BOLL WEEVIL
Anthonomus grandis Boh.

Abstracts of Research Publications
1961–65

Miscellaneous Publication No. 1092

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

PRECAUTIONS

Insecticides used improperly can be injurious to man and animals. Use them only when needed and handle them with care. Follow the directions and heed all precautions on the labels.

Some States have special restrictions on the use of certain insecticides. Before applying insecticides, check State and local regulations.

Keep insecticides in closed, well-labeled containers in a dry place. Store them where they will not contaminate food or feed, and where children and animals cannot reach them. Promptly dispose of empty insecticide containers; do not use for any other purpose.

When handling an insecticide, wear clean, dry clothing.

Avoid repeated or prolonged contact of insecticide with your skin.

Wear protective clothing and equipment if specified on the container label. Avoid prolonged inhalation of insecticide dusts or mists.

Avoid spilling an insecticide concentrate on your skin, and keep it out of your eyes, nose, and mouth. If you spill any on your skin or clothing, remove contaminated clothing immediately and wash the skin thoroughly with soap and water. Launder the clothing before wearing it again.

After handling an insecticide, do not eat, drink, or smoke until you have washed your hands and face. Wash any exposed skin immediately after applying an insecticide.

Avoid drift of insecticide to nearby wildlife habitats, bee yards, crops, or livestock. Do not apply insecticides under conditions favoring drift from the area to be treated.

Many insecticides are highly toxic to fish and aquatic animals. Keep insecticides out of all water sources such as ponds, streams, and wells. Do not clean spraying equipment or dump excess spray material near such water.

Do not apply insecticides to plants during hours when honey bees and other pollinating insects are visiting them. Notify beekeepers at least 48 hours before dusting or spraying so that measures can be taken to protect bees. Bury empty insecticide containers at a sanitary land-fill dump, or crush and bury them at least 18 inches deep in a level, isolated place where they will not contaminate water supplies.

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Abstracts of Research Publications 1961-65

Compiled by
Luceille Liston Mitlin
Mitchell Memorial Library
Mississippi State University
State College, Miss.
and
Norman Mitlin
Entomology Research Division
Agricultural Research Service

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Contents

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BOLL WEEVIL

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Abstracts of Research Publications 1961-65

Compiled by LUCEILLE LISTON MITLIN, *Mitchell Memorial Library, Mississippi State University, State College, Miss.*, and NORMAN MITLIN, *Entomology Research Division, Agricultural Research Service*

INTRODUCTION

Miscellaneous Publication 985 gave abstracts of research publications from 1845 through 1960.[1] Our compilation is a continuation of that work; it covers literature published in the years 1961 through 1965. This publication has been prepared to serve as a guide to original publications for interested researchers.

The following sources were consulted: *Biological and Agricultural Index* (formerly *Agricultural Index), Biological Abstracts, BioResearch Titles* (now *BioResearch Index), Pesticides Documentation Bulletin, Review of Applied Entomology, Series A and B, U.S. Bibliography of Agriculture,* professional publications, journals, and reports.

For accuracy the language of the author has been preserved wherever possible. Author and subject indexes are included.

We wish to express our appreciation for their interest and advice to T. B. Davich and his staff [2] and to J. R. Brazzel.[3] We are grateful also to Hernan Oropeza P.[4] and to F. Fernandez Yepez [5] for compiling the lists of publications that have been combined and are given in the appendix.

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[1] See reference 54, p. 9.

[2] Boll Weevil Research Laboratory, U. S. Agricultural Research Service, Entomology Research Division, State College, Miss.

[3] Mississippi State University, Entomology Department, State College, Miss.

[4] Republica de Venezuela, Ministerio de Agricultura y Cria, Direccion de Investigacion, Centro de Investigaciones Agronomicas, Seccion de Entomologia, Maracay, Venezuela.

[5] Universidad Central de Venezuela, Facultad de Agronomia, Instituto de Zoologia Agricola, Maracay, Venezuela.

BIBLIOGRAPHY

1. ADKISSON, P. L., and others. Evaluation of the 1964 diapause boll weevil control program on the High Plains of Texas. *Tex. Agr. Expt. Sta. Dept. Tech. Rpt.* 1, 29 pp. 1964.

J. W. Davis, W. L. Owen, and D. R. Rummel, joint authors.

A diapause boll weevil control program was initiated in September 1964 to eliminate infestations on the High Plains, to reduce infestations in the Rolling Plains, and to minimize further westward migration.

Over 1,100,000 acres of cotton were sprayed with technical malathion applied as an ultra-low-volume spray. All the boll weevil infested cotton acreage in the control zone was sprayed at least four times. Some of the most severely infested areas received a fifth and sixth application. Drastic reductions in the boll weevil populations were obtained.

2. ADKISSON, P. L., RUMMEL, D. R., and STERLING, W. L. Two-phased control program for reducing diapause boll weevil populations in the High Plains of Texas in 1965. *Tex. Agr. Expt. Sta. Dept. Tech. Rpt.* 2, 7 pp. 1965.

A new type of diapause boll weevil control program consisting of two phases was conducted in the High Plains of Texas during the fall of 1965. Phase one carried out in September had as its objective the killing of the last 1965 generation of reproductive females with three applications of malathion made at 5-day intervals. Theoretically, these applications should have broken the weevil's reproductive cycle and prevented the females from laying the eggs that might later develop into the overwintering adults. In phase two, four applications of malathion were made at 10- to 14-day intervals during October and November until the first killing frost to kill any adults that might have survived the phase-one treatments or that might have developed from eggs laid before the control program was initiated.

Results indicated that the new-type program was highly successful. The potential overwintering population in the control zone at the time of frost was estimated to be 99 percent smaller than that in nearby untreated acreages. In addition, inside the control zone the adult boll weevil population at this time was 93 percent smaller than at a similar time in 1964.

3. AGEE, H. R. Characters for determination of sex of the boll weevil. *Jour. Econ. Ent.* 57: 500. 1964.

Examination of the last two posterior segments of the body of the boll weevil with a binocular microscope reveals differences in appearance and size between the sexes, which permit differentiation with complete accuracy. The eighth tergum of the male is about one-half as wide and long as the seventh tergum of the female. The distinguishing characteristic of the eighth tergum of the male is the notch in its ventral portion. Diagrams are given.

4. ANGALET, G. W. *Bracon greeni* (Hymenoptera: braconidae), a potential parasite of the boll weevil. *Indian Jour. Ent.* 26: 447–452. 1965.

Under laboratory conditions, at Moorestown, N. J., the parasite *B. greeni* accepted boll weevil larvae as a host and was able to complete its life cycle. Larvae of five other insects were ignored.

In India *B. greeni* attack both lepidopterous and coleopterous hosts, apparently selecting hosts that feed in seed pods. In India it is an important parasite of the pink bollworm. It might be valuable in controlling such pests as the boll weevil and pink bollworm if introduced into the United States.

5. BARTLETT, A. C. Two confirmed mutations in the boll weevil. *Ent. Soc. Amer. Ann.* 57: 261–262. 1964.

Examination of 2,500 adults of a laboratory strain of boll weevils yielded 27 phenotypic deviants. Subsequent testing of these 27 adults showed that only two of the aberrations were simply inherited and both were controlled by single recessive genes. One of the mutant adults exhibited a milky eye color. The other adult had its head recessed into the prothorax and was designated bashful.

6. BARTLETT, A. C. Black body color in the boll weevil. *Genetics* 52: 427. 1965. (Abstract of paper presented at Genetics Society of America 1965 Meetings, Fort Collins, Colo., Sept. 8–10, 1965.)

Wild-type body color of the boll weevil is described as reddish brown or mahogany-red. Two-mutants, which cause black body color, have been isolated. The first, slate(s), which produces the black phenotype when homozygous, is inherited as a semidominant autosomal factor. The heterozygote (s/+) is an obvious bronze color. Ebony (e), the second mutant, is also a semidominant autosomal factor causing a black color in the homozygous state. This black is indistinguishable from the homozygous slate. The heterozygous state of ebony (e/+) body color is dark bronze and is easily distinguished from the heterozygous slate. Progeny from crosses between slate and ebony are all a dark bronze identical to heterozygous ebony. F_2 ratios indicate no linkage between the two loci, but data are not yet complete. A homozygous slate ebony line is being established so that backcross data may be obtained.

7. BECKHAM, C. M. Pelleted cotton squares and other plant parts as food for adult boll weevils. *Ga. Agr. Expt. Sta. Leaflet* (n.s.) 36, 7 pp. 1962.

Pelleted squares, blooms, and bolls were tested as possible laboratory food for boll weevils. It was concluded that whole fresh cotton squares and seedling plants are satisfactory as food for maintaining adult boll weevils in the laboratory. Weevils did not live sufficiently long on pellets made from squares, blooms, or bolls, and from pellets containing squares plus gelatin or agar. The problem encountered with the pellets was wetting and their inability to retain moisture due to their dryness and hardness.

When pellets were too moist the growth of mold on them probably reduced feeding and longevity of the weevils. However, pellets were changed frequently in the cages. Further studies are needed to find other materials to incorporate in the pellets that will overcome these difficulties and to determine why the weevils are short lived even though highly attracted to the pellets.

8. BECKHAM, C. M. Seasonal studies of diapause in the boll weevil in Georgia. *Ga. Agr. Expt. Sta. Mimeo.* Ser. 161, 12 pp. 1962.

Studies on the seasonal occurrence of diapause in the boll weevil were conducted in four areas in Georgia during 1960 and 1961. Weevils in diapause were found in Early County on August 12 and in Gordon County on August 22. The two counties are approximately 200 miles

apart from south to north. The time of entry into diapause was related to the maturity of the cotton plant. When the season was late and the plants remained in an active growing condition, diapause developed later. The sex ratio of weevils collected from growing plants was 1.2 males to 1 female, and the ratio for those removed from hibernation sites was 1.6 to 1. Hibernating weevils were consistently heavier than those collected from plants during the season. The fat content increased and the percentage moisture decreased in weevils as they began to enter diapause. The fat content of weevils in hibernation remained rather stable. Weevils mated in the field as late as November 14, and females contained eggs in their bodies on this date. Adults remained in the field and fed on green bolls after a temperature of 25°F. Some mating occurs in the fall that enables females to lay fertile eggs in the spring without spring mating.

9. BECKHAM, C. M. Seasonal occurrence of hibernation in the boll weevil. *Ga. Agr. Expt. Sta. Mimeo. Ser.* (n.s.) 164, 9 pp. 1963.

Periodic collection and examination of surface ground trash from woods adjacent to old cottonfields in the southwestern and north-central parts of the State were made to determine the earliest date when the weevils enter hibernation in summer and when they have all emerged from winter quarters in the spring. In southwestern Georgia, the earliest date on which weevils were found in hibernation in the autumn was October 20, and the latest in spring was May 14. In north-central Georgia, the respective dates were September 14 and June 18. The time when weevils entered hibernation varied from year to year, apparently being related to temperature and the maturity of the cotton plants in a given field. Weevils were found in hibernation in the late summer after several consecutive days when the minimum temperature was about 50° F. Weevils were found in hibernation in all months of the year except July and August. The sex ratio of the weevils removed from hibernation was 1.6 males to each female.

10. BECKHAM, C. M. Time of day boll weevils emerge from fallen cotton squares. *Ga. Agr. Expt. Sta. Mimeo. Ser.* 174, 8 pp. 1963.

Since it was known from earlier reports that 2-day-old square-reared weevils are 50 or more times more susceptible to insecticides than older ones, information on the specific time of emergence of weevils can be helpful in timing the insecticide application for most effective results. Present observations show that emergence occurred between 9 and 11 a.m.: at night the emergence was negligible. Most weevils emerged when temperature about 1 inch above soil surface reached 80° F. It is concluded that the weevils have a 24-hour rhythm of adult emergence and that it is temperature-dependent.

11. BEROZA, M., and GREEN, N. Materials tested as insect attractants. *U.S. Dept. Agr. Handb.* 239, 148 pp. 1963.

Results are given of screening tests with 4,868 compounds on 10 insects, including the boll weevil. All compounds were not tested against each insect. Work on the boll weevil was done by J. M. McGough.

12. BLACK, J. H., and LEIGH, T. F. Biology of boll weevil in relation to cotton type. *Jour. Econ. Ent.* 56: 789–790. 1963.

Life history of the boll weevil was investigated on five cotton types to determine if genetic type influenced the developmental stages, adult size, and feeding and egg-laying habits. *Gossypium barbadense* received the greatest number of feeding punctures, and Hopi (race of *G. hirsutum*) the greatest number of egg punctures. Survival, indicated by percentage emergence, was significantly lower from *G. herbaceum* than from other types tested. There was a correlation of square size to weevil size from *G. barbadense* and *G. arboreum*.

13. BOTTGER, G. T., and others. Recent research on the boll weevil in northern Sonora, Mexico, and the thurberia weevil in Arizona. *Jour. Econ. Ent.* 57: 286–290. 1964.

W. H. Cross, W. E. Gunderson, and G. P. Wene, joint authors.

In 1962 research was begun in northern Sonora, Mexico, to determine the amount of damage caused by boll weevils occurring in cottonfields as near as 27 miles to fields in Arizona. This involved establishment of ecological relationships among boll weevil populations in Sonora, in the old infested areas of the United States, and in southern Arizona, where a variety of the boll weevil, the thurberia weevil, *Anthonomus grandis thurberiae* Pierce, occurs on a wild cotton, *Gossypium thurberi* Todaro.

Square damage in the Mexican cotton reached an area-wide level of 10 percent in late August, and severe yield losses occurred in several fields. In Arizona, incipient infestations of thurberia weevils developed in several cottonfields by September 5. It was determined that boll weevils in Sonora developed diapause and entered surface ground trash to survive the winter. The thurberia weevil is not known to hibernate in ground trash. In addition, evidence of considerable winter survival of the Sonora boll weevils in pupal cells within old bolls was observed in northern Sonora cottonfields. This is the only known manner in which the thurberia weevil survives over winter. Applications of methyl parathion to cottonfields in Sonora in late October and early November considerably reduced overwintering populations.

14. BOTTGER, G. T., SHEEHAN, E. T., and LUKEFAHR, M. J. Relation of gossypol con-

tent of cotton plants to insect resistance. *Jour. Econ. Ent.* 57: 283–285. 1964.

In field and greenhouse tests, glandless experimental cotton strain 30-8 was eaten in preference to either glanded Acala or Pima varieties by beet armyworms, bollworms, a black fleahopper, grape colaspis, cutworms, pillbugs, and rodents. The toxic effect of gossypol was demonstrated in spray tests against cotton aphids, lygusbugs, salt-marsh caterpillars, and thurberia weevils and in tests with bollworms reared on media containing gossypol. Chemical analyses showed roughly three and four and one-half times more gossypol in glanded Acala 4-42-77 seedlings and leaves, respectively, than in comparable samples of glandless 4-42-77.

15. BOYER, W. P., WARREN, L. O., and LINCOLN, C. Cotton insect scouting in Arkansas. *Ark. Agr. Expt. Sta. Bul.* 656, 40 pp. 1962.

History of the boll weevil and of the scouting program in Arkansas is given. Techniques of scouting for the boll weevil, bollworm eggs and larvae, aphids, plant bugs, and spider mites and methods of recording and reporting results are described. Tables and graphs show the results of the scouting program.

16. BRADY, U. E., JR., and ARTHUR, B. W. Metabolism of 0,0-dimethyl 0-[4-(methylthio)-m-toly-] phosphorothioate by white rats. *Jour. Econ. Ent.* 54: 1232–1236. 1961.

Metabolism of the P^{32} labeled insecticide was studied in the house fly, German cockroach, and the boll weevil. The house fly absorbed the chemical more readily at 4 hours than did the other two insects. The boll weevil hydrolyzed a greater percentage of the absorbed dose than did the other two. Data are given also for investigations with the insecticide in white rats and in the cotton plant.

17. BRADY, U. E., JR., and ARTHUR, B. W. Absorption and metabolism of Ruelene by arthropods. *Jour. Econ. Ent.* 55: 833–836. 1962.

The absorption and metabolism of P^{32} labeled Ruelene was studied in 16 species of arthropods. The house fly, stable fly, yellow meal worm, and American cockroach absorbed greater than 80 percent of the topically applied dose by 24 hours after treatment, whereas the boll weevil, Gulf Coast tick, and brown dog tick absorbed less than 25 percent of the applied dose.

18. BRADY, U. E., JR., RAWSON, J. W., and ARTHUR, B. W. Systemic effectiveness of insecticides against boll weevil larvae and other cotton pests. *Jour. Econ. Ent.* 56: 74–76. 1963.

Bayer 31757, Bayer 30749, Gen.Chem. 3583, and Gen.Chem. 4072 applied to the foliage of cotton plants at 4 pounds technical per acre were effective in controlling boll weevil larvae in infested cotton squares. However, these materials were not highly effective against natural infestations of boll weevil adults or the bollworm. Several organophosphates were effective against the spider mite.

19. BRAGASSA, C. B., and BRAZZEL, J. R. Inheritance of resistance to endrin in the boll weevil. *Jour. Econ. Ent.* 54: 311–314. 1961.

Genetic aspects of endrin resistance in the boll weevil were investigated by subjecting the following strains and crosses to scalar doses of endrin: (a) endrin-resistance and endrin-susceptible strains, and (b) the F_1 and F_2 progeny of reciprocal crosses of these strains. Results indicated that endrin resistance was genetically controlled in these strains. From the data at hand the indications are that the endrin resistance in these strains and crosses was controlled by more than one pair of additive autosomal genes.

