P}</math> (430)</p>			
P/C. 4	4-nitrophenyl dimethyl phosphate				cotton $^{32}\text{P}$ (419)			
P/C. 5	<p>O-phenyl O'-(4-nitrophenyl) methylphosphonothioate</p>	Colep	$^{14}\text{C}$ (430-a)		<p>rat <math>^{14}\text{C}</math> (430-a)</p> <p>apple <math>^{14}\text{C}</math> (430-a)</p> <p>cotton <math>^{14}\text{C}</math> (430-a)</p>			

Table 4 (cont.)

	Chemical name	Other designations for chemical and its compositions	Synthesis	Metabolism	Residue determination
P/C. 6	O, O-dimethyl O-(3-chloro-4-nitrophenyl) thiophosphate * O-(3-chloro-4-nitrophenyl) O, O-dimethyl phosphorothioate	Chlorthion Bayer 22/190		rat 14 C (379) S S (379)	
P/C. 7	O, O-dimethyl O-(3-methyl-4-nitrophenyl) phosphorothioate * O, O-dimethyl O-(4-nitro-m-tolyl) phosphorothioate	Folition Bayer 41831 Sumithion Sumitomo S-1102 A		guinea pig S P (431) rat S P (431)	
P/C. 8	4-methylthiophenyl dimethyl phosphate			cotton S P (419)	
P/C. 9	* O, O-dimethyl O-2, 4, 5-trichlorophenyl phosphorothioate	rounel Dow ET-57 Dow ET-14 Korlan Nankor Trolene Etrolene Fenchlorphos		cattle S P (433) rat S P (433) sheep S P (433)	
P/C. 10	2, 4, 5-trichlorophenyl dimethyl phosphate			cotton S P (419)	
P/C. 11	O-p-methylthiophenyl O-methylmethyl-phosphonothioate			cotton (432)	

Table 4 (cont.)

P/C. 12	<u>O</u> - <u>p</u> -(dimethylsulfamoyl)phenyl <u>O</u> , <u>O</u> -dimethyl phosphorothioate	famphur Warber® Famophos CL 38023		Oncopeltus fasciatus 3H (434) Periplaneta americana 3H (434) mouse 3H (434) rat 3H (435)	
P/C. 13	ethyl ester of O, O-dimethyl- dithiophosphoryl α-phenyl acetic acid * ethyl (dimethoxyphosphinothioylthio) phenylacetate	Dimephenthoate Cidial			olive oil 32P (436) olive 32P (437)
P/C. 14	alpha-methylbenzyl 3-hydroxy- crotonate dimethyl phosphate	Ciodrin® Shell SD-4294		sheep (ewe) 32P (438) goat (lactating) 32P (439)	milk 32P (438-9)
P/C. 15	alpha-methylbenzyl 3-(dimethoxy- phosphinyloxy)-crotonate		14 C, 32P (401)		
P/C. 16		2605	14 C (441)		
P/C. 17		Lurgo	14 C (441)		

Table 4 (cont.)

	Chemical name	Other designations for chemical and its compositions	Synthesis	Metabolism	Residue determination
PHOSPHORUS HETEROCYCLIC DERIVATIVES					
P/H. 1	$\underline{\text{O}}, \underline{\text{O}}$ -diethyl $\underline{\text{O}}$ -3-chloro-4-methyl-2-oxo-2H-1-benzopyran-7-yl phosphorothioate * $\underline{\text{O}}$ -3-chloro-4-methylumbelliferone) $\underline{\text{O}}, \underline{\text{O}}$ -diethyl phosphorothioate $\underline{\text{O}}, \underline{\text{O}}$ -diethyl $\underline{\text{O}}$ -(3-chloro-4-methyl-7-coumarinyl) phosphorothioate 3-chloro-4-methylumbelliferone, $\underline{\text{O}}, \underline{\text{O}}$ -diethyl thiophosphate	Bayer 21/199 CO-RAL Muscotox		cattle $^{32}\text{P}$ (460)	
P/H. 2	naphthaloximido- $\underline{\text{O}}, \underline{\text{O}}$ -diethyl phosphorothioate * $\underline{\text{O}}, \underline{\text{O}}$ -diethyl $\underline{\text{O}}$ -naphthalimido phosphorothioate	Bayer 22408 ENT 24970		cattle $^{32}\text{P}$ (460)	
P/H. 3	phthalimidomethyl $\underline{\text{O}}, \underline{\text{O}}$ -dimethyl phosphorodithioate * $\underline{\text{O}}, \underline{\text{O}}$ -dimethyl 8-phthalimidomethyl phosphorodithioate	Imidan Prolate R-1504		Blattella germanica $^{14}\text{C}$ (445) insects $^{14}\text{C}$ (443) cattle $^{14}\text{C}$ (442) rat $^{14}\text{C}$ (443, 445) cotton $^{14}\text{C}$ (444)	

