UNIVERSITY OF ILLINOIS

DEPARTMENT OF ENTOMOLOGY

ENTOMOLOGY FOUR

INTRODUCTION TO ECONOMIC ENTOMOLOGY

SYLLABUS OF LECTURES

BY

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SYLLABUS OF LECTURES

INTRODUCTION

Importance of Economic Entomology.—Losses due to insect pests. Work of the U. S. Bureau of Entomology; of state entomologists and state experiment stations. State entomological work in Illinois.

The Place of Insects in the Animal Kingdom.—Characters of Arthropoda: Symmetry, segmentation, appendages, skeleton, etc. The more important distinctions between the six classes of arthropods.

Definition of an Insect.—Head: eyes, antennæ, mouth parts. Thorax: segments, legs, wings. Abdomen: segments, appendages. Spiracles. Metamorphosis.

Metamorphoses.—Direct, or incomplete, metamorphosis (examples: grasshopper, squash-bug); *nymph, imago*. Indirect, or complete, metamorphosis (examples: butterflies, beetles, flies, bees); *larva, pupa, imago, caterpillar, chrysalis, grub, maggot, puparium*. *Ecdysis*, or molting.

Outline of the Structure of an Insect.—Characteristics of the exoskeleton; *chitin*. Nervous and circulatory systems. Fat body. Digestive system. Types of mouth-parts (mandibulate and suctorial). The use of insecticides as determined by the feeding habits of an insect. Stomach poisons and contact poisons. Respiratory system in its relation to contact poisons.

FRUIT INSECTS

GREATER PEACH-TREE BORER

Sanninoidea exitiosa Say

Importance.— ———. *Distribution.*—A native of North America. In almost all states east of the Rocky Mountains; in parts of Canada. Means of distribution, natural and artificial.

Food Plants.—Peach, plum, cherry, apricot, nectarine, prune, flowering almond, azalea, wild cherry.

Injuries.—Appearance of infested tree. Burrows of the insect. Effects upon the tree.

Descriptions.—Egg, larva, pupa, imagines.

Life History and Habits.—One annual generation. Hibernation. Pupation. Emergence of adults. Adults on the wing mostly in July and August in Illinois. Habits of adults. Oviposition. Habits of young larvæ.

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Natural Enemies.—Braconids, chalcids, ichneumonids.

Control.—Digging-out. Mounding. Repellents: tobacco, Hale's wash, gas-tar. Banding.

References.—Bull. 176, Cornell Experiment Station; Bull. 128, N. J. Experiment Station; Circ. 54, U. S. Division of Entomology.

LESSER PEACH-TREE BORER

Synanthedon pictipes G. & R.

Distribution.—Native of North America. Canada to Florida; westward into California.

Food Plants.—Cultivated and wild plums and cherries, peach, chestnut, black-knot fungus of plum and cherry, etc.

Injuries.—Said to attack none but injured trees. Injuries compared with those of *S. exitiosa*.

Description.—Eggs, larvæ, pupæ, and adults compared with those of *S. exitiosa*. (Often confused with *S. exitiosa*.)

Life History and Habits.—Two generations. Hibernation. Moths emerge in May and June (Illinois). Egg period about ten days; pupal period three to four weeks.

Control.—Digging-out. Repellents.

Reference.—Bull. 68, Pt. 4, U. S. Bureau of Entomology.

CODLING-MOTH

Carpocapsa pomonella L.

Economic Importance.— ———. *Distribution*.—Europe, Siberia, W. Central Asia, South Africa, New Zealand, Tasmania, Brazil, United States, Canada. Probably introduced into United States from Europe with apples or pears. Commercial distribution.

Food Plants.—Chiefly apple and pear; also quince, plum, peach, apricot, cherry, prune, crab apple, red haw, and thin-shelled walnuts.

Injuries.—Effects on earlier and on later maturing varieties. Wormy apples. Windfalls.

Descriptions.—Egg, larva, pupa, imago.

Life History and Habits.—Two full generations and a partial third, in Illinois. Hibernation as a larva. Pupal period in spring two or three weeks. Moths in May (Illinois). Habits of the moth. Oviposition. Egg period, four to ten days. Feeding habits of young larva. Larval period twelve to thirty days. Second generation of moths winged in July and early August (Illinois).

nois). Habits of the larvæ. History of the partial third generation in Illinois.