20. BRAZZEL, J. R. Boll weevil resistance to insecticides in Texas in 1960. *Tex. Agr. Expt. Sta. Prog. Rpt.* 2171, 4 pp. 1961.

Boll weevils were collected from 20 areas of the State and treated with endrin and toxaphene. Results indicated four general areas with resistance levels sufficient to prevent economic control with these insecticides. The central and north-central Texas areas appeared to be intermediate insofar as resistance was concerned. Weevils obtained from the rest of the State were susceptible. There was evidence of a considerable reversion to susceptibility in the Mumford area, the first in which resistance was observed in 1956. The results of this investigation are based on limited data.

21. BRAZZEL, J. R. Destruction of diapause boll weevils as a means of boll weevil control. *Tex. Agr. Expt. Sta. Misc. Pub.* 511, 22 pp. 1961.

Preliminary experiments indicated that methyl parathion applied at 10- to 12-day intervals in the fall will kill boll weevils before they attain diapause. Field experiments indicate an insecticide program of two to four applications applied immediately before and during harvest period, followed by destruction of food and breeding sites by the frost or by chemical or mechanical means, materially reduce, and possibly eradicate, the overwintering boll weevil populations.

22. BRAZZEL, J. R. A cotton insect control program based on fall destruction of the boll weevil. *Tex. Agr. Expt. Sta. Prog. Rpt.* 2250, [5 pp.] 1962.

Large-scale experiments were conducted in Brazoria and Maverick counties to test the feasibility of incorporating a diapause boll weevil control program during the harvest period in a complete cotton insect control program. The basis for the experiments was to destroy sufficient weevils in the fall to eliminate the necessity for insecticidal control during the following growing period. This would enable better control by natural factors, such as predators and parasites, on such midseason and

late-season pests as aphids, spider mites, and bollworms. In the Brazoria County experiment, the diapause weevil control program in the fall of 1961 and a systemic insecticide treatment in the spring of 1962 were used. Approximately 900 of the 1,050 acres of cotton in the test produced an excellent crop without midseason or late-season insecticide treatments. Insect control requirements on the remaining 150 acres were greatly reduced. In Maverick County, 1,650 acres were treated one to three times in the fall of 1961 to destroy diapausing boll weevils, at a cost of $1 to $3 per acre. During 1962, only 650 acres of this cotton received the recommended practices for this experiment. Early-season insects were not a problem. Approximately 425 acres of this cotton were produced without insecticide treatment in 1962. The insect control costs were greatly reduced on the remaining acres.

23. BRAZZEL, J. R., DAVICH, T. B., and HARRIS, L. D. A new approach to boll weevil control. *Jour. Econ. Ent.* 54: 723–730. 1961.

Late-season applications of insecticides were made on 525 acres of cotton in the Big Bend area of Texas during 1959 to reduce the overwintering population of boll weevils. Four applications of methyl parathion were made on a 12- to 14-day schedule beginning just before harvest and continuing until frost killed the cotton. The purpose was to kill the weevils before diapause was attained. Overwintering weevils were substantially reduced in the treated area. The delay of buildup of the population appears great enough to delay the start of control programs sufficiently to effect substantial savings in the cost of control. The program offers some promise as a tool in boll weevil eradication.

24. BRAZZEL, J. R., and SHIPP, O. E. The status of boll weevil resistance to chlorinated hydrocarbon insecticides in Texas. *Jour. Econ. Ent.* 55: 941–944. 1962.

Weevils were collected from 20 acres in Texas in 1960 and treated with endrin and toxaphene. The response of boll weevils to methyl parathion, Methyl Trithion, and Sevin, in 1960–61 indicated four general areas of the State with chlorinated hydrocarbon resistance levels sufficient to prevent economic control with these insecticides. There was evidence of reversion to susceptibility in the Mumford area, where resistance was observed in 1956. There was no evidence of resistance to the organophosphorus and carbamate insecticides tested.

25. BULL, D. L. Metabolism of Di-Syston by insects, isolated cotton leaves, and rats. *Jour. Econ. Ent.* 58: 249–254. 1965.

Di-Syston was absorbed, metabolized, and excreted rapidly by fifth-instar bollworms and adult boll weevils. Insects excreted the toxic oxidative derivatives as well as the hydrolytic products of Di-Syston metabolism, but rats slowly excreted only hydrolytic products.

As many as four oxidative and nine hydrolytic metabolites of Di-Syston were detected in the biological systems used. The oxidative products included the sulfoxide and sulfone derivatives of Di-Syston and of the oxygen analog of Di-Syston. In animals and plants, the initial oxidative reaction with the Di-Syston molecule occurred at the mercapto sulfur atom. In plants, Di-Syston was converted almost quantitatively to its sulfoxide derivative during the first few minutes after treatment. The chief hydrolytic products of Di-Syston metabolism were diethyl phosphate and O, O-diethyl phosphorothioate. In addition, small concentrations of ethyl phosphate, phosphoric acid, and five unidentified products were detected in certain samples. O, O-diethyl phosphorodithioate was not formed in insects or plants, but trace amounts of the metabolite were detected in the urine of treated rats. Similar products were formed in the different biological systems, but the rates of metabolism varied considerably.

26. BULL, D. L., and LINDQUIST, D. A. Metabolism of radio-labeled SD–3562 in insects and cotton leaves. *Ent. Soc. Amer. Bul.* 8: 154. 1962.

The absorption and in vivo metabolism of C^{14} or P^{32} labeled SD–3562 by bollworms, boll weevils, and excised cotton leaves were studied; standard radiometric techniques were used.

27. BULL, D. L., and LINDQUIST, D. A. Metabolism of 3-hydroxy-N, N-dimethyl crotonamide dimethyl phosphate by cotton plants, insects, and rats. *Jour. Agr. Food Chem.* 12: 310–317. 1964.

Radiometric techniques were used to investigate the nature and rate of the in vivo metabolism of Bidrin in cotton plants, adult boll weevils, fifth-instar bollworm larvae, and white rats. In all the biological materials oxidative demethylation of the toxicant to its equally toxic N-methyl derivative occurred. All toxic products decomposed rapidly, however. Of nine phosphorus-containing metabolites detected, tentative identification was made of six hydrolytic and two oxidative products.

Boll weevils were treated topically. Absorption and excretion studies were made.

28. BULL, D. L., and LINDQUIST, D. A. The effects of chronic doses of an organophosphorus inhibitor on cholinesterase activity in boll weevils. *Experientia* 21: 262–263. 1965.

Weevils were fed sublethal Bidrin treated and untreated diets. Both groups degraded nontoxic, topical doses of C^{14} labeled Bidrin at equivalent rates. Weevils held on treated diets were always more susceptible to topical and oral doses of Bidrin than those from the untreated diet. The in vitro inhibition of ChE by OP insecticides was always significantly greater in insects from the treated diet.

29. Bull, D. L., Lindquist, D. A., and Hacskaylo, J. Absorption and metabolism of dimethoate in the bollworm and boll weevil. *Jour. Econ. Ent.* 56: 129–134. 1963.

P^{32} labeled dimethoate was absorbed and excreted rapidly by fifth-instar bollworm larvae and adult boll weevils. These insects absorbed 54.2 and 74.5 percent of topically applied dimethoate, respectively, after 24 hours. The bollworm larvae excreted 76.2 percent of an injected dose after 24 hours. The in vivo metabolism of P^{32} labeled dimethoate in adult boll weevils, fifth-instar bollworm larvae, and cotton seedlings was characterized qualitatively and quantitatively through the use of paper chromatography, autoradiography, and standard radioassay procedures. Dimethoate and 11 metabolites were detected in various insects and plant extracts. In bollworms the principal initial sites for hydrolytic cleavage of the dimethoate molecule were the carbonyl-nitrogen bond and the sulfur-carbon bond. The oxygen analog of dimethoate was formed in both plants and insects, but it was broken down rapidly by the insects to nontoxic products.

30. Bull, D. L., Lindquist, D. A., and House, V. S. Laboratory and greenhouse experiments with a new series of systemic insecticides. *Jour. Econ. Ent.* 57: 112–116. 1964.

Five American Cyanamid Company experimental organophosphorus systemic insecticides, compounds 43064, 43356, 47031, 47071, 47470, were used on cotton insect pests. Topical treatments of adult boll weevils indicated that all five compounds were more toxic than phorate, but dosage-mortality curves were unusually flat. Seed treatments of cotton with compounds 43064, 43356, and 47071 gave excellent control of adult boll weevils in greenhouse experiments for 10 to 11 weeks. Treatment with the phorate standard controlled weevils for only 6 weeks. Field experiments indicated that compound 43064 was no more effective than phorate for control of aphids, thrips, or boll weevils.

31. Bull, D. L., Lindquist, D. A., and House, V. S. Synergism of organophosphorus systemic insecticides. *Jour. Econ. Ent.* 58: 1157–1159. 1965.

Bidrin, dimethoate, CL–43064, and phorate were tested in combination with 16 chemicals on their ability to enhance the chemical's control of the boll weevil and other major chewing insect pests.

Applications were made topically to the insects and in four treatments to the plant or seed. Certain synergists increased the activity of the insecticide against the boll weevil when applied topically, but attempts to extend these combined treatments to on-plant control were not successful.

32. Burgess, E. D. Control of the boll weevil with technical malathion applied by aircraft. *Jour. Econ. Ent.* 58: 414–415. 1965.

On basis of favorable results obtained against grasshoppers, undiluted technical malathion was applied by aircraft at rates as low as 9 fluid ounces per acre for control of the boll weevil. Eight ounces of methyl parathion and 4 ounces of Guthion each applied in 3 gallons of water per acre served as standards. Results showed that all rates of technical malathion used without dilution were apparently at least equal in performance to the standards.

33. Burks, M. L., and Earle, N. W. Amino-acid composition of upland cotton squares and Arizona wild cotton bolls. *Jour. Agr. Food Chem.* 13: 40–43. 1965.

Protein and free amino acids from two sizes of cotton flower buds were analyzed by ion exchange chromatography to provide information to be used in the development of artificial diets for the boll weevil. Amino acids from several parts of the bud were analyzed; the most complete data were obtained from the anthers, since these constitute the adult weevil's main source of food. Only 9.4 percent of the total amino acids in the anthers occurred in the free form; of these, asparagine, glutamine, and proline were present in the greatest amounts. Amino acids in the protein were present in amounts comparable to those in other plant proteins, with relatively large quantities of aspartic and glutamic acids, leucine, alanine, glycine, and lysine.

34. Burt, E. C. Mechanical destruction of fallen boll weevil infested cotton squares. *Assoc. South. Agr. Workers Proc.* 61: 51. 1964. (Abstract.)

This is a progress report on the development of a machine for the destruction of boll weevils in infested cotton squares.

Few major mechanical difficulties were encountered in field tests with a flail-type tractor-mounted machine. Boll weevil control obtained was comparable with insecticide treatments as long as the migration of the insect was not a factor in the experiments.

The overall square pick-up of the machine was 84.2 percent, with an efficiency of 92 percent in the cotton middle area. The major improvement needed in the design is a more efficient method of moving the fallen squares from underneath the plants.

35. Butt, B. A., and Keller, J. C. Susceptibility of boll weevils to some phosphorodithioic acid esters. *Jour. Econ. Ent.* 54: 813. 1961.

Seventeen esters were tested against boll weevils reared from cotton squares. Five of the esters were more toxic than dieldrin; three were about equal to dieldrin; three were less

effective than dieldrin but more effective than toxaphene; and six were slightly more effective than or equal to toxaphene.

36. CHADBOURNE, D. S. Some histological aspects of the boll weevil. *Ent. Soc. Amer. Ann.* 54: 788–792. 1961.

Histological studies of microtome sections of fixed specimens of the boll weevil revealed the general structure of the alimentary canal, stomodaeum, mesenteron, proctodaeum, Malpighian tubules, male reproductive organs, fat bodies, oenocytes, labial glands, muscle, and attachment to body wall. Detailed drawings are given.

37. CLARK, E. W., RICHMOND, C. A., and MCGOUGH, J. M. Artificial media and rearing techniques for the pink bollworm. *Jour. Econ. Ent.* 54: 4–9. 1961.

Pink bollworms, boll weevils, and phorid flies were raised on an artificial diet of cottonseed meal combined with other constituents. Growth of the boll weevil was slow and sporadic. A peanut-flour diet was tested on the pink bollworm. Other diets and techniques for handling the eggs and larvae are described.

38. CLEVELAND, T. C. A nematode parasite of the boll weevil. *Jour. Econ. Ent.* 56: 897. 1963.

A nematode, *Hexamermis* sp., was discovered in the boll weevil while analyses for diapause status were being made. The nematodes, recovered from boll weevils collected from certain localities near Tallulah, La., during the springs of 1960 and 1961, were 2 to 6 cm. in length and ivory in color.

39. CLEVELAND, T. C., and SMITH, G. L. Effects of postseason applications of insecticides, defoliants, and desiccants on diapausing boll weevils. *Jour. Econ. Ent.* 57: 527–529. 1964.

In a 3-year field study at Tallulah, La., postseason applications of insecticides, defoliants, and desiccants were all effective in reducing the number of diapausing boll weevils entering ground trash. Defoliants and desiccants appeared to cause the greatest reduction in overwintering populations entering winter quarters. Weekly applications of methyl parathion and Guthion during this period also reduced the overwintering weevil populations to a low level. However, none of the treatments completely eliminated the weevil populations in this series of experiments.

40. COLE, C. L., and ADKISSON, P. L. Daily rhythm in the susceptibility of an insect (boll weevil, *Anthonomus grandis*, Boh.) to a toxic agent. *Science* 144: 1148–1149. 1964.

Adult boll weevils exhibited a daily rhythm in their susceptibility to standardized doses of the insecticide methyl parathion. The mortality produced by the insecticide was intimately related to the time of day at which the toxicant was applied. The rhythm appeared to be photoperiodically entrained and, regardless of the length of day or "clock time-of-day" of treatment, a period of greatest resistance always occurred at dawn and recurred at 6-hour intervals throughout the 24-hour cycle. The greatest difference in response occurred in a photoperiod having 10 hours of light per 24-hour cycle. In this photoperiod, the same dose of methyl parathion killed approximately 10 percent of the weevils treated at dawn but almost 90 percent of those treated only 3 hours later.

41. COLE, C. L., and ADKISSON, P. L. Circadian rhythm in the susceptibility of an insect to an insecticide. *In* Jurgen Aschoff, ed., Circadian Clocks. Proceedings of the Feldafing Summer School, 7–18 September, 1964., pp. 309–313. 1965. North-Holland Publishing Co. Amsterdam.

Proof that circadian rhythm is photoperiodically entrained was obtained in experiments with adults kept in continuous light. In weevils so kept there were no significant differences in mortality of those treated at different times of day. An exposure to seven or eight light-dark cycles was necessary to establish rhythm.

In furthur tests weevils were decapitated and the wound sealed with a small amount of melted paraffin. These and normal adults were exposed to the same photoperiods and the same insecticidal treatment. Decapitated controls were maintained. Decapitated weevils behaved as if they were under continuous illumination. This indicates that the cephalic region in the insect is involved in the sensitivity rhythm.

42. CORY, R. A., MOYE, W. C., and HALL, W. E. Laboratory and field evaluation of SD9129 as an insecticide. *Jour. Econ. Ent.* 58: 658–660. 1965.

The discovery of a highly toxic metabolite of Bidrin in house flies led to the synthesis of SD9129, a relatively nonvolatile, persistent systemic insecticide. It is highly toxic to many insect pests, especially lepidopterous larvae. It is promising for control of bollworm and boll weevil.

43. COWAN, C. B., JR., and DAVIS, J. W. Control of several late-season cotton pests in field experiments in 1962. *Jour. Econ. Ent.* 56: 790–793. 1963.

Stauffer R–1504 in a 1:1 mixture of Guthion plus ethyl Guthion compared favorably in control of the boll weevil with Guthion plus DDT. Monsanto CP–40294 and Bayer 29493 plus DDT were less effective. Zectran and Bayer 37344 gave boll weevil control comparable to that obtained with Sevin. Data are given for bollworm, cabbage looper, and desert spider mite.

44. COWAN, C. B., JR., DAVIS, J. W., and PARENCIA, C. R., JR. Winter survival of the boll weevil in cotton bolls in central Texas. *Jour. Econ. Ent.* 56: 494–496. 1963.

Boll weevils can overwinter in bolls on standing stalks in the fields, and, also, in bolls on the soil surface, even during winters of more than usual severity. When bolls were buried to a depth of 2 inches on December 1, survival occurred even though stalks were destroyed and fields plowed in early winter. Such survival was considerably less than for bolls left on soil surface. Such survival could be important in areas where favorable hibernation sites are scarce or nonexistent.

45. COWAN, C. B., JR., PARENCIA, C. R., JR., and DAVIS, J. W. Control of several cotton insects in field experiments in 1960. *Jour. Econ. Ent.* 54: 1011–1014. 1961.

Dusts or sprays of toxaphene plus DDT or Strobane plus DDT were equally effective against the boll weevil and the bollworm. Geigy 30494, or Bayer 29493, Shell SD–5539, and Shell SD–5533 gave fair-to-good control of the boll weevil, but none of these materials were so effective as Guthion. Methyl Trithion plus DDT was ineffective against the cabbage looper when used in a regular schedule of applications against the bollworm and boll weevil.