Table 4 (cont.)

P/H. 4	O, O-diethyl O-3, 5, 6-trichloro-2-pyridyl phosphorothioate	Dursban	Properties % CI (446)		<sup>36</sup> Cl (446)
P/H. 5	O, O-diethyl O-(2-isopropyl-6-methyl-4-pyrimidinyl) thiophosphate * O, O-diethyl O-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate	diazinon Basudin G-24480		Musca domestica <sup>14</sup> C (336, 447) x p (423)	<sup>14</sup> C (448)
CHEMOSTERILANTS					
R. 1	* tris(1-aziridinyl) phosphine oxide	tepa aphoxide ENT. 24915 APO		Musca domestica <sup>14</sup> C (496) rat x p (497)	
R. 2	* tris(1-aziridinyl) phosphine sulphide	thiotepa		Anthonomus grandis x p (500) Blattella germanica x p (500) Musca domestica x p (500) Stomoxys calcitrans x p (500) rat x p (500)	
R. 3	* tris[1-(2-methylaziridinyl)] phosphine oxide	metepa metaphoxide ENT. 50003 MAPC methyl aphoxide		Aedes aegypti x p (498) Anopheles quadri- maculatus x p (498)	



Table 4 (cont.)

	Chemical name	Other designations for chemical and its compositions	Synthesis	Metabolism	Residue determination
				Cochliomyia hominivorax 22 P (495) Musca domestica 22 P (498) Stomoxys calcitrans 22 P (495)	
R. 4	* 5-fluorocetic acid	fluorocrotic acid		Musca domestica 14 C (499)	
CARBAMATES					
X. 1	dimethyl 5-(1-isopropyl-3-methylpyrazolyl)-3-methyl-5-pyrazolyl dimethylcarbamate	Isolan® G 23611		Musca domestica (463) (effect of insecticide on feeding, 14 C)	
X. 2	* g-isopropoxyphenylmethylcarbamate 2-isopropoxyphenyl methylcarbamate	Baygon® UNDEN® propoxur Bayer 9010 Bayer 39007		Anopheles albimanus 14 C (464) Culex pipiens quinquefasciatus 14 C (464) Musca domestica 14 C (454) Periplaneta americana 14 C (454) beans 14 C (459)	

Table 4 (cont.)

X. 3	4-methyl(uto) 3, 5-xylyl methylcarbamate	MESUROL® mercaptodimethur Bayer H-321 Bayer 9026 Bayer 37344 ENT-25726		beans 14C (459)	
X. 4	4-dimethylamino-m-tolyl methylcarbamate	MATACIL® aminocarb azprocarb Bayer 44646 ENT-25784		beans 14C (459)	
X. 5	4-dimethylamino-3, 5-xylyl methylcarbamate	Zectran® Dowco 139® ENT 25766	14C (451)	Musca domestica 14C (462, 465) dog 14C (449, 450) beans 14C (459) broccoli 14C (452-3)	beans 14C (459) broccoli 14C (453)
X. 6	*1-naphthyl methylcarbamate 1-naphthyl N-methylcarbamate α-naphthyl N-methylcarbamate	carbaryl Sevin® 7744		Musca domestica 14C (454, 501) Periplaneta americana 14C (454) cattle (460) goat 14C (454) guinea pig 14C (455)	apple 14C (456)

Table 4 (cont.)