Natural Enemies.—Parasitic insects. Woodpeckers.

Control.—Banding. Screening of storerooms. Destruction of windfalls; use of pigs for this purpose. Spraying: importance; experiments in Illinois. Paris green, 1 lb. to 150 gallons water, with 2 lbs. of freshly slaked lime. Paris green with Bordeaux mixture. Arsenate of lead, 1 lb. to 50 gallons water, to replace Paris green. Advantages of arsenate of lead. Rules for spraying. Relation of these rules to the habits of the insect. Experiments in Illinois on spraying for the second generation of codling-moth. Cost of spraying. Little if any danger of arsenical poisoning from sprayed apples.

References.—Bull. 41, U. S. Division of Entomology; Bull. 142, Cornell Experiment Station; Bull. 114, Illinois Experiment Station.

PLUM-CURCULIO

Conotrachelus nenuphar Hbst.

Economic Importance.— ———. *Distribution.*—Native to North America. Canada to Gulf of Mexico; Atlantic to the one hundredth meridian.

Food Plants.—Chiefly plum, cherry, peach, apple; and pear, quince, apricot, nectarine, prune, persimmon; also wild plum, wild crabs, and haws. Black-knot of plum and cherry.

Injuries.—Work of beetle on buds, leaves, and bark of fruit trees. Effects of food punctures on young fruit and on old fruit. Effects on plums, cherries, peaches, and apples compared. Egg punctures and crescent-cuts. Failure of larval development in fruit that does not fall, or that does not decay. Injury in apple orchards in Illinois.

Descriptions.—Egg, larva, pupa, imago.

Life History and Habits.—One annual generation. Hibernates as adult. Beetles appear the last of April or early in May. Process of oviposition. Egg period, four to seven days. Crushing of eggs or larvæ by the growth of the pulp. Larval period, about three weeks. Average period as larva and pupa in the soil, four weeks. Ninety-three percent pupate within two inches of surface of ground. Beetles issue mostly in July and August. Habits of the beetles in summer.

Natural Enemies.—Parasitic insects. Poultry.

Control.—Trapping on the ground. Destruction of windfalls by use of hogs. Result of raking fallen fruit into the sun-

light. Control in apple orchard by surface cultivation with disk or harrow, at intervals between July 10 and August 10. Jarring: description of process; effectiveness; cost. Spraying: results as compared with those of jarring. Forbes' experiments in 1885. Arsenate of lead $2\frac{1}{2}$ lbs. to 50 gallons water; three applications; benefit; cost, 17 cents per tree. Self-boiled lime-sulphur wash.

References.—Bull. 98 and 108, Illinois Experiment Station; Circ. 73 and 120, U. S. Bureau of Entomology; Bull. 103, U. S. Bureau of Entomology; Bull. 21, Mo. State Fruit Experiment Station; Farmers' Bull. 440, U. S. Department of Agriculture.

APPLE-CURCULIO

Anthonomus quadrigibbus Say

Importance.— ———. *Distribution.*—Native to North America.

Food Plants.—Wild crab-apples, hawthorns, cultivated apples.

Injuries.—Food punctures and egg punctures. Deformities caused by the punctures.

Descriptions.—Compare with plum-curculio in its several stages.

Life History and Habits.—Hibernates as a beetle.. Beetles appear on trees early in May. Oviposition. Egg period, four days. Eggs laid from last of May to last of July. Larval period, three weeks; pupal, one week. Pupation inside the apple. Habits of the beetles. One annual generation.

Control.—Experiments with arsenicals.

Reference.—Bull. 98, Illinois Experiment Station.

ROUND-HEADED BORER

Saperda candida Fab.

Distribution.—Native to North America. In most states east of Rocky Mountains; Oregon, Canada.

Food Plants.—Wild crab, mountain ash, hawthorn, apple, pear, quince.

Injuries.—Weakening and death of affected trees.

Descriptions.—Egg, larva, pupa, imago.

Life History and Habits.—Three-year cycle. Eggs on bark of trunk; period, two weeks. Feeding habits of larva; length of life. Pupation; period, three weeks. Exit of beetle. Habits of beetles: appear in May and June; nocturnal; oviposition, June to September.

Natural Enemies.—Braconidæ. Woodpeckers.