46. CROSS, W. H., and MITCHELL, H. C. Color chart for marking insects. *Jour. Econ. Ent.* 57: 301. 1964.

A color chart was developed for use of one to five colors applied on one to five positions on the boll weevil. Individual adults may be marked and their movements studied in the cottonfield. As many as 7,775 weevils may be marked. Copies of a chart prepared for the use of four colors, numbering all 3,124 possible combinations in a systematic sequence, are available.

47. CURL, L. F. Mexico-United States cooperative plant pest control programs. *Jour. Econ. Ent.* 57: 450–452. 1964.

History of the 45 years of cooperative efforts are given with histories of the six insects in the current pest control program. The boll weevil is included.

48. DAVICH, T. B., and others. Mass marking boll weevil field populations. *Jour. Econ. Ent.* 58: 1035–1037. 1965.

Hardee, D. D., Cleveland, T. C., and Burt, E. C., joint authors.

A slow-drying, nontoxic blue enamel and other enamels were applied to fields from a spray plane and from a tractor-mounted sprayer. Weevils were collected after 0 to 38 days. Tables of percentages and duration of markings are given. It is believed that more than 50 percent of the weevils could be marked if the field were sprayed by plane by the prescribed method. This method may be useful in studies with other insects.

49. DAVICH, T. B., and others. Preliminary field experiments with sterile males for eradication of the boll weevil. *Jour. Econ. Ent.* 58: 127–131. 1965.

J. C. Keller, E. B. Mitchell, P. Huddleston, R. Hill, D. A. Lindquist, G. McKibben, and W. H. Cross, joint authors.

During 1962 apholate-sterilized males, normal males, and virgin untreated females were released in two experimental 1-acre plots in Virginia and Tennessee in the ratio of 20:1:1 in each of five uniformly distributed points. In seven additional weekly releases, about 20 sterile males were placed at each distribution point. Release of the sterile males failed to achieve eradication, possibly because of low competitiveness of the males subject to this sterilant. In a third experimental plot in Louisiana, 10 gravid females were released and permitted to oviposit for 6 days before the initiation of a sterile-male release program designed to provide an overwhelming number of sterile males at the height of the F_1 emergence. A total of 8,850 sterile males released over an 8-week period prevented or nullified matings between the ensuing F_1 males and females. Dissection of oviposition-punctured squares, collected from the 4th to 11th week after release of sterile males began, failed to yield a larva, pupa, or adult. Proof that eradication was achieved was obtained on the 17th week of the experiment when no egg or feeding punctures were found in two examinations of all the squares and bolls on plants in the field. A high ratio of sterile insects was required to achieve eradication; but the experiment established that the sterility principle could be applied for the elimination of a boll weevil population, even when the sterile males used were low in mating competitiveness.

50. DAVICH, T. B., and LINDQUIST, D. A. Exploratory studies on gamma radiation for the sterilization of the boll weevil. *Jour. Econ. Ent.* 55: 164–167. 1962.

Boll weevil adults, pupae, and eggs were exposed to cobalt.^{60} Longevity and egg-laying capacity of reproducing weevils were drastically reduced at doses of 5,000 roentgens or higher; whereas, egg hatch was greatly reduced at doses as low as 2,500 r. Exposure to 10,000 r produced transient sterility of virgin males; 15,000 r resulted in permanent sterility. These doses resulted in rapid mortality in both sexes. A ratio of 3.8:1:1 of sterilized males: normal males: normal females did not affect egg-laying or hatch. There was little, if any, effect of age of adults on susceptibility to lethal effects of gamma rays.

Emergence of adults from prepupae, young pupae, and old pupae exposed to 10,000 r was eliminated, greatly reduced, and unaffected, respectively. However, the lethal effects were carried over because all the adults died within

2 weeks. Exposure of eggs to 600 r did not affect hatch or subsequent development; whereas, 2,400 r drastically reduced hatch and prevented subsequent development.

51. Davich, T. B., Lindquist, D. A., and Hacskaylo, J. Implanting boll weevil eggs in cotton squares for systemic insecticide and host-plant-resistance studies. *Jour. Econ. Ent.* 58: 366–368. 1965.

A simple technique involving infestation of cotton squares with eggs of the boll weevil can be used in systemic insecticide and host-plant-resistance studies against the larvae. Adult weevil yields from implanted eggs averaged 57.9 percent and 76.9 percent in two tests. Adult yields were generally higher from squares remaining on plants from 3 to 7 days and measuring 9.1 to 13.0 mm. long.

52. Davis, J. W., Cowan, C. B., Jr., and Parencia, C. R., Jr. Field experiments with insecticides on cotton for control of the boll weevil, bollworm, and cotton leafworm in 1961. *Jour. Econ. Ent.* 55: 688–692. 1962.

Stauffer R–1504 compared favorably in control of the boll weevil with Sevin or Guthion. Geigy 30494, Methyl Trithion, and Bayer 41831 were as effective as methyl parathion. In two experiments endrin plus DDT gave control equal to that obtained with toxaphene plus DDT but not equal to that obtained with Sevin or Guthion. Dusts or sprays of toxaphene plus DDT and Strobane plus DDT were equally effective against boll weevils and bollworms, but were less effective than Guthion plus DDT against boll weevils. Results are given of tests against bollworms and cotton leafworms.

53. Davis, J. W., Parencia, C. R., Jr., and Cowan, C. B., Jr. Field experiments for control of thrips, cotton fleahoppers, and overwintered boll weevils in 1960. *Jour. Econ. Ent.* 54: 966–970. 1961.

Good kills of overwintered boll weevils were obtained with Shell Compounds SD–5539 and SD–5533, Geigy 30494, Methyl Trithion, and Bayer 29493. Bayer 30911 was ineffective. American Cyanamid Anti-feeding Compound 24055 was ineffective against thrips, the cotton leafhopper, and overwintered boll weevils.

54. Dunn, H. A., Compiler. Cotton boll weevil (*Anthonomus grandis*, Boh.) abstracts of research publications, 1843–1960. *U.S. Dept. Agr. Misc. Pub.* 985, 194 pp. 1964.

An annotated bibliography.

55. Earle, N. W., and Newsom, L. D. Initiation of diapause in the boll weevil. *Jour. Insect Physiol.* 10: 131–139. 1964.

It was found that diapause could be induced by 11-hour and suppressed by 13-hour photoperiods. The immature stages were sensitive to photoperiod. Adults were not. Response to photoperiod was modified by temperature and food, but maturity of the host plant had little or no effect. Ability to diapause differed in strains of different geographical origin.

56. Earle, N. W., Walker, A. B., Burks, M. L. Storage and excretion of steroids in the adult boll weevil. *Compar. Biochem. and Physiol.* 16: 277–288. 1965.

Anthonomus grandis required about 20 mg. of cholesterol per 100 g. of diet for sustained egg production and normal longevity. Nutritional and radiotracer experiments indicated a high rate of replacement of body cholesterol. The mean life span for adult weevils on sterol-deficient diets was 14 days compared with the normal range of 55 to 89 days for controls. Sterol-deficient females laid almost no eggs. Significant amounts of sterol were carried over from the larval to the adult stage. A high percentage of the cholesterol in newly emerged adults was replaced within 15 days by labeled cholesterol in the diet. Fat weevils contained more sterol esters than lean weevils, but about the same amount of free sterols was found in fat and lean groups. The boll weevil is the only insect in which dietary sterol has been shown to be essential for adult survival.

57. Enkerlin, S. D. Effectiveness of calcium arsenate for control of cotton pests under conditions of Apocado, Nuevo León [Mexico]. *Agronomia* [Monterrey] 96:2–7. Sept. 1964. [In Spanish.]

Results of field tests for control of *Anthonomus grandis*, *Alabama argillacea*, and *Bucculatrix thurberiella* in 1960, 1961, and 1962 indicated that calcium arsenate was more effective than the six other insecticides tested.

58. Enkerlin, S. D., and Fernandez, F. The effect of calcium arsenate against the cotton boll weevil *Anthonomus grandis* (Boheman) and other cotton pests. *Folia Ent. Mex.* 5: 3–20. 1964. [In Spanish.]

During 3 consecutive years eight different insecticides were used at the rate of 15 kg. dust/ha.; in each ha. 30,000 cotton plants were planted. The effect of calcium arsenate was compared with other insecticides in common use in cotton pest control. The 3-year average shows that treatment with calcium arsenate gave better results than that with other insecticides; BHC was the least successful. The application of insecticides at the beginning of July is recommended. As to crop yields, heptachlor and calcium arsenate gave best results. The maximum economic returns are obtained with calcium arsenate.

59. Everett, T. R. Feeding and oviposition reaction of boll weevils to cotton, althea, and okra flower buds. *Jour. Econ. Ent.* 57: 165–166. 1964.

Okra is not a host plant of the boll weevil. Althea is only moderately acceptable. Laboratory observations suggest the presence of constituents in the perianth that are repellent to

boll weevils. The anthers of these two mallows are acceptable for feeding and egg deposition.

60. EVERETT, T. R. Inherited behavioral varient in the boll weevil. *Jour. Econ. Ent.* 57: 760–761. 1964.

A strain of boll weevils that laid more eggs in water-filled paraffin wax shells than in cotton squares was selected from a laboratory culture. The behavior was maintained through four generations. Results from controlled matings further indicated the heritable quality of the characteristic ovipositional behavior.

61. EVERETT, T. R., and EARLE, N. W. Boll weevil oviposition responses in cotton squares and various other substrates. *Jour. Econ. Ent.* 57: 651–656. 1964.

Laboratory experiments conducted in 1961–62 at Baton Rouge, La., showed that boll weevils preferred cotton squares weighing about 319 mg. for oviposition. Neither square size nor whether or not the squares were coated with paraffin influenced puncturing preference. Weevils punctured paraffin shells with curved tops more frequently than those with flat tops. Shells about 8 mm. in diameter and 9 mm. high were preferred to larger shells.

A water-soluble component of cotton anthers stimulated egg deposition. This material, not extractable with acetone, passed through a cellophane dialysis membrane.

62. EVERETT, T. R., and RAY, J. O. Utility of sealed punctures for studying fecundity and egg laying by the boll weevil. *Jour. Econ. Ent.* 55: 634–636. 1962.

As the boll weevil removes its ovipositor from the puncture after egg deposition, a seal is formed over the opening. Counts were made of sealed and open punctures and eggs in cotton fed upon by weevils in the laboratory. A good correlation existed between sealed punctures and eggs. Regression analysis showed that as the number of punctures increased, the number of eggs recovered decreased. Counts of sealed punctures in squares required only about one-third of the time necessary for dissection of eggs from the squares.

63. EVERETT, T. R., and RAY, J. O. Observations of puncturing and oviposition behavior of boll weevils. *Jour. Econ. Ent.* 57: 121–123. 1964.

Activities of individual weevils were observed. Observations of puncturing, feeding, and oviposition in normal and modified cotton flower buds and artificial substrates showed that eggs were laid in response to numerous sequential stimuli supplied by factors present in cotton squares. A hypothetical pattern of behavior associated with boll weevil oviposition is presented.

64. FYE, R. E., and HOPKINS, A. R. Boll weevil populations as affected by removal of shed cotton forms. *U.S. Dept. Agr. Tech. Bul.* 1277, 9 pp. 1962.

Results of a preliminary study conducted in South Carolina to determine the feasibility of developing a vacuum device for collecting shed cotton forms and to find out what percentage of shed forms would have to be removed, and at what intervals, are discussed. The procedure in which 18 field cages, carrying an equivalent of 40,000 plants per acre, were arranged in randomized blocks is described and data are presented. It is concluded that for a successful control of the weevil any square removal in the field must be at the rate of 90 to 100 percent and the interval of removal must be 5 days or less. Removal must be most efficient in early-fruiting and midfruiting periods.

65. FYE, R. E., HOPKINS, A. R., and WALKER, R. L. Field experiments on control of overwintered boll weevils. *Jour. Econ. Ent.* 54: 622–624. 1961.

Field experiments at Florence, S. C., (1956–59) strongly indicated the value of an insecticidal control program that started just before the formation of the first squares on the cotton plant and was directed primarily at the overwintered boll weevil. Early insecticide-application programs conducted before July 1 were nearly as effective as the same programs with additional later sprays when the infestation reached 10 percent. In 1958 the 10 percent level was not reached for 5 weeks and in 1959 for 4 weeks after the early program was discontinued. There was some tendency for bollworm buildup when the early program was practiced.

66. GARCIA, R. L. Life cycle of the boll weevil (*Anthonomus grandis*, Boh.) [Bogotá.] *Inst. de Fomento Algodon. Bol de Not.* 2(5): 1–2. 1961. [In Spanish.]

The life cycle is given.

67. GAST, R. T. Some shortcuts in laboratory rearing of boll weevils. *Jour. Econ. Ent.* 54: 395–396. 1961.

A rapid method for extracting eggs from cotton squares is given. If sufficient squares are available, several thousand eggs can be obtained in 10 minutes. A motor-driven set of rollers capable of removing leaf bracts from several hundred cotton squares in 5 minutes is described. Both shortcuts save time, labor, and money.

68. GAST, R. T. Mass producing artificial diet pellets for adult boll weevils. *Jour. Econ. Ent.* 58: 1024–1025. 1965.

Method and materials are given for producing 11,700 uniform diet pellets from 7,500 ml. of diet in less than 1 hour. Illustrated.

69. GAST, R. T., and VARDELL, H. Mechanical devices to expedite boll weevil rearing in the laboratory. *U.S. Agr. Res. Serv. ARS* 33–89, 10 pp. 1963.

Simple mechanical devices that materially reduce cost of mass rearing are described and illustrations given.

Preparation of square powder from three-fourth ton of cotton squares involves freeze-drying, extraction with acetone, grinding in gallon-sized blenders, and draining and squeezing with aid of a large screw press.

Germinated cottonseed puree preparation utilizes a hand-turned stainless steel double roller device. Hulls and seeds are separated by means of water, and meats are pureed in a Waring Blender. Thirty to forty pounds of seed per hour can be hulled as compared with 1 pound per hour by handsqueezing.

With the adult diet press 75 feet of ¼-inch diet cylinders can be formed.

A motorized cotton-boll slicer prepares bolls for extraction of approximately 65 percent of eggs present. The average hatch of mechanically collected eggs is 95 percent.

A mechanized egg planter, with 78 hypodermic needles and the forces of vacuum and compressed air, can plant more eggs in 5 minutes than can be done by hand in 4½ hours, and with less contamination.

70. GRAVES, J. B., and ROUSSEL, J. S. Status of boll weevil resistance to insecticides in Louisiana during 1961. *Jour. Econ. Ent.* 55: 938–940. 1962.

Expansion of areas in Louisiana infested with chlorinated hydrocarbon resistant boll weevils has occurred yearly since 1955, with the result that all cotton-producing areas of the State are now affected. Considerable reversion to susceptibility has occurred in field populations, but resistance remains at a level sufficiently great to prevent effective control with these insecticides. After 5 or 6 years of intensive use of organic phosphorus insecticides or toxaphene-DDT mixtures in certain areas, there has been no measurable change in response of the boll weevil to these insecticides. Under laboratory conditions, a tenfold to twelvefold increase in the LD–50 of a boll weevil culture to toxaphene-DDT mixture was obtained in 22 generations.

71. HANNA, R. L., and WALKER, J. K., JR. Youden square as an experimental design for the field evaluation of boll weevil insecticides. *Jour. Econ. Ent.* 56: 586–588. 1963.

Youden square plot arrangement has advantages when comparing large numbers of insecticidal treatments. Guthion was the most consistently effective insecticide against the boll weevil during the trials in 1959–60.

72. HEDIN, P. A., CODY, C. P., and THOMPSON, A. C., JR. Antifertility effect of the chemosterilant apholate on the male boll weevil. *Jour. Econ. Ent.* 57: 270–272. 1964.

Effectiveness of apholate in decreasing the sperm viability of the male boll weevil was determined by allowing the weevils to feed on a diet containing from 0.001 to 0.020 percent of the chemosterilant and on plants sprayed with 0.5 and 2.5 percent solutions of it. After both treatments, virgin females mated to treated males oviposited eggs with decreased hatchability and emergence of the F_1 progeny. At the higher levels of treatment longevity of males was reduced. Repeated spray applications of the chemosterilant to plants, especially at the higher levels, caused phytotoxicity manifested by leaf necrosis, stunting of growth, and cessation of square production.

73. HOLLINGSWORTH, J. P., WRIGHT, R. L., and LINDQUIST, D. A. Spectral response characteristics of the boll weevil. *Jour. Econ. Ent.* 57: 38–41. 1964.

A Y-tube test chamber was used in group-response studies with adult boll weevils to determine relative attractiveness of equal energy, narrow-band stimuli in the spectral region from 315 to 665 mμ. Maximum response was obtained for wavelengths in the blue-green (490 to 515 mμ) region of the spectrum, with decreased response indicated for both shorter and longer wavelengths.

74. HOPKINS, A. R., and TAFT, H. M. Field experiments for control of the boll weevil, bollworm spp., and the cotton aphid on cotton in 1960–62. *Jour. Econ. Ent.* 57:509–511. 1964.