	Chemical name	Other designations for chemical and its compositions	Synthesis	Metabolism	Residue determination **
				man $^{14}\text{C}$ (455) rat $^3\text{H}$ (435) $^{14}\text{C}$ (455) apple $^{14}\text{C}$ (458) beans $^{14}\text{C}$ (454, 459) cotton $^{14}\text{C}$ (454)	
X. 7	* 1-(dimethylcarbamoyl)- 5-methyl-3-pyrazolyl dimethylcarbamate 2-dimethylcarbamyl-3-methylpyrazolyl- (5)-dimethylcarbamate 2-dimethylcarbamoyl-3-methyl- 5-pyrazolyl dimethylcarbamate	dimetilan Dimetilan ® Dimetilane GS-13332		Blattella germanica $^{14}\text{C}$ (457-8) Musca domestica $^{14}\text{C}$ (457-8) Petiolaria americana $^{14}\text{C}$ (457-8)	
X. 8	Various phenyl N-methylcarbamates		$^{14}\text{C}$ (461)	beans $^{14}\text{C}$ (459, 461) Musca domestica $^{14}\text{C}$ (461-2, 465) rat $^{14}\text{C}$ (461, 467)	

Y. SYNERGISTS					
Y. 1	* $\alpha$ -[2-(2-butoxyethoxy)ethoxy]-4,5-methylenedioxy-2-propyltoluene butylcarbitol-6-propylpiperonyl ether	piperonyl butoxide Butocide	<sup>14</sup> C (501)		
Y. 2	4-allyl-1,2-methylenedioxybenzene	safrole	<sup>14</sup> C (501)		
Y. 3	4-propyl-1,2-methylenedioxybenzene	dihydrosafrole	<sup>14</sup> C (501)		
Y. 4	* 1,2-methylenedioxy-4-[2-(octylsulfinyl)propyl]benzene <u>n</u> -octyl sulphoxide of isosafrole	sulfoxide Sulfox-Cide	<sup>14</sup> C (501)		
Y. 5	5-allyl-1-methoxy-2,3-methylenedioxybenzene	myricidin	<sup>14</sup> C (501)		
Y. 6	* isobornyl thiocyanacetate (-82%, other related terpenes - 18%) terpinyl thiocyanacetate mixture of fenchyl and isobornyl thiocyanacetate	Thanite		Miscia domestica <sup>14</sup> C (462)	

\*\* Simple apparatus for residue analysis by combustion of samples containing <sup>14</sup>C-pesticides (1050)

# INSECTICIDE INDEXES

## COMMON AND MANUFACTURERS' NAMES INDEX

Insecticide	Category	Insecticide	Category
aldrin	C. 4	malathion	P/A. 8
Alkron	P/C. 2	Malathion	P/A. 8
aminocarb	X. 4	Malix	C. 6
aphoxide	R. 1	Matacil ®	X. 4
arpocarb	X. 4	mercaptodimethur	X. 3
Azodrin	P/A. 3	mercaptophos	P/A. 5
Basudin	P/H. 5	Mesuroi ®	X. 3
Baygon ®	X. 2	metaphoxide	R. 3
Bidrin	P/A. 4	metepa	R. 3
Black Leaf (40)	N. 1	methyl aphoxide	R. 3
Butocide	Y. 1	methyl parathion	P/C. 1
carbaryl	X. 6	Metron	P/C. 1
chlordan	C. 3	Muscotox	P/H. 1
Chlorophenothene	D. 1	myricistin	Y. 5
chlorophos	P/A. 1	Nankor	P/C. 9
Chlorthion	P/C. 6	Neguvon	P/A. 1
d-trans-chrysanthemic acid	B. 3	nicotine (sulphate)	N. 1
Cidtal	P/C. 13	Niran	P/C. 2
Ciodrin ®	P/C. 14	Octachlor	C. 3
Colep	P/C. 5	Octa-Klor	C. 3
cubé	B. 1	Octalene	C. 4
Cygon	P/A. 10	paraaxon	P/C. 3
demeton	P/A. 5	parathion	P/C. 2
derris	B. 1	phorate	P/A. 6
diazinon	P/H. 5	piperonyl butoxide	Y. 1
dichlorvos	P/A. 2	Prolan	D. 4
dihydrosafrole	Y. 3	Prolate	P/H. 3
Dimephenthoate	P/C. 13	propoxur	X. 2
dimethoate	P/A. 10	prussic acid	F. 3
dimerilan	X. 7	pyrethrin I	B. 2
Dimerilan ®	X. 7	pyrethrin II	B. 2
Dimetilane	X. 7	pyrethrum	B. 2
Dipteres	P/A. 1	Rhothane ®	D. 2
Dipterex	P/A. 1	Rogor	P/A. 10
Di-Syston	P/A. 7	rotenone	B. 1
dithiodemeton	P/A. 7	safrole	Y. 2
Dursban	P/H. 4	Sevin	X. 8
Dylox	P/A. 1	Sulfox-Cide	Y. 4
Ekatine	P/A. 7	sulfoxide	Y. 4
endosulfan	C. 6	Sumithion	P/C. 7
Etolene	P/C. 9	Systox	P/A. 5
Famophos	P/C. 12	Telodrin	C. 7
famphur	P/C. 12	tepa	R. 1
Fenchlorphos	P/C. 9	Thanite	Y. 6
fluoroorotic acid	R. 4	Thimet	P/A. 6
Folthion	P/C. 7	Thiodan	C. 6
gammexane	C. 1/2	Thiophos	P/C. 2
Herkol	P/A. 2	thiotepa	R. 2
hydrogen cyanide	F. 3	trichlorfon	P/A. 1
Imidan	P/H. 3	Trolene	P/C. 9
Isolan ®	X. 1	Tugon	P/A. 1
Kelthane ®	D. 3	Unden ®	X. 2
Korlan	P/C. 9	Vapona	P/A. 2
lindane	C. 1/2	Vikane	F. 1
Lurgo	P/C. 17	Warbex ®	P/C. 12
malaaxon	P/A. 9	Zectran ®	X. 5