Control.—Cutting out, in August and September, or May. Barriers. Repellent washes: soft soap and caustic potash or washing soda; fish-oil soap; white lead and linseed oil.

References.—Circ. 32, U. S. Division of Entomology; Bull. 74, N. Y. State Museum.

FLAT-HEADED BORER

Chrysobothris femorata Fab.

Distribution.—Almost the entire United States; southern Canada. Native of North America.

Food Plants.—Fruit trees. Many common shade and forest trees.

Injuries.—Prefers weakened or dying trees. Injury to nursery stock.

Descriptions.—Comparisons with *S. candida*.

Life History and Habits.—One-year cycle. Beetles in May, June, July; diurnal. Eggs on trunk and larger limbs. Larval habits. Pupation; period, three weeks. Hibernates as a larva.

Natural Enemies.—Braconidæ, Chalcididæ, Ichneumonidæ. Ants. Woodpeckers.

Control.—Cutting-out. Scalding. Alkaline washes, as for *S. candida*. Trapping.

Reference.—Circ. 32, U. S. Division of Entomology.

SHOT-HOLE BORER

Scolytus rugulosus Ratz.

Importance.— ———. *Distribution.*—Introduced from Europe. Massachusetts to Kansas; Michigan to Alabama. Southern Canada. On nursery stock.

Food Plants.—Plum, peach, and apple, especially. All stone fruits, pear, quince, hawthorn, mountain ash.

Injuries.—Attacks unhealthy trees as a rule. Withered leaves, shriveled bark, death of limbs. Destruction of cambium layer.

Descriptions.—Egg, larva, pupa, imago.

Life History and Habits.—Winters as larva, in outer part of sapwood or in inner bark. Pupates in spring, beetles emerging in April. Habits of beetles. Egg-laying habits. Larval habits. Pupation. Exit of adults. Three or four annual generations; cycle about five weeks in summer. Eggs in September (Illinois).

Natural Enemies.—Chalcids. Woodpeckers.

Control.—Trimming and burning. Kerosene. Washes: 1 lb. fish-oil soap to 2 gallons water, applied late in March or early in April; one gallon soft soap, one pint crude carbolic acid, eight gallons water.

References.—17th Report, State Entomologist, Illinois; Circ. 29, U. S. Division of Entomology; Bull. 44, Mo. Experiment Station; Bull. 180, N. Y. Experiment Station (Geneva).

WOOLLY LOUSE OF APPLE

Schizoneura lanigera Hausm.

Importance.— ———. *Distribution*.—Western Europe, South Africa, Australia, India, Chile, North America. Most injurious in latitude of Ohio valley. Distributed widely on nursery stock.

Food Plants.—Apple, alternating with elm. Pear, quince, wild haws, wild crab-apple. Some varieties of apple said to be immune (northern spy, golden pippin, etc.).

Injuries.—Aerial forms, on wounds, scars, or water shoots; often cause leaves to fall. Subterranean forms, about crown of plant; cause galls and often kill young trees.

Descriptions.—Egg, viviparous females (winged or wingless), oviparous females, males. Waxy secretion.

Life History and Habits.—The oviparous females are said to lay but one winter egg. Migration in autumn from apple to elm. Eggs on elm or on apple. Viviparous females may survive winter on branches or roots, in the South. Migration of third generation in spring from elm to apple.

Natural Enemies.—Chalcididæ, Syrphidæ, Coccinellidæ, Chrysopidæ.

Control.—Bisulphid of carbon dangerous to plants. Tobacco dust in furrows in which trees are to be planted; in furrows beside rows of trees. Treatment of old trees with tobacco dust. Kerosene-soap emulsion (7 percent), tobacco decoction, fish-oil soaps (1 lb. to 6 gal. water), for aerial forms. Gasoline blast lamp. Hot water. Gas-lime.

References.—Bull. 35, Mo. Experiment Station; Bull. 80, Ky. Experiment Station; Bull. 17, U. S. Division of Entomology; Circ. 20, U. S. Bureau of Entomology; Bull. 217, Me. Experiment Station.

PEAR-SLUG

Eriocampoides limacina Retz.

Importance.— ———. *Distribution*.—Europe. North

America. Carried in soil about roots of plants.

Food Plants.—Pear, plum, cherry, quince.

Injuries.—Skeletonizes leaves, which turn brown and die. Occasionally kills a tree.