In field experiments in Florence, S. C., Geigy G–30494–DDT, Methyl Trithion-DDT, Monsanto CP–40294–DDT, Stauffer R–1504–DDT, and toxaphene-DDT gave control of the boll weevil equal to Guthion-DDT. Results for the other insects named are given.

75. HOPKINS, A. R., and TAFT, H. M. Control of certain cotton pests with a new systemic insecticide, UC–21149. *Jour. Econ. Ent.* 58: 746–749. 1965.

An experimental systemic insecticide, Union Carbide UC–21149, was compared with Di-Syston and phorate in granular formulations applied at planting as in-furrow treatments for control of early-season cotton insects. Additional tests were conducted with UC–21149 as seed treatment or sidedress applied at various stages of cotton plant growth for control of the boll weevil.

Mortality of overwintered boll weevils was significantly greater with UC–21149 and phorate than with Di-Syston. Sidedress treatments produced significant mortality of boll weevil larvae developing within the squares and bolls and of adults feeding on terminal growth.

76. HUNTER, R. C., and others. Evaluation of a selected cross-section of cottons for resistance to the boll weevil (*Anthonomus grandis* Boh.) *Ark. Agr. Expt. Sta. Bul.* 700, 38 pp. 1965.

T. F. Leigh, C. Lincoln, B. A. Waddle, and L. A. Bariola, joint authors.

Selected cotton stocks of diverse origin and growth patterns were obtained from obsolete cultivars maintained at Stoneville, Miss., from primitive types collected in Mexico and Central America and maintained at College Station,

Tex., and from assorted stocks maintained at Fayetteville, Ark. Evaluations initially were for tolerance and preference forms of resistance. Significant advances were made with red plant color, increased pubescence, rapid fruit set, and Frego bract characters, but supplemental controls still were needed for competitive levels of yield. Four years of selection for antibiosis revealed that little genetic advance was possible, largely because the nongenetic sources of variation were proportionately large. Cottons of Hopi and Yugoslav origin, however, did show some promise.

77. JENKINS, J. N., LAFEVER, H. N., and MAXWELL, F. G. Boll weevil resistance factors in cotton. *Agron. Abs.* 1964: 69. 1964.

The regional collection of upland cottons contains approximately 800 entries. In general, all lines are susceptible to the boll weevil. Several hundred of these lines have been assayed for components that contribute to boll weevil resistance. Antibiosis for adult weight and rate of boll weevil oviposition on the cotton line were selected as the resistance components to be measured. An antibiosis technique was developed and used to assay 356 cotton lines. Forty lines were selected that reduced weevil size by more than 10 percent. A technique was developed to measure the rate of boll weevil oviposition on cotton lines. Three hundred seventy-five lines were assayed in nonreplicated tests. Replicated tests were conducted on selections from the nonreplicated screen, selections from the antibiosis screen, and on certain F_1 crosses between oviposition screen selections. Testing of the F_1's has not been completed. In replicated tests, weevils on 15 cotton lines had an egg production ratio ($\bar{x}$ of test line/$\bar{x}$ of commercial check) of less than 0.8. Three of these 15 were selections from the antibiosis screen and are thus selected lines in two categories of boll weevil resistance.

78. JENKIN, J. N., and MAXWELL, F. G. Chemotrophic responses of the boll weevil to cotton extracts I–II. 15th *Ann. Cotton Impr. Conf. Proc.*, pp. 64–75. 1963.

Various methods of searching for boll weevil resistance mechanism in cotton are discussed. The biologically active compounds found in cotton are discussed. These are an arrestant and feeding stimulant, an attractant, and a repellent. Data are presented that show some cottons contain antibiosis to the boll weevil. The possibilities of utilizing the antibiosis approach as well as building resistance through a combining of the biologically active compounds in the correct proportions are discussed.

79. JENKINS, J. N., MAXWELL, F. G., and BUFORD, W. T. Differential rates of egg laying by the boll weevil on several varieties of cotton. 16th *Ann. Cotton Impr. Conf. Proc.*, pp. 56–65. 1964.

A laboratory test to determine the boll weevil oviposition rate on cotton lines is described. The method developed was utilized to screen a large number of cotton lines. A few were found that reduced oviposition 30 percent when compared with a commercial variety. Theoretical calculations are presented showing the effect of such a resistance mechanism on population dynamics.

80. JENKINS, J. N., and others. Investigations of the water extracts of *Gossypium, Abelmoschus, Cucumis* and *Phaseolus* for an arrestant and feeding stimulant for *Anthonomus grandis,* Boh. *Crop Sci.* 3: 215–219. 1963.

F. G. Maxwell, J. C. Keller, and W. L. Parrott, joint authors.

Four *Gossypium* species, a two-species hybrid, a three-species hybrid, two genetic mutants, two Upland varieties, and two Upland strains were surveyed. A bioassay method, with agar used as a substrate in the form of cylindrical plugs wrapped in Whatman No. 1 filter paper, is described. From the data presented the following conclusions were drawn: (1) The water extract of cotton plants contained a substance(s) that acted as a powerful arrestant and feeding stimulant to the boll weevil. (2) The boll weevils exhibited preference differences for the water extracts from various genetically different *Gossypium* lines and species. The same preference order was shown for whole fresh squares. (3) The Asiatic species *G. herbaceum* and *G. arboreum* were the least preferred of all *Gossypium* lines tested. (4) Seedlings were shown to be usable in a screening program for low concentrations of arrestant and feeding stimulant. (5) Of the four genera tested, the substances were found in *Gossypium* only. (6) Beans and okra seedlings normally nonacceptable to the boll weevil became acceptable for feeding after being sprayed with the extract from Delfos squares.

81. JENKINS, J. N., MAXWELL, F. G., and PARROTT, W. L. A technique for measuring certain aspects of antibiosis in cotton to the boll weevil. *Jour. Econ. Ent.* 57: 679–681. 1964.

The technique described utilizes lyophilized cotton-square powder as the basic ingredient. It makes possible the rapid evaluation of different lines of cotton for antibiosis. This technique was shown to be much less variable than field measurements for the same properties. It minimizes the morphological and nutritional aspects of various square sizes as a factor in antibiosis. By using the technique, antibiosis was found to be present in *Gossypium thurberi,* which resulted in smaller weevils and a longer developmental period. The limitations of the technique are discussed. The technique is believed to have application with other insects and crop plants in host-plant resistance programs.

82. JOHNSTON, H. G. The impact of insecticidal resistance upon the use and development of insecticides for cotton pests. *Ent. Soc. Amer. Misc. Pub.* v.2, pp. 41–44. 1960–61.

Intensive and widespread use of certain organic insecticides for cotton pest control resulted in the rapid development of resistance to these chemicals. By 1958, 12 species of insects and spider mites were known to be resistant and four others were strongly suspected. Resistant boll weevils were more widespread than any of the other species.

Boll weevil resistance to chlorinated hydrocarbons was first recognized in Louisiana in 1955, and it is more widespread in that State than in any other. Sixty-five percent or more of the total cotton acreage in the State is now infested with weevils showing varying levels of resistance. Annual reports of insecticides sold in Louisiana show that in 1954 98 percent of all insecticides used for boll weevil control were chlorinated hydrocarbons but that by 1958 only 34 percent of the total sold was of this type. Organophosphorus insecticides were not available for boll weevil control until 1956, but they accounted for 20 percent of the total that year and for 55 percent in each of the next 2 years.

On a short-range basis, cotton pest resistance is being handled satisfactorily by changing to alternate chemicals with different modes of action. However, if cotton pests develop resistance to alternate chemicals, then this cannot be the answer to the long-range problem.

83. JONES, J. E., and TIPTON, K. W. Breeding cotton for resistance to major diseases and insects. *La. Agr. Expt. Sta. Rpt. Proj., Dept. Agron.* 1963, pp. 65–75. 1964.

Results of field experiments conducted over 4 consecutive years indicate that Empire Red and Stoneville Frego cotton biotypes possess an important degree of nonpreference by the boll weevil. Red-Frego biotype averaged significantly less squares with egg punctures in 2 years of testing than its parent strains Empire Red and Stoneville Frego.

84. KELLER, J. C., and DAVICH, T. B. Response of five species of insects to water extracts of their host plants. *Jour. Econ. Ent.* 58: 164–165. 1965.

In laboratory tests five species of insects (including the boll weevil) fed extensively on the extracts of their preferred hosts and failed to feed or fed very little on extracts from other plants or the agar water blanks.

85. KELLER, J. C., and others. Extraction of a boll weevil attractant from the atmosphere surrounding growing cotton. *Jour. Econ. Ent.* 58: 588–589. 1965.

T. B. Davich, F. G. Maxwell, J. N. Jenkins, E. B. Mitchell, and P. Huddleston, joint authors.

The boll weevil attractant in the cotton plant was extracted from air drawn over cotton grown both under a polyethylene canopy and in a plastic greenhouse. Trapping was accomplished by activated charcoal and by bubbling through methanol at the temperature of frozen CO_2.

86. KELLER, J. C., MAXWELL, F. G., and JENKINS, J. N. Cotton extracts as arrestants and feeding stimulants for the boll weevil. *Jour. Econ. Ent.* 55: 800–801. 1962.

Debracted cotton squares were extracted with organic solvents. Little if any of the arrestant appeared to be extracted. Weevils fed readily on organic-solvent-extracted squares but failed to feed on water-extracted squares.

Water extract from debracted cotton squares was found to elicit an arresting or feeding response, or both, in the boll weevil. After 15 to 24 hours' exposure to weevils, moderate to extensive feeding damage was found on corks, green snap beans, pinto bean seedlings, and agar plugs treated with the extract, but controls had none. Traps containing distilled water caught as many weevils as traps containing the extract; therefore, the substance or substances appeared to be an arrestant or feeding stimulant, or both, rather than an attractant.

87. KELLER, J. C., and others. Boll weevil attractant from cotton. *Jour. Econ. Ent.* 56: 110–111. 1063.

F. G. Maxwell, J. N. Jenkins, and T. B. Davich, joint authors.

Chloroform extract of water from a defrosted freeze-drying apparatus used for drying homogenized cotton-plant parts attracted 10 times more boll weevils than checks with solvent only. Erlenmeyer flasks with funnels were used as traps. Agar plugs wrapped with filter paper and treated with the attractant, attractant and a boll weevil arrestant at a 1:1 ratio, arrestant only, and distilled water were compared. The first two were equally attractive, about 10 times more attractive than the plugs containing the arrestant alone, and about 20 times more attractive than control plugs. The arrestant-attractant plugs were more extensively damaged than plugs with the attractant or arrestant alone.

88. KELLER, J. C., and others. A sex attractant for female boll weevils from males. *Jour. Econ. Ent.* 57: 609–610. 1964.

E. B. Mitchell, G. McKibben, and T. B. Davich, joint authors.

Air surrounding several thousand males was pumped for 11 weeks through an activated charcoal filter. Chloroform extracts of the charcoal attracted 31.2 percent of the females under test to glass traps in 1 hour. Males failed to respond to the extract.

89. KNIPLING, E. F. Potential role of the sterility method for insect population control

with special reference to combining this method with conventional method. *In U.S. Agr. Res. Serv. ARS* 33–98, pp. 26–34. 1964.

Economic losses caused by the boll weevil and the side effects resulting from the extensive use of insecticides in its control have indicated the desirability of eliminating the insect.

Combined fall and spring treatment programs might achieve 99 percent reduction in populations. If during the next three generations, 6 billion sterile males could be released eradication should be achieved with a high safety margin.

When mass rearing methods for the boll weevil are perfected it should be possible to produce 2 million insects (1 million males) for $5,000 or less. The $30 million necessary for 10 million acres of cotton would be less than the cost of insecticides and, theoretically, should be more effective.

To date fully competitive sterile males have not been produced, but if one-half or one-third competitive sterile males are eventually produced eradication should be possible at a cost of $190 million. This $19 per acre is less than many growers now spend on control. Research effort by scientists to achieve this end seems justified.

90. LaChance, L. E., and Knipling, E. F. Control of insect populations through genetic manipulations. *Ent. Soc. Amer. Ann.* 55: 515–520. 1962.

The possibility of using insects with inherited lethal factors to control their own populations is discussed. Mutant strains of the boll weevil with such characteristics as inability to fly, inability to enter diapause, susceptibility to low temperatures or nutritional or morphological defects in the larval stage that would be lethal in the field but not under rearing conditions in the laboratory might achieve the desired effects. The theoretical results of releasing males carrying recessive lethal genes into a natural population on cotton in the United States are described in detail. This might prove a valuable method of control.

91. Lafever, H. N., Jenkins, J. N., and Maxwell, F. G. Influence of glanded and glandless cottons on insect preference and development. *Agron. Abs.* 1964: 72. 1964.

Current interest in commercial use of glandless cotton varieties along with reports of greater insect susceptibility of glandless lines indicated a need for data on insect preference and development on glandless versus glanded lines. Emerging boll weevil adults and bollworm larvae tended to weigh more when reared on glandless cotton square powder diets and glandless field-collected squares than on corresponding glanded "isogenic" lines. In paired comparisons of water extracts of glanded and glandless "isogenic" lines of cotton incorporated in agar plugs, weevils fed more on the plugs containing extract from the glanded line of the pair in three of five cases. In nonpaired weevil-feeding tests with seven lines, three glandless lines were significantly lower in feeding stimulation that four glanded lines. More eggs were oviposited by boll weevils on two unimproved glandless lines than on the glanded commercial check, but all improved glandless lines were below the check. Oviposition tests comparing glanded lines with glandless "isogenics" showed no general trend.

92. Lambremont, E. N. Homogenate respiration of diapausing and nondiapausing boll weevils. *Ent. Soc. Amer. Ann.* 54: 313–316. 1961.

Measurements on succinate-fortified homogenates of both field-collected and laboratory-reared boll weevils showed that the homogenates of nondiapausing weevils consistently took up more oxygen than those of diapausing weevils. The difference in respiration rate between these two physiological states was significant at the 1-percent level. A difference at the 5-percent level was noted between the respiration of three cultures. There was no significant difference between the sexes. Homogenates of weevils in diapause contained approximately 20 percent more dry-weight material than those of nondiapausing weevils.

93. Lambremont, E. N. Enzymes in the boll weevil—I. Dehydrogenases of the brain and related structures. *Jour. Insect Physiol.* 8: 181–190. 1962.

Dehydrogenases were studied in the brain and the related neural and secretory structures in the boll weevil. A reaction system containing an artificial electron acceptor (tetrazolium salt) was used to detect the activity of the various dehydrogenases. Endogenous dehydrogenase activity measured on freshly dissected tissue was found to produce the characteristic pattern of formazan deposition similar to that produced in the tissues of other organisms incubated in tetrazolium solutions. The endogenous activity was inhibited by prior freezing, with the result that the only way in which a reaction could be obtained was by adding a subtrate. Various pathways of intermediary metabolism were studied in thawed tissue. All the Krebs cycle intermediates produced positive reactions. Of seven glycolytic intermediates and end-products, alpha-glycerophosphate was dehydrogenated most actively. Glucose-1 phosphate and lactate were reacted upon to a lesser extent; but acetate, ethanol, pyruvate, and glycerol gave doubtful or negative results. Three amino acids (glutamate, proline, and aspartate) and one fatty acid (beta-hydroxybutyrate) gave positive reactions. There was no reaction with choline or hippurate. The coenzyme dependence of the dehydrogenases was studied. The reaction with lactate was increased by diphosphopyridine nucleotide, that

with isocitrate by triphosphopyridine nucleotide, but malate and glutamate were increased by both coenzymes in roughly equal amounts. The oxidation of glycerol, ethanol, beta-hydroxybutyrate, pyruvate, alpha-ketoglutarate, and choline was not influenced by added coenzyme. The results are discussed and compared with those obtained by other workers who have used the tetrazolium method.

94. LAMBREMONT E. N. *In vivo* incorporation of acetate-1-C^{14} into lipids by the boll weevil. (Abstract 36.) *Ent. Soc. Amer. Bul.* 9 (3) : 162. 1963.

Boll weevil adults incorporate injected acetate-1-C^{14} into the saponifiable and nonsaponifiable lipid fractions. The ratio of incorporation is approximately 9:1 in favor of the saponifiable lipids during the 2 hours after injection. Higher synthesis rates in the cholesterol esters and phospholipids than in the neutral glycerides are indicated in silicic acid chromatography tests.

95. LAMBREMONT, E. N. Biosynthesis of fatty acids in aseptically reared insects. *Compar. Biochem. Physiol.* 14: 419–424. 1965.

Both aseptic and nonaseptic adult boll weevils synthesize long-chain fatty acids from injected C^{14}-1-acetate. Equivalent synthesis rates and patterns of fatty acid labeling also were found when C^{14}-2-acetate was the precursor.

Most radioactivity was in the C^{16}- and C^{18}-saturated and mono-unsaturated fatty acids. This insect appears to be incapable of synthesizing the C^{18} dienoic acid, linoleic acid.

96. LAMBREMONT, E. N., and BLUM, M. S. Fatty acids of the boll weevil. *Ent. Soc. Amer. Ann.* 56: 612–616. 1963.

The fatty acid fraction of the boll weevil is a complex mixture of 23 fatty acids ranging in chain length from six to 20 carbon atoms. Eight major acids account for 98 percent of the total. These eight are: myristic (C_{14}), palmitic (C_{16}), palmitoleic ($C_{16.1}$), heptadecanoic (C_{17}), stearic (C_{18}), oleic ($C_{18.1}$), linoleic ($C_{18.3}$), and linolenic ($C_{18.3}$). Their relative percentage composition is in the same overall proportion both in total body fat and in the isolated triglyceride fraction. About 62 percent of the boll weevil's fatty acids contain at least one double bond; these unsaturated acids occur mainly in the C_{18} series. The remaining 38 percent are saturated, with palmitic acid accounting for 30 percent.