# LETTER AND NUMBER INDEX

Letter/Number	Chemical classification code	Letter/Number	Chemical classification code
AC 3911	P/A. 6	ENT 25784	X. 4
AC 12880	P/A. 10	ENT 50003	R. 3
Amer. Cyan. 3422	P/C. 2	FW-293	D. 3
APD	R. 1	G-23611	X. 1
Bayer 8173	P/A. 5	G-24480	P/H. 5
Bayer 9010	X. 2	GS-13332	X. 7
Bayer 9026	X. 3	Bayer H-321	X. 3
Bayer 19639	P/A. 7	HCH	C. 1/2
Bayer 22408	P/H. 2	HCN	F. 3
Bayer 37344	X. 3	HEOD	C. 5
Bayer 39007	X. 2	HHDN	C. 4
Bayer 41831	P/C. 7	Hoe 2671	C. 6
Bayer 44646	X. 4	Bayer L13/59	P/A. 1
Bayer 21/199	P/H. 1	L11/6	P/A. 6
Bayer 22/190	P/C. 6	MAPO	R. 3
BHC	C. 1/2	NC-262	P/A. 10
gamma BHC	C. 1/2	Niagara 5462	C. 6
BIO-5462	C. 6	R-1504	P/H. 3
CL 38023	P/C. 12	SD 3562	P/A. 4
CP-14957	C. 7	SD 4402	P/C. 14
CS645A	D. 4	SD 9129	P/A. 3
DDD	D. 2	Shell SD-4294	P/C. 14
DDT	D. 1	Sumitomo S-1102A	P/C. 6
Dowco 139®	X. 5	TDE	D. 2
Dow ET-14	P/C. 9	Veliscol 1068	C. 3
Dow ET-57	P/C. 9		
Bayer E-600	P/C. 3	Compounds identified	
Bayer E-601	P/C. 1	by number only	
Bayer E-605	P/C. 2	666	C. 1/2
E-1069	P/A. 5	1068	C. 3
ENT 24650	P/A. 10	1805	P/C. 16
ENT 24970	P/H. 2	4049	P/A. 8
ENT 24915	R. 1	7744	X. 6
ENT 25726	X. 3	Compound 118	C. 4
ENT 25766	X. 5	Compound 497	C. 5

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- National Institute of Radiological Sciences, Chiba City, Japan: 505
- Norsk Hydro's Institute for Cancer Research, Oslo, Norway: 780
- Oak Ridge National Laboratory, Oak Ridge, Tenn., USA: 250, 521, 544, 568, 569, 570, 613
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