Descriptions.—Egg, larva, pupa, imago.

Life History and Habits.—Larva hibernates in the soil, pupating in spring. Adults issue when pear leaves are expanding. Process of oviposition. Egg period, two weeks. Sensitiveness of eggs and larvæ to cold wet weather. Larval period, three or four weeks; pupal period, two weeks. Injury in Illinois in June, July, August, September. Two generations. Second generation of slugs full grown in September and October.

Control.—Arsenical sprays. Whale-oil soap, 1 lb. to 4 gals. water; or simple soap solution, $\frac{1}{2}$ lb. to 1 gal. water. Hellebore, 1 oz. to 2 gals. water; or dry, with 5 to 10 parts of flour. Effect of heavy rains. "Black Leaf 40", 1 gal. to 1000 gals. water.

Reference.—Circ. 26, U. S. Division of Entomology.

SPRING CANKER-WORM

Paleacrita vernata Peck

Importance.— ———. *Distribution*.—New England to Mississippi valley. Spreads slowly, by natural means. Young larvæ sometimes carried by strong winds.

Food Plants.—Apple, elm, cherry, plum, and a few other plants.

Injuries.—Larvæ skeletonize leaves, diminishing the vitality of a tree, and sometimes killing it, by repeated defoliations.

Descriptions.—Egg, larva, pupa, imago.

Life History and Habits.—One annual generation. Hibernates as a pupa in the soil. Moths emerge in early spring, the males preceding the females; emerge in Illinois March 7 to April 7. Females crawl up trunks of trees to lay their eggs. Oviposition. Eggs hatch as young leaves push from bud. Larval period, three to four weeks. Larval habits.

Control.—Banding: tanglefoot, coal-tar, printers' ink, sorghum molasses and flour. Kill eggs laid below the band. Use of arsenicals. Jarring. Cultivation.

References.—Third Report, U. S. Entomological Commission; Bull. 44, 85, N. H. Experiment Station; Bull. 68, Pt. 2, U. S. Bureau of Entomology.

SCURFY SCALE

Chionaspis furfura Fitch

Distribution.—A native of North America. Occurs throughout the United States and in most parts of Canada.

Food Plants.—Thirty-six species listed, the most important being apple, pear, plum, and cherry. Also many other fruit trees, wild or cultivated; currant, gooseberry, ash, hickory.

Injuries.—Trees are stunted by this scale, particularly young trees. Occasionally on leaves or fruit. Reddish discoloration of green tissue.

Descriptions.—Male and female scales. Adult males and females. Larvæ. Eggs.

Life History and Habits.—One annual generation in Northern States. Females die at approach of winter. Eggs under female scales; purplish; average number, 66. Hatch early in June (Illinois). Males issue in September. Eggs laid in late September or early October (Illinois).

Natural Enemies.—Mites. Chalcididæ. Coccinellidæ.

Control.—Lime-sulphur wash, applied to dormant trees. Whale-oil soap, 1 lb. to 3 or 4 gals. water, for larvæ.

References.—Circ. 121, U. S. Bureau of Entomology; Bull. N. Y. State Museum, Vol. 9, No. 46; Bull. 143, Conn. Experiment Station; Special Bull. Hatch Experiment Station, (Mass.), 1899; Bull. 43, Ia. Experiment Station; Bull. 136, N. Y. Experiment Station.

OYSTER-SHELL SCALE

Lepidosaphes ulmi L.

Importance.—Commonest and most wide-spread of orchard scales.

Distribution.—Probably a European species; now cosmopolitan. Occurs throughout the United States, and in all the Canadian provinces. Larvæ carried on feet of birds, on various insects, and possibly also by the wind. Distribution on nursery stock.

Food Plants.—More than one hundred. Commonest on apple, poplar, lilac, willow, elm, maple, and ash. On most of the common fruit trees and shade trees.

Injuries.—Trees stunted and weakened. Incrusted trees killed by the scale insect.

Descriptions.—Male and female scales. Adult males and females. Larvæ. Eggs.

Life History.—Winters in the egg. Eggs white, 50 to 100 per

female. Eggs hatch by May 15 (Urbana); shortly after the apple petals fall. Development of the scale. Females full grown by August 1; oviposit during the latter part of August.

Natural Enemies.—Predaceous mites. Parasitic Hymenoptera. Coccinellidæ.