97. LAMBREMONT, E. N., BLUM, M. S., and SCHRADER, R. M. Storage and fatty acid composition of triglycerides during adult diapause of the boll weevil. *Ent. Soc. Amer. Ann.* 57: 526–532. 1964.

Total body fat of the boll weevil and relative distribution in major lipid classes, as shown by silicic acid column chromatography, is dependent on adult age, larval and adult diet, and diapause. Neutral glyceride and free fatty acid fractions account for as much as 90 percent of extractable lipids of diapausing adults. Newly emerged weevils have 2 to 6 percent body fat (about 2 percent triglyceride). After 2 to 3 weeks of feeding, nondiapausing adults have 6 to 10 percent body fat (40 to 60 percent triglyceride), but diapausing adults have 18 to 25 percent body fat (75 to 85 percent triglyceride). The triglyceride level drops during winter when the insects are not feeding. By the following June fat content drops to 3 percent (28 to 30 percent triglyceride). Boll-fed adults accumulate more triglycerides than square-fed; adults feeding on both squares and bolls accumulate an intermediate amount. Adult diet is the major factor controlling the type of fatty acid incorporated into the triglycerides. Square-fed adults have about equal amounts of oleic and palmitic acids, the two major fatty acids. However, boll-fed adults have a much higher proportion of oleic. On a given diet the amount of palmitic acid appears to be constant for both physiological states, but oleic acid is slightly higher in diapausing than in nondiapausing weevils. The mono-unsaturated fatty acids tend to decrease during reproductive activity and the C_{18} poly-unsaturated fatty acids to increase. Preliminary evidence with the thurberia weevil, as with the boll weevil, indicates that incorporated triglyceride fatty acids are a reflection of those in the diet.

98. LAMBREMONT, E. N., and EARLE, N. W. Longevity of the boll weevil under laboratory conditions. *Jour. Econ. Ent.* 54: 964–966. 1961.

Two cultures (F_9 and F_{15}) of adult boll weevils were caged in a temperature- and humidity-controlled room in trays containing cotton squares placed in moistened sand under a low-pressure mercury-vapor ultraviolet light. Another culture (F_1) was caged on squares on drier sand under a high-pressure mercury-vapor ultraviolet light. All weevils were fed fresh debracted squares changed daily. Survival data plotted for the three cultures approached the typical sigmoid or semirectangular curve characteristic of an animal population having a senescence. Longevity was variable and depended on sex, culture, and holding conditions. Male weevils from Mexico lived the longest, with a mean of 121.5 days and maximum of 199 days.

99. LAMBREMONT, E. N., and SCHRADER, R. M. Electrophoresis of an insect inorganic pyrophosphatase. *Nature* [London] 204: 883–884. 1964.

By the use of paper electrophoretic methods (Durrum type) at least six bands were found derived from an acetone extract of the boll weevil. When tested for pyrophosphatase activity the results suggested that the enzyme extract had four alkaline inorganic phosphatases capable of producing orthophosphate

from pyrophosphate. The greatest activity was found in a single band that had migrated toward the anode.

100. LAMBREMONT, E. N., and SCHRADER, R. M. Enzymes of the boll weevil—II. Inorganic pyrophosphatase. *Jour. Insect Physiol.* 10: 37–52. 1964.

The properties of the enzyme inorganic pyrophosphatase in the boll weevil have been determined as follows: The enzyme is confined to the soluble cell fraction. Kinetics are zero order for up to 1 hour under optimal conditions of 2.5 x 10^{-3}M pyrophosphate, 1.0 x 10^{-3}M Mg Cl_2, and pH 8.0. Michaelis constant is approximately 1.0 x 10^{-3}, and optimum pH range 7.8 to 8.2. Experimental activation energy is 15,600 cal./mol., and temperature for optimal activity is 50° C. Magnesium is the only divalent metal ion that will activate the enzyme, and the activity with magnesium is almost completely blocked by equimolar amounts of Mn, Sn, Ca, Co, and Ba. The enzyme is inhibited by reagents that oxidize or interfere with thiol groups. A discussion comparing these results with other published work on inorganic pyrophosphatase is presented.

101. LAMBREMONT, E. N., and STEIN, C. I. $C^{14}O_2$ production in the boll weevil, *Anthonomus grandis*, after injection of C^{14}-1-acetate. *Ent. Soc. Amer. Ann.* 58: 765–766. 1965.

Acetate-1-C^{14} injected into the boll weevil undergoes immediate oxidative metabolism with the subsequent release of $C^{14}O_2$. Maximum $C^{14}O_2$ production is reached about 1 hour after injection, at which point about 25 percent of the injected acetate is converted to CO_2; thereafter, the rate of release declines steadily.

102. LAMBREMONT, E. N., STEIN, C. I., and BENNETT, A. F. Synthesis and metabolic conversion of fatty acids by the larval boll weevil. *Compar. Biochem. Physiol.* 16: 289–302. 1965.

Larval *Anthonomus grandis* synthesized long-chain fatty acids from labeled NaOAc in the larval diet. Larvae, pupae, and newly molted unfed adults had an identical labeling pattern. Oleic acid possessed 60 percent of the incorporated radioactivity. The weevil also desaturated dietary palmitic acid and stearic acid to palmitoleic acid and oleic acid. Some dietary palmitic acid underwent chain elongation to stearic acid, which was desaturated subsequently. Dietary oleic acid was not hydrogenated. The weevil was unable to form linoleic acid from acetate and could not convert closely related long-chain fatty acids into linoleic acid. The direct desaturation pathway may be in operation on all dietary long-chain fatty acids and on fatty acids synthesized from acetate.

103. LEIGH, T. F., and LINCOLN, C. Feeding and development of the boll weevil, *Anthonomus grandis* Boh., on several cotton types. *Ark. Agr. Expt. Sta. Bul.* 692, 18 pp. 1964.

Resistance of cotton to the boll weevil was investigated in a group of strains and varieties selected to represent a range of fruiting prolificity, a range in maturation rate, and in bollwall thickness. Tests were made to determine the extent of damage to squares and bolls from boll weevil feeding, the survival of weevils in squares and bolls, and the resistance of bolls to mechanical puncture.

Failure of larvae to develop in squares where an egg apparently had been laid suggested some form of "antibiosis," and similar results in bolls suggested physical impedance. The results were interesting biologically, but little progress was made toward developing a cotton resistant to the boll weevil.

104. LINCOLN, C., and others. The point sample method of scouting for boll weevil. *Ark. Agr. Expt. Sta. Bul.* 666, 31 pp. 1963.

G. C. Dowell, W. P. Boyer, and R. C. Hunter, joint authors.

All squares of 5.6 mm. diameter and larger are examined at one point until a sample of 50 is obtained. The feet of row sampled is then measured. Results can be converted to total squares and weevil-punctured squares per acre. Boll weevil infestations increased at the rate of 2½ times weekly. Total squares increased at a similar rate for 4 or 5 weeks, then leveled off for about 3 weeks before dropping. Percentage control with insecticides can be calculated if scouting and application dates are synchronized. Sampling error is large, with coefficients of variation in the range of 40 to 90 percent. The point-sample method is also useful for measuring bollworm infestations. Cutting bolls 10 to 21 days old is a useful measure of weevil infestation after squares become scarce.

105. LINDQUIST, A. W. Insect population control by the sterile-male technique. Comprehensive report of a panel, held in Vienna 16–19 October 1962. *Vienna, Internatl. Atomic Energy Agency Tech. Rpt. Ser.* Nr. 21, 59 pp. 1963.

The factors influencing the induction of sterility, some aspects of nutrition, and the mass culture of insects are reviewed. The suitability for mass releases of sterile males is considered for a number of species including the boll weevil.

106. LINDQUIST, D. A., BRAZZEL, J. R., and DAVICH, T. B. Fate of DDT and toxaphene applied topically to susceptible and resistant boll weevils. *Jour. Econ. Ent.* 54: 299–300. 1961.

The metabolism of DDT by susceptible and resistant boll weevils treated topically with DDT or DDT plus toxaphene was studied. Little difference was found between strains receiving the same treatments. Extracts of weevils treated with DDT plus toxaphene contained slightly more DDT than those of weevils

treated with DDT alone. Poor recovery of the applied DDT was obtained. Tests with C^{14} labeled DDT indicated that the treated weevils rubbed off much of the toxicant and converted a small quantity to a compound that did not respond to the colorimetric analysis used.

Resistant weevils treated with toxaphene absorbed less than similarly treated susceptible weevils.

107. LINDQUIST, D. A., and others. Laboratory studies on sterilization of the boll weevil with apholate. *Jour. Econ. Ent.* 57: 745–750. 1965.

L. J. Gorzycki, M. S. Mayer, A. L. Scales, and T. B. Davich, joint authors.

Male boll weevils can be sterilized with apholate. Treatment methods that resulted in at least partial sterility were: (1) Dipping the male weevil in aqueous apholate solutions, (2) feeding apholate to the weevils, (3) exposure to apholate residues on glass, and (4) topical application. Apholate was toxic to boll weevils and effective sterilizing dosages resulted in high mortalities. However, treated male weevils often regained fertility in 10 to 20 days after treatment. Egg hatch was not a good criterion for estimating sterility, since data indicated that apholate treatment produced a type of dominate lethal that was expressed in the newly hatched larvae.

108. LINDQUIST, D. A., and others. Systemic activity of dimethoate applied to cotton seeds. *Jour. Econ. Ent.* 54: 1132–1135. 1961.

J. Hacskaylo, J. C. Clark, and T. B. Davich, joint authors.

Dimethoate was not exceptionally effective as a systemic cottonseed treatment against the boll weevil and cotton aphid. Applied as a seed treatment it caused considerable reduction in seedling emergence.

P^{32} labeled dimethoate applied as a cottonseed treatment was most rapidly absorbed 1 to 3 days after planting. It did not reduce the total emergence of artificially deteriorated seed, but it did reduce the rate of emergence somewhat. Seeds deteriorated for 2 days absorbed more dimethoate than seeds deteriorated for 0, 1, 3, or 4 days.

Dimethoate was less toxic than phorate to boll weevil larvae and adults.

109. LLOYD, E. P., LASTER, M. L., and MERKL, M. E. A field study of diapause, diapause control, and population dynamics of the boll weevil. *Jour. Econ. Ent.* 57: 433–436. 1964.

In 1960–61, 1-year tests were conducted in three cottonfields in Mississippi to study the relation between plant fruiting and the first entry of boll weevils into diapause. Tests were set up to evaluate the effectiveness of methyl parathion in controlling diapausing weevils and to measure population increases on dryland cotton. In the diapause studies first diapausing weevils appeared in all three fields at cessation of flowering, when only bolls remained as the food source. In the diapause-control studies, seven applications of methyl parathion spray applied at one half pound per acre greatly reduced the overwintering population, but they did not eliminate it. In the limited studies of population dynamics, seasonal generation-to-generation increases averaged fivefold and ranged from onefold to 9.6-fold.

110. LLOYD, E. P., MCMEANS, J. L., and MERKL, M. E. Preferred feeding and egg laying sites of the boll weevil and the effect of weevil damage on the cotton plant. *Jour. Econ. Ent.* 54: 979–984. 1961.

Females damaged fruit of the cotton plant more than did the males. Preferred feeding and egg-laying sites were the squares on the upper half of the plants when the population was low. As the population increased, small bolls were damaged as well as squares; the damage was intensified on the upper part of the plants and reached into the lower fruiting branches. Bolls 1 to 19 days old were damaged.

Exposure of the cotton plant to feeding and egg-laying for 4 or 5 days resulted initially in increased square abcission and slightly reduced boll abcission. No difference occurred in total boll set for the entire season between the test and the check plants.

111. LLOYD, E. P., and MERKL, M. E. Seasonal occurrence of diapause in the boll weevil in Mississippi. *Jour. Econ. Ent.* 54: 1214–1216. 1961.

In the one field studied in 1958 dispause occurred by August 26. In the seven fields studied in 1959 it was observed as early as August 11 and as late as September 8. Weevil populations generally entered diapause in two distinct periods. Gross observations indicated that entry in the first period was related to the maturity of the plants in the different fields. Adequate food supply appeared to be necessary.

Diapausing weevils were first recovered from ground trash September 10, 1958, and September 9, 1959, which indicated movement of diapausing segments of the weevil populations to overwintering quarters well in advance of the first killing frost.

112. LLOYD, E. P., MERKL, M. E., and CROWE, G. B. Effect of boll weevil infestations on yield and quality of cotton. *Jour. Econ. Ent.* 55: 225–227. 1962.

The effect of four different levels of infestation by the boll weevil on earliness, yield, and quality of cotton lint were evaluated in a replicated field-cage experiment at Stoneville, Miss., 1959–60. Seasonal square infestation levels of about 0, 25, 50, and 75 percent were used. As infestation levels increased plant fruit-

ing was delayed, with a subsequent delay in time of harvest. Total yield decreased as percentage of squares damaged increased throughout the season. Grade indexes and lint values indicated no significant loss in quality of lint at the different infestation levels. Differences in value of lint per acre for the four treatments actually reflected differences in yield.

113. LUKEFAHR, M. J., and MARTIN, D. F. A native host plant of the boll weevil and other cotton insects. *Jour. Econ. Ent.* 55: 150–151. 1962.

Cienfuegosia sulphuria, a wild malvaceous plant, was found to be a host of the boll weevil. Other cotton insect pests reared from this plant were the cotton square borer (*Strymon melinus* and *Noctuelia rufofascialis*). The cotton leafworm completed its development when larvae were placed on the plant.

114. LUKEFAHR, M. J., and MARTIN, D. F. Additional non-cotton hosts of the boll weevil and cotton leafworm. *Jour. Econ. Ent.* 58: 784–785. 1965.

Four additional species were found to be hosts of the boll weevil. These were *Cienfuegosia argentinia* Garcke and *C. drummondii* (A. Gray) Lewton of South America, *C. hildebrandtii* Garcke of Africa, and *Thespesia lampas* Cav. of Asia. The susceptibility of the various species differed. In general, the species that are not found in areas inhabited by the boll weevil were the least susceptible. Two additional species (*C. hildebrandtii* Garcke and *C. argentinia* Garcke) were found to be hosts of the cotton leafworm, *Alabama argillacea* (Hubner), which showed a preference for the same species as the boll weevil.

115. MCGARR, R. L., and CHAPMAN, A. J. Control of three important cotton insects in the lower Rio Grande Valley in 1960. *Jour. Econ. Ent.* 56: 902–903. 1963.

Field tests showed that Bayer 29493 plus DDT, methyl parathion plus DDT, toxaphene plus DDT, or strobane plus DDT did not give outstanding control of the boll weevil. Sevin was effective as a spray or dust. Telodrin was effective against the boll weevil. Results are given for the bollworm and pink bollworm.

116. MCGARR, R. L., CHAPMAN, A. J., and MARTIN, D. F. Field tests with several insecticides for control of pink bollworm. boll weevil, and bollworm. *Jour. Econ. Ent.* 58: 693–694. 1965.

In field-plot tests in the lower Rio Grande Valley of Texas in 1961 and 1962, of four carbamates tested, carbaryl and Bayer 37344 gave the best control of pink bollworm and boll weevil and Zectron and Bayer 44646 gave significantly better results against the bollworm-tobacco budworm complex. Imidan, an phosphorus compound, gave fair control of pink bollworm and boll weevil but was ineffective against the bollworm complex. A standard dieldrin-DDT mixture failed to give satisfactory control of boll weevils and bollworm complex in one experiment.

117. MCLAUGHLIN, R. E. Infectivity tests with *Beauveria bassiana* (Balsamo) Vuillemin on *Anthonomus grandis* Boheman. *Jour. Insect Pathol.* 4: 386–388. 1962.

Biological control tests in Mississippi and Texas showed that *Beauveria bassiana* can infect larvae, pupae, and adult boll weevils in the laboratory. High moisture levels were maintained. Further investigations are being conducted.

118. MCLAUGHLIN, R. E. *Mattesia grandis* n. sp., a sporozoan pathogen of the boll weevil, *Anthonomus grandis* Boheman. *Jour. Protozool.* 12: 405–413. 1965.

Laboratory cultures of the boll weevil became infected with *Mattesia grandis* n. sp. (Neogregarinida, Ophryocystidae). The ensuing epizootic resulted in destruction of the weevil colony. Infection occurred *per os* in larval and adult weevils. Sporozoites penetrate the intestinal wall and infect adipose tissue cells. Micronuclear schizogony with production of merozoites is the primary method of multiplication and spread to new foci. Micronuclear schizonts may grow as large as 30μ in size and produce up to 200 or so merozoites, which may be 20μ long and 1μ–2.5μ wide and are motile. Macronuclear schizonts are formed from these first schizogony merozoites, and can become 20μ–30μ in diameter and produce up to 80 or so macronuclear merozoites. These can be 15μ long but 2μ–3μ wide with limited motility. Second schizogony merozoites form gamonts, which pair and form gametocysts. Nuclear division results in four equal-sized nuclei and two pairs of residual nuclei. Four gametes are formed by cytoplasmic construction around the nuclei. The gametes rapidly pair to form two zygotes in the gametocyst, normally resulting in two spores. Nuclear pairing in one of the two zygotes often lags slightly behind. Abnormal development of zygotes is rare, but the result sometimes is one spore with three poles and a normal spore or only one spore. Near maturity, gametocysts are about 12.5μ long and 14.0μ wide, with the gametocyst wall tightly stretched over the poles of the spores. Spores often are slightly flattened on the adjacent side in the gametocyst, but they frequently attained evenly curved walls on all sides after release. The spores are octozoic, with sporozoite development occurring after release from the gametocyst. Spores measured 7.1μ x 11.8μ. Characters are given to separate *M. grandis* from other species of *Mattesia*.