Control.—Lime-sulphur wash. Resistance of eggs to sprays. Whale-oil soap, 2 lbs. to 1 gal. water, for larvæ. Kerosene-soap emulsion, 15 percent, for larvæ.

References.—Circ. 121, U. S. Bureau of Entomology; Bull. N. Y. State Museum, Vol. 9, No. 46; Bull. 64, Del. Experiment Station; Bull. 143, Conn. Experiment Station; Bull. 111, Md. Experiment Station; Bull. 43, Ia. Experiment Station; Bull. 136, N. Y. Experiment Station.

SAN JOSE SCALE

Aspidiotus perniciosus Comst.

Importance.—"A permanent menace to horticulture" in the United States.

Distribution.—A native of China. Introduced into Japan, Hawaii, Chile, Australia, United States, Canada. San Jose valley, California, 1870; a pest there by 1873; New Jersey, 1886 or 1887. Present distribution in North America. Distribution on nursery stock or cuttings; little danger from distribution on fruit. Natural distribution of larvæ by means of wind, birds, insects, etc. Spread of larvæ on a tree.

Food Plants.—Britton lists 72 species as being commonly infested, including all the common fruit trees, currant, rose, lilac, poplar, willow, elm, Osage orange, basswood, privet; 66 species occasionally infested, as raspberry, blackberry, mulberry, grape, maple, ash, catalpa, birch, walnut, spruce, alder, elder; 76 species not infested, as magnolia, tulip-tree, butternut, hickory, oak, and most coniferous trees. Exemption of citrus plants, excepting the trifoliate orange. Exemption of certain varieties, as Kieffer pear.

Injuries.—Appearance of an infested tree. Rapid death of affected branches and of entire tree. Purplish discoloration of green fruit and green bark. Effects of insect on cambium and sapwood. Injury to fruit.

Descriptions.—Scale of adult female: circular, diameter 2 mm., almost flat, nipple central and prominent, ring distinct; color usually gray, sometimes yellowish gray or blackish; exuviae lemon-yellow. Scale of adult male: oblong oval, twice as long as wide, length, 1 mm., nipple between center and anterior

margin; color gray, buff, or black; ring distinct. Scales of hibernating insects: small, circular, black, volcano-like in form, with prominent central nipple surrounded by a deep ring-like depression. Adult female: microscopical characters. Adult male. Larva.

Life History and Habits.—Winters in the "black" stage. Males issue in April. Females bear living young. Earliest larvæ in May. One to three generations in central Illinois. Larval habits: active 12 to 48 hours; locomotion; influence of temperature on activity. Development of the scale. Male and female larvæ alike until after the first molt. The process of molting. The female molts twice; the male, four times. Exuviae. Development of the female. Reproduction.

Natural Enemies.—Eight species of parasites. A predaceous mite. Predaceous Coccinellidæ. Experiments with the fungus *Sphærostilbe coccophila*.

Control.—Legislation against the San Jose scale. Nursery inspection. Operations of the State Entomologist of Illinois.

Fumigation of nursery stock with HCN; KCN (1 oz.) H_2SO_4 (1 oz.), H_2O (3 oz.), per 100 cubic feet. Dipping.

Fumigation of large trees, as practiced in California; experiments in Illinois.

Soap washes. Fish-oil soap, 2 lbs. to 1 gal. water.

Danger from use of sprays containing kerosene or petroleum.

Lime-sulphur wash. Method of preparation: lime, 15 lbs., sulphur, 15 lbs., water, 50 gals. (cost 42 cents.) Cautions concerning preparation and application.

Self-boiled lime-sulphur wash: preparation, uses.

Concentrated lime-sulphur: convenience, cost.

Chemistry of lime-sulphur wash; insecticidal effects.