119. MCLAUGHLIN, R. E. Some relationships between the boll weevil, *Anthonomus grandis*, Boheman, and *Mattesia grandis*, McLaughlin (Protozoa: Neogregarinida). *Jour. Invert. Pathol.* 7: 464–473. 1965.

The neogregarine infects larvae and adults of the boll weevil when the spores are ingested. All instars, pupae, and adults are susceptible. Usually sporogony and production of free spores occurred 7 days after infection. The pathogen development was retarded in adults when little or no lipoid material was deposited in the adipose tissue. When the adult diet was altered to result in the deposition of fat, normal development resumed. The rate of development of the pathogen also appeared to vary directly with changes in temperature. Infected females laid fewer eggs per day than healthy females.

120. McLaughlin, R. E., and Allen, G. Description of hemocytes and the coagulation process in the boll weevil, *Anthonomus grandis* Boheman (Curculionidae). *Biol. Bul.* 128: 112–124. 1965.

Hemocytes were classified into four types. Prohemocytes had a large nucleus and a thin band of peripheral cytoplasm. All gradations were observed to spherical plasmatocytes. Plasmatocytes were characterized by their extensive pleomorphis capability, a cytoplasm that varied from finely granular with few larger granules and that was dense and uniform to phase contrast or heterogeneous with vacuoles or various inclusions. They assumed pseudopodial, fusiform shapes or irregular shapes during the process of stranding during coagulation. Plasmatocytes were phagocytic. Adipohemocytes were filled with lipoid globules. Spherule cells were characterized by having one to several large, amorphous globules. A slow process of network formation occurred by stranding of plasmatocytes. Networks were formed by extension, retraction, and anastomosis of cytoplasmic strands and represented the only observed process of coagulation.

121. McLaughlin, R. E., and Keller, J. C. Antibiotic control of an epizootic caused by *Serratia marcescens*, Bizio in the boll weevil, *Anthonomus grandis* Boheman. *Jour. Insect Pathol.* 6: 481–485. 1964.

Adults of the boll weevil were collected at a rearing station in Mexico and shipped to the Boll Weevil Laboratory, State College, Miss. Extremely high weevil mortality occurred at the rearing station and in transit, and no healthy weevils were available for experimental use. Mortality was caused by *Serratia marcescens*, Bizio. An antibiotic, in 10 percent sugar solution substituted for cotton plant material as food at the rearing station and during shipment, effectively controlled the epizootic. Novobiocin and tetracycline were the active compounds.

122. Matteson, J. W., and Taft, H. M. Carbamate-induced systemic repellency to boll weevil on cotton. *Jour. Econ. Ent.* 56: 892–893. 1963.

Thirty-eight carbamates were screened as systemic repellents to boll weevil on seedling cotton plants. Of the 15 compounds released for publication, six exhibited systemic repellent properties. Compared with the standard Bayer 39007, three of these six were more repellent than toxic and three were more toxic than repellent. Because of the lack of correlation between the repellent and toxic action of the six, it is believed that the mode of action that induces toxicity is independent of that which induces repellency.

123. Matteson, J. W., and Taft, H. M. The effect of various adjuvants on the systemic insecticidal activity of phorate and Zectran. *Jour. Econ. Ent.* 57:325–326. 1964.

Eighty-seven adjuvants were screened for their influence. The insecticides at 100 p.p.m. and the adjuvants at 50 p.p.m. were added to plant-nutrient solutions in which cotton seedlings were placed. Boll weevils were confined on the plants for 48 hours. The mortality of weevils on plants in insecticide plus adjuvant was compared with that on plants exposed to Zectran alone. None of the adjuvants affected the activity of phorate; however, three significantly enhanced the systemic activity of Zectran. All three were quaternary ammonium chlorides and the only chemicals of this type included in the tests. No synergistic effect was involved; the adjuvants were either affecting the roots or the insecticide in such a manner that the insecticidal activity of Zectran was increased.

124. Matteson, J. W., Taft, H. M., and Rainwater, C. F. Chemically induced resistance in the cotton plant to attack by the boll weevil. *Jour. Econ. Ent.* 56: 189–192. 1963.

Plant extracts representing 117 families and 358 species and 400 fermentation filtrates representing a wide spectrum of bacteria, molds, yeasts, and fleshy fungi were screened against the boll weevil-cotton plant complex for systemically induced repellency, attractancy, and effects on fecundity and development of larvae in squares. The results obtained were negative.

Nine compounds of known chemical identity were screened. One of these, Bayer 39007, exhibited definite systemically induced repellency to the boll weevil in seedling cotton plants and in plants in the four-leaf stage in the laboratory.

125. Maxwell, F. G., Jenkins, J. N., and Keller, J. C. Boll weevil repellent from the volatile substance of cotton. *Jour. Econ. Ent.* 56: 894–895. 1963.

During the process of purifying a crude boll weevil attractant extract in chloroform obtained from cotton, the residue remaining after chloroform evaporation at room temperature was biologically assayed and found to be repellent to the boll weevil. Treated cotton seedlings were protected from weevils for 5 to 12 hours and treated squares and bolls in presence of untreated controls for 36 hours. Weevils exposed to treated bolls and squares, without

other food available, were effectively repelled for 8 hours. Repellency appeared to be associated with the highly pungent odor of the oily residue.

126. MAXWELL, F. G., and others. An arrestant and feeding stimulant for the boll weevil in water extracts of cotton-plant parts. *Jour. Econ. Ent.* 56: 449–454. 1963.

J. N. Jenkins, J. C. Keller, and W. L. Parrott, joint authors.

A powerful arrestant and feeding stimulant was found in water extracts of all cotton-plant parts and square components investigated.

All cotton-plant parts investigated were found to contain the arrestant in sufficient concentration for bioassay. Flowers at the stage of anthesis and whole squares contained the highest. In the square, the calyx contained the highest, and the amount progressively decreased interiorly, with the lowest in the ovary.

Presence of the arrestant and feeding stimulant in germinated seed or seedlings indicated they could be used as screening agents in host-plant resistant programs, which obviates need for fruiting plants. Correlation between weevil feeding response and concentration was almost direct, with the bottom limit at 10,000 p.p.m. Agar plugs with small amounts of water extract from squares elicited a much higher feeding response than a commonly used artificial adult-weevil diet.

A biological assay method is given.

127. MAXWELL, F. G., and others. A boll weevil feeding deterrent from the calyx of an alternate host, *Hibiscus syriacus*. *Jour. Econ. Ent.* 58: 985–988. 1965.

W. L. Parrott, J. N. Jenkins, and H. H. Lafever, joint authors.

A biologically active material present in the calyx of Rose-of-Sharon is responsible, in part, for reducing boll weevil feeding significantly on or ovipositing in the developing bud of this plant. This feeding deterrent is water soluble and readily extractable. The calyx extract brushed on cotton buds reduced feeding thereon significantly for 20 hours. When a mixture of freeze-dried feeding deterrent and feeding stimulant, containing 2½ times more deterrent than stimulant by weight, was formulated into plugs containing 2½ percent of agar, feeding response of the boll weevil was completely masked. In a 20-hour test, 10 weevils made only two feeding punctures in 2½ percent agar plugs containing 0.00166 percent of feeding deterrent by weight as compared with 92 punctures in plugs without the deterrent.

128. MAYER, M. S., and BRAZZEL, J. R. Certain biological effects produced in the boll weevil by tagging it with P^{32}. *Jour. Econ. Ent.* 54: 1197–1203. 1961.

Boll weevils were tagged with radioactive phosphorus by feeding P^{32} to adults in solutions or rearing them in larval diets in which $H_3P^{32}O_4$ had been added in varying quantities. The rates of loss of radioisotope were higher for those fed P^{32} as adults than for those reared on the radioactive larval diet.

The fecundity, longevity, and length of oviposition and preoviposition periods were more adversely affected in the weevils raised on radioactive larval diets than in those fed P^{32} as adults. Females reared on the two highest dosages in the diet failed to lay eggs. Larval mortality increased in proportion to the amount of radioactivity in the diet, and mortality was always greater and began sooner for weevils reared on the diet.

129. MAYER, M. S., and BRAZZEL, J. R. Mating behavior of the boll weevil, *Anthonomus grandis*. *Jour. Econ. Ent.* 56: 605–609. 1963.

Studies were made to determine percentages of weevils mating in various age groups and time interval between repeat mating. The number of males mating increased as their ages increased. The length of the interval of confinement and the age of the female had less effect on the percentage increase of mating than the age of the male.

The female would attempt to repulse the male if she had been mated within 24 hours before the mating attempt. Males were found to mate more frequently than females.

Analyses were made of certain biological phenomena of nonmated, once-mated, and multiple-mated females. Nonmated females laid a high percentage of eggs on the outside of the cotton square, but mated females deposited the majority of eggs on the inside of the square. Once-mated females laid eggs normally for about 19 to 21 days and then reverted to an unmated behavior pattern.

130. MERKL, M. E., and MEYER, J. M. Studies of resistance of cotton strains to the boll weevil. *Jour. Econ. Ent.* 56: 860–862. 1963.

This 4-year resistance study at Stoneville, Miss., included these strains: M–8, D_2–Smooth, Pilose-Okra leaf, Nectariless, Glandless, Yugoslav-Early Upland, Red Plant, and Asiatic. The Asiatic strain was significantly more resistant than any of the others. Yugoslav-Early had the earliest and greatest boll weevil infestation. D_2–Smooth, Glandless, and Nectariless had intermediate infestations, all of the same level. Plant height, color, and growth characteristics were factors affecting the percentage of squares punctured.

131. MISTRIC, W. J., JR. Effectiveness of rotenone and pyrethrins when mixed with other chemicals for boll weevil control. *Jour. Econ. Ent.* 57: 765–766. 1964.

In 1962, a proprietary emulsion concentrate containing rotenone, pyrethrins, and other chemicals was widely publicized and offered for sale on a large-scale experimental basis for boll weevil control. No data were available. Field tests run by the N. C. Agricultural Experiment

Station indicated that the spray offered little, if any, control of the boll weevil. The loss resulting from its use was about $100 per acre greater than with recommended methods.

132. MITCHELL, E. R., and MISTRIC, W. J., JR. Concepts of population dynamics and estimation of boll weevil populations. *Jour. Econ. Ent.* 58: 757–763. 1965.

Information on recovery, movement, and mortality of the boll weevil was observed from field-cage studies in North Carolina during 1962. The average recovery of weevils on cotton plants was 65.5 percent, and 88.8 percent of the recovered weevils were found on squares, flowers, and bolls. Variation from the average recovery in excess of 10 percent occurred in about one out of four examinations. This variation appeared to be due to many factors acting together rather than to single factors such as generation, age, sex, and the number of weevils or date and time of day of examination. However, plant maturity enhanced recovery. Migration of first-generation weevils (mostly females) was indicated on July 28 and 30, but the tendency to escape did not persist. The mortality rate of overwintered and second-generation weevils was approximately 2 percent per day, and that of first-generation weevils was 1 percent.

Formulae for the estimation of weevil populations are given.

133. MITCHELL, E. R., and MISTRIC, W. J., JR. Seasonal occurrence of diapause and hibernation of the boll weevil in North Carolina. *Jour. Econ. Ent.* 58: 309–312. 1965.

Investigations were conducted in 1961 and 1962 in and near a cottonfield with high productive level and effectively treated with insecticides for boll weevil control and a field with low productive level and virtually untreated. With one exception, the initiation of diapause in the field was closely associated with the onset of maturity in the cotton plants. Diapausing weevils began to hibernate in late August near the untreated field and in late September near the treated field. A large number of weevils hibernated rather abruptly during late September near the untreated field. However, the number of weevils in hibernation near the untreated field gradually declined during October and November; which indicates that many of the hibernating weevils apparently died before the onset of winter. During the same period, the number of hibernating weevils steadily increased near the treated field.

134. MITLIN, N. The physiology and toxicology of chemosterilants. 12th *Internatl. Cong. Ent. Proc.* London. 1964: 511–513. 1965. (Abstract)

Several guanine analogs were tested as inhibitors of reproduction. Two, 8-bromoguanine and 9 methyl, 2 butyl guanine were found to be effective ovarian growth inhibitors in the boll weevil.

135. MITLIN, N., BARTLETT, A. C., and KELLER, J. C. Elimination rate and effect on reproduction of ingested radiophosphorus in the boll weevil. *Jour. Econ. Ent.* 58: 119–121. 1965.

The biological half-life of ingested P^{32} was 5.3 days in females and 7.3 days in males. Germ cells were relatively resistant to effects of the isotope. Ingested amounts up to 3.5μc caused only a small decrease in fecundity, and when either the male or female was fed the isotope no effects on progeny or genetic changes could be detected. Sterile matings resulted only when both sexes were fed the isotope. There was no obvious chromosomal damage in the germ cells, and no phenodeviants appeared in insects reared to the third filial generation. By feeding P^{32}, sperm or seminal fluid or both could be labeled and traced to the spermatheca and ovaries of mated females. Larvae reared in a radioactive medium were inhibited in their development and only a small percentage developed to adulthood.

136. MITLIN, N., and VICKERS, D. H. Guanine in the excreta of the boll weevil. *Nature* [London] 203: 1403–1404. 1964.

The purine guanine was identified in the excreta of the boll weevil by paper chromatography and spectrophotometry. It is hypothesized that the appearance of this unusual purine may be the result of the deficiency of the enzyme guanase.

137. MITLIN, N., VICKERS, D. H., and GAST, R. T. Estimation of nitrogenous compounds in the feces of boll weevils, *Anthonomus grandis*, fed different diets. *Ent. Soc. Amer. Ann.* 57: 757–759. 1964.

The effects on the nitrogenous end products of the metabolism of the boll weevil fed on artificial diet, cotton squares, or bolls were determined. Fecal analyses for amino nitrogen, ammonia, creatine, creatinine, guanine, urea, and uric acid showed that presence of these materials varied with the type of diet fed the insects. The purine guanine was found in relatively large quantities in the feces of weevils fed all three diets. A metabolic block in its deamination was hypothesized.

138. MITLIN, N., VICKERS, D. H., and HEDIN, P. A. End products of metabolism in the boll weevil, *Anthonomus grandis* Boheman: Nonprotein amino acids in the faeces. *Jour. Insect Physiol.* 10: 393–397. 1964.

As a part of a study of nitrogen metabolism, the feces of the boll weevil were examined for nonprotein amino acids. By use of chromatographic techniques, 20 amino acids in an ethanolic extract were detected and the quantities estimated. By acid hydrolysis, 23 amino acids were detected. The free and bound non-

protein amino acids and ammonia accounted for 3.23 percent of total feces nitrogen.

139. Moore, R. F., Jr., and Taft, H. M. Effect of DDT and toxaphene alone and in combination on succinic dehydrogenase activity in homogenates of the boll weevil. *Jour. Econ. Ent.* 57: 772–773. 1964.

The phenazine methosulfate method used in vertebrate-tissue studies was used. It measures oxygen uptake as a function of enzyme activity. No striking effects of DDT, toxaphene, or a combination of these two insecticides on the activity of succinic dehydrogenase were shown. It is suggested that the effects of DDT on the activity of the enzyme in other insects, as reported by some investigators, may have been due to the less specific method employed.

140. Moore, R. F., Jr., and Taft, H. M. Some *in vitro* effects of dinitrocresol and magnesium chloride on ATPase in the boll weevil. *Ent. Soc. Amer. Ann.* 57: 28–31. 1964.

In a study of the activity of ATPase in homogenates of the boll weevil sufficient magnesium occurred to activate the enzyme. Additional magnesium did not increase activity of the enzyme. A higher level of ATPase occurred in a laboratory-reared than in a field-collected population. Dinitrocresol added to homogenates containing no exogenous magnesium ions increased ATPase activity but depressed it when $5x10^{-3}M$ magnesium chloride was present.

141. Moore, R. F., Jr., Taft, H. M., and Whisnant, F. F. Effect on boll weevil progeny of cholesterol added to the adult diet as a powder or an ether solution. *Jour. Econ. Ent.* 57: 1005. 1964.

Adults fed on an artificial diet to which cholesterol was added as an ether solution produced more viable eggs and larger progeny than those fed on a diet to which cholesterol was added as a powder.

142. Neff, D. L., and Vanderzant, E. S. Methods of evaluating the chemotropic response of boll weevils to extracts of the cotton plant and various other substances. *Jour. Econ. Ent.* 56: 761–766. 1963.

Two methods are described. In one, solutions of pure chemicals or extracts of the cotton plant were applied to a feeding dish containing diet. In the other, plant parts were placed in a small container covered with a paraffin film to prevent contact of the test material by the insect. The behavior of the boll weevil in both assay methods is described, and the applications of the methods are discussed.