References:—

General: Bull. 3, 12, 62, U. S. Division of Entomology; Bull. N. Y. State Museum, Vol. 9, No. 46. *Food plants:* Rep. State Entomologist, Conn., 1902; Bull. 62, U. S. Division of Entomology. *Natural Enemies:* Bull. 62, 67, U. S. Division Entomology; Bull. 41, Fla. Exper. Station. *Fumigation:* Bull. 57, 131, Md. Exper. Station; Bull. 122, Cal. Exper. Station; Bull. 80, Ill. Exper. Station. *Lime-sulphur wash:* Bull. 107, Ill. Exper. Station; Circ. 124, U. S. Bureau Entomology; Bull. 144, 169, Ohio Exper. Station. *Self-boiled lime-sulphur:* Bull. 228, 273, N. Y. Exper. Station; Bull. 169, Ohio Exper. Station; Bull. 99, Md. Ex-

per. Station; Bull. 18, Mo. State Fruit Exper. Station. *Concentrated lime-sulphur*: Bull. 18, Mo. State Fruit Exper. Station. *Chemistry of lime-sulphur wash*: Bull. 101, U. S. Bureau of Chemistry; Bull. 56, Wash. Exper. Station; Bull. 228, N. Y. Exper. Station.

CHERRY SCALE, FORBES SCALE

Aspidiotus forbesi Johns.

Economic Importance.— ———. *Distribution*.—Illinois, Michigan, Ohio, New York, Massachusetts, Connecticut, Maryland, Georgia, West Virginia, Iowa, Kansas, New Mexico. Ontario, Quebec, Nova Scotia.

Food Plants and Injuries.—Chiefly cherry, wild or cultivated. Apple, pear, plum, quince, currant, peach, hawthorn, ash. Principally on trunk and branches. Less destructive than scurfy scale.

Descriptions.—Scales of female; of male. Adult female; adult male. Larvæ. Eggs. Comparison with San Jose scale.

Life History.—Winters as partly grown insect. Two annual generations. Males emerge about April 15. Larvæ early in May. Second generation of males, July 10 to August 1. Larvæ during August and September.

Natural Enemies.—Hymenopterous parasites. Coccinellidæ.

Control.—Lime-sulphur wash. Whale-oil soap. Kerosene-soap emulsion.

References.—Bull. Ill. State Lab. Nat. Hist., Vol. IV., p. 380; Bull. N. Y. State Museum, Vol. 9, No. 46; Bull. 43, Ia. Exper. Station.

PUTNAM SCALE

Aspidiotus ancylus Putn.

Economic Importance.— ———. *Distribution*.—United States east of Rocky Mountains. Washington. Canada.

Food Plants and Injuries.—About forty plants, chiefly maple and currant. Apple, pear, plum, peach, cherry, ash, Osage orange, willow, hawthorn, box-elder, lilac, etc. Occasionally destructive when abundant.

Descriptions.—Scales of male and of female. Adult males and females. Eggs. Larvæ. Comparison with San Jose scale.

Life History.—Winters partly grown. One generation. Males late in April. Eggs (30 or 40 per female) in late spring or early summer. Larvæ active in July.

Natural Enemies.—Chalcididae.

Control.—Lime-sulphur. Whale-oil soap. Kerosene-soap emulsion.

References.—Bull. N. Y. State Museum, Vol. 9, No. 46; Bull. 43, Ia. Exper. Station; Proc. Davenport Academy Sciences, Vol. 2, p. 346.

CORN INSECTS

CORN ROOT-LOUSE

Aphis maidiradicis Forbes

Economic Importance.— ———. *Distribution.*—United States east of Rocky Mountains, in almost all states where corn is grown.

Food Plants.—Indian corn. Sorghum and broom-corn to a slight extent. Cotton, strawberry, pumpkin, squash, smartweed, foxtail (pigeon) grass, crab-grass, purslane, dock, mustard, dandelion, plantain, pigweed, cocklebur, sorrel, and many other weeds. Does not thrive on wheat, oats, rye, cow-peas, or clover.

Injuries.—Corn plants stunted and yellowish; may be killed in a dry season. Presence of ants. Retardation of growth of plant. Large numbers of barren stalks or nubbins on affected plants. Injury that is due to the removal of soil from the roots by the ants. Intensification of injury by drought.

Descriptions.—Egg, viviparous female (wingless or winged), oviparous female, male. Species of ants that attend the root-louse.

Life History and Habits.—Winters in the egg, in ants' nests. Care of eggs by ants. Eggs begin to hatch April 8 (Urbana). Transfer of root-lice by ants to roots of smartweed or pigeon-grass, and later to roots of corn or other plants. Number of generations: maximum, 22; minimum, 11. Birth to maturity, 8.1 days. Bearing period, 10.6 days. Length of life of viviparous female, 20.1 days. Number of young per day, per female: average, 4; maximum, 11. Total number of young per female: average, 44; maximum, 96. Oviposition in October and November. Eight generations present at one time in autumn. Relations between ants and aphids.