A solvent extraction of cotton-plant parts and the chromatography of the extract are described. By the use of the diet method, several fractions attractive to the boll weevil were found.

143. Nettles, W. C., Jr., and Betz, N. L. Glycogen in the boll weevil with respect to diapause, age, and diet. *Ent. Soc. Amer. Ann.* 58: 721–726. 1965.

On a dry-weight basis, the glycogen content of the boll weevil is maximum (11 percent) in the eggs. It is about 1.5 percent through most of the larval period, but it rises to 6 percent late in the last larval instar. It declines rapidly in the first half of the pupal period but less rapidly in the second half, and the minimum titer (99 percent less than in the late last larval instar) is found in the 1-day-old adult. Adults, whether fed on bolls or squares, have their highest glycogen content at 6 to 15 days of age, but the titer is several times higher in boll-fed than in square-fed weevils. This phenomenon and the higher triglyceride content of boll-fed individuals probably result from the five to eight times greater sugar content (principally glucose and fructose) in bolls as compared with squares. In boll-fed adults the glycogen titer differs little or not at all between diapausing and reproducing weevils, but in square-fed weevils it is higher in those that are diapausing, though still below the level found in boll-fed, reproducing weevils. The glycogen titer of whole weevils decreases during storage at –20°C., but this loss was prevented by storing the weevils in ethanol at –20°.

144. Oliver, A. D., and Sloane, L. W. Effects of various water volumes on the effectiveness of methyl parathion-DDT in controlling the cotton boll weevil, *Anthonomus grandis*. *Jour. Econ. Ent.* 57: 292. 1964.

There were no differences in boll weevil control or yield of cotton when treatment was made with constant rates of methyl parathion and DDT in 2,5, or 8 gallons of total spray per acre.

145. Parencia, C. R., Jr., Davis, J. W., and Cowan, C. B., Jr. Studies on the ability of overwintered boll weevils to find fruiting cotton plants. *Jour. Econ. Ent.* 57: 162. 1964.

Experiments during 1960, 1961, and 1962 in central Texas showed that overwintered boll weevils emerging from hibernation sites found groups of five and of 20 fruiting plants more readily than they found single plants. Some weevils were collected by this method near the hibernation sites in early spring before field-grown plants were available. However, the method was not of practical value in reducing overwintered populations.

146. Parish, J. C., and Arthur, B. W. Mammalian and insect metabolism of the chemosterilant thiotepa. *Jour. Econ. Ent.* 58: 976–979. 1965.

Thiotepa was synthesized with a P^{32} label, and its metabolic fate was studied in white rats and four species of insects, including the boll weevil.

Maximum absorption after topical application occurred by 4 hours after treatment in all insects except the boll weevil.

Tepa was the only chloroform-soluble metabolite of thiotepa recovered from the insects. The amount of thiotepa decreased with time after treatment in all insects except the boll weevil.

147. PARKER, R. E., and others. Effectiveness of a USDA-developed middle flamer on boll weevil (*Anthonomus grandis*) destruction inside cotton squares. *U.S. Agr. Res. Serv. ARS* 42–104, 12 pp. 1964.

E. C. Burt, F. E. Fulgham, and M. E. Merkl, joint authors.

Once-a-week flame applications with a hooded burner satisfactorily controls weeds in the middle of cotton rows at a cost of 20 to 40 cents per acre per application.

From results of controlled tests it was concluded that boll weevils inside fallen cotton squares can be reduced by approximately two-thirds by flaming the squares with a standard hooded burner traveling at a speed of one-fourth mile per hour. With the hood extended to 34 inches the same results were obtained at one-half mile per hour.

From results it is theorized that lethal temperatures of boll weevils depend upon the boll weevil's stage of development.

148. PFRIMMER, T. R., and MERKL, M. E. Field insecticide tests against several cotton pests. *Jour. Econ. Ent.* 55: 121–124. 1962.

Tests were made against the thrip, tarnished plant bug, boll weevil, bollworm, and spider mite. Geigy 30494, Methyl Trithion, Trithion, Sevin wettable powder, and mixtures of DDT with endrin, toxaphene, methyl parathion, Strobane, or Guthion all gave good control of the boll weevil and the bollworm.

149. RENJHEN, P. L., SANKARAN, T., and ATRI, S. P. Mexican cotton boll weevil and measures to prevent its entry into India. *Indian Cotton Growing Rev.* 16: 319–323. 1962.

India must guard against bringing the boll weevil into the country with the large quantity of raw cotton imported from the United States.

A life cycle of the boll weevil and a resumé of pesticide acts and quarantine measures are given. Unginned cotton may not be imported. Restrictions are put on importation of ginned cotton. Fumigation of imported cotton is compulsory.

150. RIDGWAY, R. L., and GORZYCKI, L. J. Evaluation of some experimental phosphorus and carbamate compounds as systemic insecticides. *U.S. Agr. Res. Serv. ARS* 33–106, 6 pp. 1965.

Five experimental compounds, Bayer 30237, Bayer 30554, CL–47031, NIA–10242, and UC–21149, were evaluated as systemic insecticides against the boll weevil, cotton aphid, and carmine spider mite in the laboratory, greenhouse, and field. When all methods of application were considered, UC–21149 and CL–47031 were the most promising against these pests. UC–21149 was slightly better than CL–47031 under field conditions.

151. RIDGWAY, R. L., GORZYCKI, L. J., and LINDQUIST, D. A. Evaluation of systemic insecticides for cotton insect control. *Jour. Econ. Ent.* 58: 666–669. 1965.

Four experimental systemic insecticides, American Cyanamid compounds CL–47031, CL–47470, CL–43064, and E. I. 47772, were compared in one or more tests with phorate, Di-Syston, Bidrin, phosphamidon, demeton, methyl parathion, and Guthion-Ethyl Guthion for cotton insect control. When applied in or near the seed furrow, as sidedressings to established plants, directly to the stem, or as foliar sprays, one or more of the experimental compounds was equal or superior to currently available compounds. The insects used for biological evaluation included the boll weevil.

152. RIDGWAY, R. L., JONES, S. L., and LINDQUIST, D. A. Effect of American cyanamid CL–47031 on fecundity and longevity of the boll weevil. *Jour. Econ. Ent.* 58: 790–791. 1965.

American Cyanamid experimental insecticide CL–47031 (cyclic ethylene (diethoxyphosphinyl) dithioimidocarbonate) and two other organophosphorus insecticides fed to the boll weevil greatly reduced egg production. Low levels of CL–47031 fed to boll weevils also produced high mortalities.

153. RIDGWAY, R. L., LINDQUIST, D. A., and BULL, D. L. Effect of method of application on uptake of Di-Syston by the cotton plant. *Jour. Econ. Ent.* 58: 349–352. 1965.

P^{32} labeled Di-Syston was applied to the soil with and without irrigation and at several locations in relation to the cotton plant. Results indicated that irrigation, deep placement, and sidedressing on both sides instead of on one side of the drill row increased uptake. Radioassay of different parts of the cotton plant after applications were made to the soil indicated that greater quantities of radioactivity accumulated in the leaves than elsewhere. After application to the stem, Di-Syston did not translocate to other parts of the plant to the extent reported for some other systemic insecticides. Laboratory-reared insects, including boll weevils, were used for bioassays.

Studies indicated that stem treatments with the more water-soluble metabolites of Di-Syston were more effective against the boll weevil than the less soluble Di-Syston.

154. SHIPP, O. E., and BRAZZEL, J. R. Distribution of C^{14} labeled dieldrin in dieldrin-resistant and susceptible boll weevils, *Anthonomus grandis*. *Jour. Econ. Ent.* 57: 174–175. 1964.

The relation of total fat content of an insect-body part to the distribution of topically applied C^{14} labeled dieldrin in the boll weevil was studied. Results revealed no apparent relation

between the insecticide distribution and fat content. There was no apparent difference in the distribution of the insecticide between the dieldrin-resistant and dieldrin-susceptible boll weevil. There was no difference in the penetration of the cuticle by the C^{14} labeled dieldrin between the resistant and susceptible boll weevil at the single applied dosage.

155. SHIPP, O. E., LINDQUIST, D. A., and BRAZZEL, J. R. Characteristics of residues of methyl parathion applied to field cotton. *Jour. Econ. Ent.* 56: 793–798. 1963.

Methyl parathion applied to field cotton by a high-clearance spray machine at the rate of 0.5 pounds in 6 gallons of water per acre was found to persist on and in the foliage up to 12 days. The principal site of the residues was in and under the cuticle of the leaf and not on the surface. Residues found 1, 3, 7, and 12 days after treatment were toxic to the weevil.

Analysis of P^{32} labeled methyl parathion indicated the residual half-life of the insecticide applied to cotton leaves was approximately 24 hours. Maximum penetration of the leaf by the insecticide occurred within the first 2 hours after application. The P^{32} labeled methyl parathion was not translocated from its site of application on the leaf. Most of the residual deposit was located within the leaf tissues, with some remaining in the cuticular layer of the leaf. Four compounds containing P^{32} were found in the residue. Two were identified as methyl parathion and methyl para-oxon. The others were not identified.

More of the residual parathion in the leaf was converted to methyl para-oxon at high temperatures (72°–112° F.) than at lower temperatures (70°–90°). The toxicity of methyl parathion residues over extended periods was due in part to the presence of methyl para-oxon.

156. SIMPSON, D. R., BULL, D. L., and LINDQUIST, D. A. A semi-microtechnique for the estimation of cholinesterase activity in boll weevils. *Ent. Soc. Amer. Ann.* 57: 367–371. 1964.

Hestrin's colorimetric method was modified to allow a consistent measurement of the comparatively low cholinesterase activity found in the boll weevil. The technique yielded results that were independent of the amount of insect material present; and if the established limits of the technique were not exceeded, the results varied only slightly in consecutive analyses. Sixty or more analyses often were made concurrently.

157. SMITH, G. L., CLEVELAND, T. C., and CLARK, J. C. Boll weevil control with emphasis on early season and fall treatment in 1960, 1961, and 1962 at Tallulah, La. *U.S. Agr. Res. Serv. ARS* 33–100. 1964.

Results indicated that fall applications of methyl parathion were effective in reducing hibernating boll weevil populations. A 7-day application interval would probably be more effective than a 10-day interval. Although control of overwintered boll weevils with Guthion required a minimum of late-season treatment, the best control was obtained when fall treatment with methyl parathion was followed with Guthion. This procedure would be more effective in reducing overwintered populations in the boll weevil belt than fall treatment or early-spring treatment alone.

158. SMITH, G. L., CLEVELAND, T. C., and CLARK, J. C. Cost of cotton insect control with insecticides at Tallulah, La. *U. S. Agr. Serv. ARS* 33–96, 7 pp. 1964.

The boll weevil became resistant to the chlorinated hydrocarbon insecticides in Louisiana in the midfifties. Until cotton growers learned to cope with the situation control costs ran as high as $60 per acre. ARS scientists cooperated with local growers to obtain information on cost and effectiveness of cotton insect control programs.

In 1957 the cost of insecticides and their application was $38.22 per acre; in 1962 the cost had decreased to $19.66. The yield of lint for 1957 and 1962 was 558 and 745 pounds, respectively.

159. SMITH, G. L., CLEVELAND, T. C., and CLARK, J. C. Boll weevil movement from hibernation sites to fruiting cotton. *Jour. Econ. Ent.* 58: 357–358. 1965.

From 1960 to 1963 groups of greenhouse-grown cotton plants were placed in hibernation sites, cottonfields, or adjacent soybeanfields or grassfields to determine movement of boll weevils from hibernation sites. Weevils were not collected on plants in hibernation sites, but they were found on plants 100 feet or more from such sites, with greater numbers on plants in cottonfields than in grassfields or soybeanfields, even when cottonfields were farther away. Temperature and rainfall greatly influenced the numbers found. However, it was not possible to collect enough weevils by this method to be of practical value in reducing overwintered populations.

160. SMITH, G. L., CLEVELAND, T. C., and CLARK, J. C. Field tests for control of overwintered boll weevils. *Jour. Econ. Ent.* 58: 360–361. 1965.

Resistance to chlorinated hydrocarbon insecticides used individually against overwintered boll weevils was evident; but certain mixtures, such as toxaphene, Strobane, or endrin plus DDT, and organophosphorus compounds gave effective control when applied at the proper time.

161. SMITH, G. L., and SCALES, A. L. The effect of air and ground surface temperature on boll weevil winter survival. *Jour. Econ. Ent.* 58: 174–175. 1965.

Records and observations indicated that very little winter mortality of boll weevils results

from low winter temperatures in northeastern Louisiana. Prolonged periods of low temperature under dry conditions appear to cause some mortality of hibernating weevils in surface ground trash, but these conditions rarely occur in the area. The winter's lowest temperatures are usually accompanied by snow, which serves as a protecting blanket.

162. STEPHENS, S. G., and LEE, H. S. Further studies on the feeding and oviposition preferences of the boll weevil (*Anthonomus grandis*). *Jour. Econ. Ent.* 54: 1085–1090. 1961.

Weevils did not discriminate between flowerbuds of red and other strains of cotton in the laboratory. In similar tests they preferred normal to glandless buds and nonhairy either glandless or normal to hairy either glandless or normal.

In a field test a standard Upland variety and three mutant strains, hairy, hairy-glandless, and hairy-glandless-red, were compared. All hairy strains received less damage than the standard Upland. Weevils did not discriminate between hairy and hairy-glandless types. Data on the hairy-glandless-red type were incomplete, but they suggested that the red character might increase resistance to attack.

Resistance associated with hairiness could be separated into two categories—mechanical and presumed antibiotic effects.

163. STERLING, W. L., and others. A cottonseed-meal diet for laboratory cultures of the boll weevil. *Jour. Econ. Ent.* 58: 867–869. 1965.

S. G. Wellso, P. L. Adkisson, and H. W. Dorough, joint authors.

Adults reared on a cottonseed-meal diet emerged sooner and over a shorter period, were heavier, lived longer, and females produced more eggs than weevils reared under similar conditions on a cottonleaf-meal diet. The cottonseed meal is available from commercial sources and is less expensive than the cottonleaf meal.

164. SUNDMAN, J. A., and KING, D. R. Morphological, histological, and histochemical studies of the alimentary canal and Malpighian tubes of the adult boll weevil, *Anthonomus grandis*. *Ent. Soc. Amer. Ann.* 57: 89–95. 1964.

The alimentary canal of the boll weevil begins in the head-capsule proper. The frontal ganglion is situated ventral to the frontal fovea, which is approached by the anterior tentorial arms. The dorsal surface of the snout is composed principally of the clypeus. Studlike projections on the anterior, saclike portion of the ventriculus are "diverticula," which probably regenerate epithelial cells. Caeca, arranged in two opposed rows, are found on the posterior, tubular portion of the ventriculus. The peritrophic membrane appears to be secreted in this portion of the ventriculus. The Malpighian tubes enter into a cryptonephridial arrangement. There is an abundance of PA/S-positive materials in the alimentary canal. Glycogen is present mainly in the muscles associated with the alimentary canal and in the epithelium of the hindgut. Certain structures in the alimentary canal (e.g., the Stützlamelle and the peritrophic membrane) give both PA/S- and alcian blue-positive reactions. This may be due to the location of PA/S- and alcian blue-positive substances in the same sites, or, in part, to a reaction of alcian blue with nonacidic, PA/S-positive materials. Chitinous structures in the alimentary canal did not react or reacted very little with alcian blue.

165. TAFT, H. M., and AGEE, H. R. A marking and recovery method for use in boll weevil movement studies. *Jour. Econ. Ent.* 55: 1018–1019. 1962.

An invisible green fluorescent powder used in crime detection and a portable black light were used in a method developed for marking and recovery of boll weevils released in movement studies. Marked weevils were readily detected by gross examination in the release area after dark.

166. TAFT, H. M., and HOPKINS, A. R. A community effort in boll weevil control. *U.S. Agr. Res. Serv.* ARS 33–82, 15 pp. 1963.

Data showed that the early-season community-wide boll weevil control program held weevil populations to very low levels during the application period and below the 10-percent punctured-square level for 3 to 5 weeks thereafter. Thus, mass migration usually resulting from the emergence of the F_2 generation will not occur in populations when fields have received effective early-season applications of insecticide and four or more late-season applications, beginning when the infestation reaches approximately 3 to 5 percent.

The greatest economic returns will be gained only if other necessary production practices are followed. An early-season insecticide program followed by a series of effective late-season applications will materially reduce the numbers of weevils entering hibernation and surviving within the treatment area.

Complete control with available materials and equipment is extremely difficult. But the number of weevils can be reduced to levels at which other approaches to control, such as the sterile-male-release technique or plant resistance, could be used effectively to further reduce or to decimate the population.

The success of the early-season community-control program should encourage other similar groups to consider this approach to boll weevil control.

167. TAFT, H. M., HOPKINS, A. R., and JAMES, W. Differences in reproductive potential, feeding rate, and longevity of boll weevils

mated in the fall and in the fall and spring. *Jour. Econ. Ent.* 56: 180–181. 1963.

Oviposition capabilities, viability of eggs produced, amount of feeding, and longevity were determined. From 8 to 20 percent of female weevils were incapable of producing eggs. Females not allowed to remate in the spring produced about 50 percent fewer eggs than those that remated, but the oviposition and preoviposition periods were not significantly different. Among groups of weevils that emerged normally there was no difference in longevity between females remated in the spring and those mated only the previous fall.

168. TAFT, H. M., and JERNIGAN, C. E. Elevated screens for collecting boll weevils flying between hibernation sites and cottonfields. *Jour. Econ. Ent.* 57: 773–775. 1964.

The equipment was designed for comparing flight movements of boll weevils leaving hibernation sites in the spring and those leaving a cottonfield to enter hibernation sites in the fall. Weevils flew out of the cottonfields at greater altitudes than out of the hibernation sites. The equipment could be used for studies of other flying insects.

169. THOMAS, J. G., and BRAZZEL, J. R. A comparative study of certain biological phenomena of a resistant and a susceptible strain of the boll weevil, *Anthonomus grandis*. *Jour. Econ. Ent.* 54: 417–420. 1961.

An increase of 12.5 hours in the developmental period of the resistant strain over the susceptible strain and a 22 percent decrease in the fecundity of the resistant females were the most significant biological differences observed. No differences were observed in mortality rates, sex ratios, length of preoviposition and oviposition periods, or percentage egg hatch.

170. TIPPINS, H. H., and BECKHAM, C. M. Variations in susceptibility to endrin of four boll weevil populations. *Ga. Agr. Res.* 3(1): 4–5. 1961.

The toxicity of endrin to 2-day-old boll weevils reared from cotton squares collected periodically from single fields in four counties in Georgia was determined during 1960. The weevils from Gordon County were highly susceptible to endrin. Weevils from Early and Sumter Counties exhibited resistance to endrin. Those from Pike County were intermediate in reaction to this insecticide. This is not interpreted, however, as meaning that all weevils in the three counties are resistant to endrin. The data apply only to the weevil populations in the particular fields sampled. Additional studies are needed to delimit the areas of resistance.

171. TIPPINS, H. H., and BECKHAM, C. M. Boll weevil resistance to several chlorinated hydrocarbon insecticides in Georgia. *Jour. Econ. Ent.* 55: 944–947. 1962.

Studies were conducted in the laboratory on weevils collected in 16 counties in Georgia. Only those weevils from extreme northern counties were highly susceptible to endrin. There was some indication of reversion to susceptibility to endrin in 1959 and 1960. However, little or no difference was found in the susceptibility of weevils after a change in field applications from chlorinated hydrocarbon to organic phosphate insecticides during 1961. Resistance to BHC and toxaphene was established. Two years' results showed field-collected weevils of unknown age to be 50 to 210 times harder to kill than 2-day-old square-reared weevils.

172. VANDERZANT, E. S. Nutrition of the adult boll weevil: Oviposition on defined diets and amino acid requirements. *Jour. Insect Physiol.* 9: 683–691. 1963.

Boll weevil adults were fed and oviposited on defined diets consisting of casein, amino acids, sugars, corn oil, cholesterol, inositol, choline, mineral salts, B-vitamins, agar, and water. No extractives of the cotton plant were needed to induce egg laying. Good oviposition also was obtained in protein-free diets in which amino acids and dextrin were substituted for casein. No eggs were obtained when arginine, histidine, isoleucine, leucine, lysine, threonine, tryptophan, valine, methionine, or phenylalanine were omitted one at a time from the diet. Eggs were laid by females fed diets containing the 10 indispensable amino acids, glutamic acid, and glycine as the only sources of nitrogen for protein formation.

173. VANDERZANT, E. S. Nutrition of the boll weevil larva. *Jour. Econ. Ent.* 56: 357–362. 1963.

Dietary requirements of larvae reared on a purified casein diet are reported.

Compounds of myo-inositol are just as effective in promoting growth as free inositol. Choline is needed and cannot be replaced by betaine, carnitine, or ethanolamine. Dietary fat improves development of the larvae and permits more larvae to become adults. Sterols are indispensable for growth; cholesterol, stigmasterol, and sitosterol can all be used.

Six B-vitamins found to be needed in casein diets are pantothenic acid, thiamine, riboflavin, pyridoxine, niacinamide, and folic acid. Biotin was not required. In tests performed, antimetabolites of thiamine, biotin, and pantothenic acid did not interfere with growth.

Sodium alginate, used in previous diets as a stabilizer, was found to inhibit growth.

174. VANDERZANT, E. S. Axenic rearing of the boll weevil on defined diets: amino acid, carbohydrate, and mineral requirements. *Jour. Insect Physiol.* 11: 659–670. 1965.

Boll weevils were reared from egg to adult on defined diets composed of amino acids, sugars, fatty acids, cholesterol, choline, inositol, B vitamins, mineral salts, agar, and water. Yields and weights of adults and their rates of development were similar to those obtained

from casein diet. In deletion experiments, threonine, tryptophan, and valine were found to be indispensable for growth. Among sugars tested, fructose and sucrose produced the best growth. Maltose, cellobiose, starch, lactose, and glucose were less effective, and poor development occurred with mannose, melibiose, galactose, and ribose. Larvae died without dietary carbohydrate. Dietary fatty acids or the lack of them had no effect on growth. Magnesium was the only mineral indispensable for proper growth. Insects matured in diets without added sodium, calcium, iron, copper, zinc, manganese, molybdenum, cobalt, and iodine salts. Deficiencies of potassium and phosphate ions were not studied. The effects of changes in kinds and concentrations of nutrients are discussed.

175. VANDERZANT, E. S., and DAVICH, T. B. Artificial diets for the adult boll weevil and techniques for obtaining eggs. *Jour. Econ. Ent.* 54: 923–928. 1961.

The boll weevil preferred curved- to flat-surfaced diets. On a cylindrically shaped diet that was hemispheric at one end, the weevils fed and oviposited as well as on cotton buds.

Composition of diets, method of preparing cylinders, and a mechanical method of removing eggs are given.

176. VANDERZANT, E. S., POOL, M. C., and RICHARDSON, C. D. The role of ascorbic acid in the nutrition of three cotton insects. *Jour. Insect Physiol.* 8: 287–297. 1962.

Purified diets were used to determine the effect of dietary ascorbic acid on the development of the boll weevil, the bollworm, and the salt-marsh caterpillar. It was shown that ascorbic acid is an indispensable nutrient for the growth and development of these three insects when reared under aseptic conditions. Boll weevil adults fed on diets deficient in ascorbic acid laid fewer eggs with lower hatch than those that received this vitamin. Larvae from eggs that hatched did not survive beyond the second moult unless ascorbic acid was provided in the larval diet. When ascorbic acid was present in the adult diets, the eggs laid hatched into larvae some of which developed to adults even though their larval diets lacked the vitamin. Of the various stages of the boll weevil that were analysed, the egg contained the largest amount of ascorbic acid. Insects fed on diets deficient in ascorbic acid contained very little ascorbic acid. The bollworm and salt-marsh caterpillar have not been reared previously on purified diets. These two insects did not survive beyond the larval stage when their diets contained no ascorbic acid.

177. VANDERZANT, E. S., and RICHARDSON, C. D. Nutrition of the adult boll weevil: Lipid requirements. *Jour. Insect Physiol.* 10: 267–272. 1964.

Adult boll weevils reared from a defined diet, fed and oviposited similarly on defined adult diets with and without corn oil or fat-soluble vitamins. However, when both corn oil and fat-soluble vitamins were omitted from the adult diet, egg laying was markedly reduced. When adult diets lacked inositol, choline, or cholesterol, oviposition was less than half that obtained with the complete diet. Adults reared from larval diets without corn oil had a long preoviposition period and a high mortality. When fed the defined adult diet, they laid about half the number of eggs laid by females reared from a larval diet containing corn oil. Omission from the adult diet of corn oil or both corn oil and fat-soluble vitamins further reduced the number of eggs laid. Corn oil could be partially replaced by polyunsaturated fatty acids. The omission of most lipids and lipogenic factors did not seriously affect egg hatch. However, when adults were fed a diet deficient in cholesterol, not a single egg hatched after the 11th day after their emergence.

178. WALKER, J. K., JR. Emergence pattern of first-generation boll weevils in an isolated plot during 1960 and 1961. *Jour. Econ. Ent.* 55: 795–796. 1962.

Insecticides might be used more efficiently if the size of population of the F_1 generation and the time and duration of emergence could be anticipated. In both years studied, the peak of emergence of the F_1 generation occurred about 30 days after the first square attained size acceptable for oviposition. Results from both years indicate that insecticides applied on a 5-day schedule, initiated automatically 25 days after the appearance of the first squares might have been effective in controlling a high percentage of the F_1 generation.

Although the infestation of overwintered weevils and the percentage of squares punctured were similar in 1960 and 1961, a much greater population of first-generation weevils developed in 1960 even though climatic conditions were considered unfavorable for weevil increases.

179. WALKER, J. K., JR., and BARIOLA, L. A. Oviposition by virgin overwintered boll weevils. *Jour. Econ. Ent.* 57: 781–782. 1964.

Thirty-three virgin overwintered boll weevil females deposited about 20 eggs per female during a period of about 26 days. Four of the eggs hatched but the young larvae died shortly thereafter.

180. WALKER, J. K., JR., and HANNA, R. L. A study of boll weevil populations during 1960. *Tex. Agr. Expt. Sta. Prog. Rpt.* 2211, 8 pp. 1961.

Populations of boll weevils were studied in five treated and one untreated field near College Station. Data were recorded from 1/22-acre plots, counting areas within each field. Weevil populations in the untreated field doubled from the overwintered to the first generation and redoubled from the first to the

second. An average late-season population of about 1,300 weevils per acre resulted in severe yield loss. In the treated fields, populations were generally held well below 1,000 insects per acre. Organophosphorus insecticides were more effective for the control of overwintered weevils than the chlorinated hydrocarbon mixture at the dosage used.

181. WALKER, J. K., JR., and HANNA, R. L. Development of populations of the boll weevil in fields treated with various insecticides during 1959, 1960, and 1961. *Jour. Econ. Ent.* 56: 350–356. 1963.

Seasonal populations were carefully sampled in a number of small contiguous fields where control programs with different insecticides were being conducted. Cotton fruiting and fruit damage in these and in untreated areas were recorded. Organophosphorus compounds were generally more effective for control of overwintered weevils than other types of insecticide used, but continued emergence of weevils after squaring began during 1960 and 1961 reduced effectiveness of programs depending on a single application for the control of overwintered weevils. Continuously high populations in the untreated areas resulted in greatly reduced boll set, but the emergence of large numbers of weevils in the treated fields that increased square damage temporarily did not reduce boll set. However, in the treated areas higher percentages of punctured squares were usually followed by higher percentages of weevil-damaged bolls. The rate of population increase from generation to generation and the amount of damage caused by each weevil depended to a great extent on the number of squares on the cotton and the intensity of competition for those squares.

In untreated fields in 1960 and 1961 first-generation increases over overwintered populations were about threefold and twofold, respectively.

182. WALKER, J. K., JR., and PICKENS, L. G. Egg deposition by boll weevils isolated from males during hibernation period and after spring emergence. *Jour. Econ. Ent.* 55: 268–269. 1962.

Three hundred field-collected female boll weevils were isolated from males in small screen cages and buried in ground trash during fall and winter. The cages were removed from the ground trash the following March and 70 weevils were alive. Thirty-four were healthy. Twenty-nine of these deposited fertile eggs. Apparently sperm from fall matings remained viable during winter months.

Thus early-spring insecticide treatments to reduce numbers of females would be more important than other methods of control designed to reduce chances of additional spring matings.

183. WALKER, J. K., JR., and SHIPP, O. E. Occurrence of developmental stages of the boll weevil in cotton bolls during the dormant season of 1962–63 at College Station. *Tex. Agr. Expt. Sta. Prog. Rpt.* 2282, 5 pp. 1963.

February and March examinations of cotton bolls heavily infested with immature stages of the boll weevil in early winter showed significant numbers of all stages of the pest were alive as late as March 15. Some of the surviving adults contained fat despite having never fed in the adult stage. Surviving pupae contained more fat than pupae reared on an artificial laboratory diet. Successful overwintering in this manner occurred more times where a hardened, firm cell had been formed around the developing insect. The survival of small numbers of boll weevils, especially in South or West Texas, appears possible in this manner.

184. WATSON, T. F., and others. Effect of several insecticides and application schedules on cotton insect control. *Ala. Agr. Expt. Sta. Prog. Rpt. Ser.* 88, 5 pp. 1965.

F. A. Arant, W. G. Eden, and M. C. Sconyers, joint authors.

The only insects causing serious damage to cotton in the Wiregrass Area of Alabama during the 4-year period of 1961 through 1964 were boll weevil and bollworms. This investigation revealed that insecticidal treatment was essential at some time during the growing season to control these pests. Control during the major fruiting period was of greatest importance. Yields of cotton were not increased by control of minor pests.

185. WATSON, T. F., and SCONYERS, M. C. Comparison of insecticide application schedules for control of cotton insects. *Jour. Econ. Ent.* 58: 1124–1127. 1965.

Toxaphene-DDT, endrin-methyl parathion, and azinphosmethyl-DDT were used in a 3-year study, with six different control schedules. Yield losses were caused only by boll weevil, bollworm, and tobacco budworm. There were no significant differences among the yields from the application-schedule treatments, but all were highly significant when compared with the untreated checks.

186. WEIDEN, M. H. J., MOOREFIELD, H. H., and PAYNE, L. K. *O*-(methylcarbamoyl) oximes: a new class of carbamate insecticide-acaricides. *Jour. Econ. Ent.* 58: 154–155. 1965.

Preliminary toxicity data are presented for several insects for 3-chloro-6-cyano-2-norbornaone *O*-(methylcarbomoyl) oxime and 2-methyl-2-(methylthio) propionaldehyde *O*-(methylcarbamoyl) oxime. The LD 50's for the boll weevil were 5 and 0.1, respectively.

187. WILKES, L. H., ADKISSON, P. L., and COCHRAN, B. J. Use of an air-carrier sprayer for cotton insect control. *Tex. Agr. Expt. Sta. Prog. Rpt.* 2205, 3 pp. 1961.

In experiments conducted in 1960 near College Station, Tex., comparable control of cotton

insects and yields of seed cotton were obtained with the same amount of active ingredients applied with an air-carrier sprayer at the rate of 30 gallons of spray material per acre as with a conventional boom-type sprayer at 6 gallons of spray material per acre.

188. WILKES, L. H., and others. Spray nozzle arrangements, types and rates of application for cotton insect control. *Tex. Agr. Expt. Sta. Misc. Pub.* 595, 12 pp. 1962.

P. L. Adkisson, B. J. Cochran, and R. L. Hanna, joint authors.

Research has been conducted for the past several years on the effects of nozzle types and arrangements and of application rates of concentrated spray materials on cotton-insect control. The effectiveness of the variables studied has been based on field insect infestations and the yields of cotton. Effective control of boll weevils and bollworms can be maintained with low rates of total spray material applied with simple nozzle arrangements. Complicated nozzle arrangements for applying high rates of spray material per acre are not necessary to obtain effective cotton-insect control. In these studies a nozzle arrangement with only one nozzle per row was equally effective for controlling insects as an arrangement with up to three nozzles per row, provided the same amount of active insecticide and total spray was applied. Equally effective control of cotton insects was obtained with an application rate of 2 gallons per acre as compared with 6 and 14 gallons per acre if the same amount of insecticide per acre was used with each rate. The three types of boomless nozzles evaluated did not prove satisfactory for the application of insecticides in cotton.

189. WILKES, L. H., COCHRAN, B. J., and ADKISSON, P. L. Further studies of the effectiveness of certain spray nozzle types and sizes and arrangements for controlling boll weevils and bollworms. *Tex. Agr. Expt. Sta. Prog. Rpt.* 2264, 5 pp. 1963.

A variety of spray nozzle types and orifice sizes will produce effective control of the boll weevil and bollworm provided adequate amounts of insecticide are applied at opportune times. Results of this study showed no significant differences in insect control or yields produced in plots sprayed with nozzles ranging from size X3 to X18. Sprayed plots showed increased yields of approximately 1,000 to 1,100 pounds of seed cotton over the unsprayed check.

190. WILKES, L. H., and WALKER, J. K., JR. Modification of a commercial high-clearance sprayer for use in small plot spraying. *Jour. Econ. Ent.* 54: 601–603. 1961.

Development of low-gallonage sprays for control of cotton insects created a need for suitable sprayers for researchers. Diagrams for modifications of the spraying system of commercial sprayers are given.

191. WOLFENBARGER, D. A. Insecticides and insecticide-oil combinations for corn earworm, boll weevil, and cowpea curculio control. *Fla. Ent.* 48: 101–109. 1965.

Paraffinic oil-DDT plus toxaphene combination at 1½ and 3 gallons per acre gave better control of the boll weevil than DDT plus toxaphene alone, any of the other treatments, and the check. The rate of oil in the insecticide-oil combination did not increase insect control. All aerosol-applied insecticide and insecticide-oil combination applications gave better boll weevil control than the oil-insecticide-water combination applications. The oil-insecticide-water combinations or insecticide combinations were ineffective in controlling the boll weevil. Data for the other two insects are given.

APPENDIX

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16. LABRADOR, J. R. Principales plagas del algodón en Venezuela. Cagua. Serv. Shell para el Agr. Ser. A. Informe 12: 42–45. 1959.
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18. MARIN ACOSTA, J. C. Las plagas del algondonero y su control. Agronomica 5(26): 24–29. 1962.
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