Natural Checks.—Freedom from predaceous or parasitic enemies. Effects of heavy rains.

Control.—Rotation. Spring plowing. Experiments on additional cultivation. Use of repellents on seed-corn. Advantages and disadvantages of oil of lemon. Danger from kerosene. Three ounces of 3-percent carbolic acid in water to each gallon

of seed-corn. Three ounces of 4-percent formalin per gallon of seed.

References.—17th and 18th Reports, State Ent., Illinois; Bull. 104, 130, 131, 178, Ill. Exper. Station; Bull. 12, Pt. 8, tech. ser., U. S. Bureau of Entomology; Bull. 85, Pt. 6, U. S. Bureau of Entomology; 10th Report, Ill. Farmers' Institute, 1905.

NORTHERN CORN ROOT-WORM

Diabrotica longicornis Say

Economic Importance.—*——. Distribution.*—Injuries in Missouri, Kansas, Iowa, Nebraska, Illinois, Indiana, Ohio. Occurs also in Kentucky, New York, Arizona, New Mexico, Canada, and Central America.

Food Plants.—Chiefly Indian corn; also sorghum and broom-corn.

Injuries.—Corn plant retarded in all stages of its growth and development. Barren stalks; nubbins; soft ears; lodging of plant. Injury intensified by drought. Roots die from tip toward base; loss of many rootlets; bark of root loosened by burrows of larvæ. Beetles feed on silk and pollen, without causing serious injury; injure flowers of clover and rinds of cucurbits.

Descriptions.—Egg, larva, pupa, imago. Distinguish from wireworms, dipterous larvæ, etc.

Life History.—One generation. Winters in the egg, in old corn-fields. Eggs hatch May 15 to July 15 in latitude of central Illinois. Larvæ occur until last part of August. Pupation in the soil, among the corn roots. Beetles emerge in July and August. Feeding habits of beetles. Oviposition.

Control.—Rotation; follow corn with oats or wheat, for example. Two-year period in corn.

References.—12th and 18th Reports, State Ent., Illinois; Bull. 44, 60, Ill. Exper. Station; Bull. 51, Ohio Exper. Station; Circ. 59, U. S. Bureau Entomology; 10th Report, Ill. Farmers' Institute, 1905.

WHITE-GRUBS

Lachnosterna and *Cyclocephala*

Importance.—Among the worst enemies of cultivated plants. *Lachnosterna*,—some forty species in Illinois, eight of them injurious to corn; *Cyclocephala*,—one species, on corn and grass. *Melolontha* in Europe.

Food Plants and Injuries.—White-grubs natives of prairie sod. Injury to pastures and lawns, especially in times of drought.

Injury to corn, wheat, barley, etc., particularly on newly broken sod land. All cereals affected; potatoes, sugar-beets, beans, strawberries. Injury in young nurseries. Clover practically immune. Injury by beetles to foliage of fruit, shade, and forest trees. Effects on corn; plants dwarfed or killed; leaves yellowish; effects are like those of drought, and are intensified by latter; leaning and lodging of plants; barren stalks; nubbins; roots eaten away, leaving short stubs. Bare spots in corn field in autumn, with grubs in the hills. Corn injured for two years following sod.

Descriptions.—Eggs, larvæ ("white-grubs," "grub-worms"), pupæ, beetles ("May-beetles," "June-bugs"). Differences between *Lachnosterna* and *Cyclocephala*.

Life History and Habits.—Life cycle, between two and three years. Studies on the life history in Illinois by Forbes. Oviposition in June and July; egg period, 10 to 18 days. Feeding habits of grubs; descent to escape frost. Pupation in summer (pupal period about three weeks). Beetles emerge from pupæ in August or September, but remain in the soil over winter. Winter passed as beetle or larva. Habits of beetles. Some of the beetles of June, 1914, are from eggs laid about June, 1911. Periodicity of adults of cockchafer in Europe.

Vertebrate Enemies.—Toads and frogs eat the beetles. Moles and ground-squirrels (grubs); skunks (grubs and beetles); raccoon (beetles). Pigs (see *Control*). Grubs and beetles eaten by robin, blackbirds, English sparrow, crow, hawks, owls; grubs by blue jays, yellowhammers; beetles by catbird, thrushes, bluebird. Chickens, ducks, and turkeys destroy both grubs and beetles; poultry, in freshly plowed fields. Birds that destroy grubs in lawns.

Insect Enemies.—*Pelecinus*, *Tiphia*, *Ophion*, *Sparnopolius*, *Pyrgota*, Tachinidæ, Carabidæ, ants, mites.

Fungi.—*Cordyceps*, *Sporotrichum*, *Isaria*; experiments in Illinois.

Control.—Break sod the year before it is to be put into corn. Pasture hogs on meadows or pastures before plowing for corn. Use of poultry, following the plow. Hand picking in gardens. Cultivation and fertilization to strengthen plants. Rotation; freedom of clover from attack. Experiment at Ludlow in clearing infested field of grubs. Control of beetles: by use of arsenicals; practice of jarring in Europe; light traps (mostly males attracted); pigs in orchards and woodlands.

References.—17th, 18th, and 20th Reports, State Ent. Ill.; 10th Report, Ill. Farmers' Institute, 1905; Bull. 116, Ill. Exper. Station; Bull. 19, U. S. Division Entomology.

WIREWORMS

Melanotus and other Genera

Importance.—Eight species injurious to corn in Illinois.

Food Plants and Injuries.—Corn, wheat, rye, barley, oats, potatoes, turnips, cabbages, carrots, beets, onions, lettuce, strawberry, and many garden plants. Grass the main food of injurious species. Injury to corn following sod. Failure of seed-corn to start; sudden withering of young plants. Wireworms eat or bore into seeds, roots, or bases of stems of corn.

Descriptions.—Larvæ, pupæ, adults.

Life Histories and Habits.—*Melanotus communis*: Larval period not less than three years; pupation in July in an earthen cell; pupal period one month; beetles common in September, and winter under bark of trees or in the ground or elsewhere. Habits of the beetles, known as "click-beetles" or "skip-jacks"; beetles abundant in April, May, and June.

Melanotus fissilis: Abundant in Middle and Southern States. Life history similar to that of *M. communis*.

Melanotus cribulosus: The commonest wireworm in corn fields in Illinois. Does considerable damage to corn on sod land the first year, and more damage the second year. Larvæ common in June and July. Larval period about two years. Pupates in August, in the ground. Adults emerge from pupa in September, but may remain in the ground over winter.

Agriotes mancus: Very injurious to small grains and to corn. In corn following sod. Larval period probably three years at least. Pupates in July, in the ground. Beetles emerge from pupæ by September, but remain in the ground over winter.

Drasterius elegans: Abundant. Especially injurious to young wheat and to corn. Larval period about two years. Beetles hibernate under leaves, boards, rubbish, etc., and are common in May, June, and July.

Natural Enemies of Wireworms.—Crow (worms and beetles); and the robin, blackbirds, and thrushes destroy large numbers of wireworms.

Control.—Experiments with repellents used on seed-corn. Late fall-plowing. Rotation. Late replanting, between the old rows. Fertilizers. Poisons, for use in gardens.

References.—18th Report, State Ent. Ill.; Bull. 33, 107, Cornell Exper. Station; 4th Report, Cornell Exper. Station; Bull. 46, Ohio Exper. Station; Fitch's 11th Report, Insects of New York; Bull. 44, Ill. Exper. Station; Bull. 43, U. S. Division of Entomology; 10th Report, Ill. Farmers' Institute, 1905.

CORN CUTWORMS

Hadena, Agrotis, Peridroma, Noctua, Feltia, Nephelodes

Economic Importance.— ———. *Food Plants.*—Grasses, clover, corn, small grains, garden vegetables.

Injuries.—Most destructive to crops following grass or clover. Cut off plants near the ground. Eat leaves and stalks. Replanting often necessary.

Descriptions.—General characteristics of cutworms and their moths.

Life Histories and Habits.—Most species winter as partly grown caterpillars, become full grown late in June or early in July, and pupate in the soil. One to three annual generations, according to the species. Cutworms hide during the daytime; often buried near plants they have attacked. Moths attracted by lights.

Control.—Plow grass-lands in midsummer or early fall. Pasture pigs on grass or clover lands. Replant as late as possible and between the old rows. Poisons: Paris green 1 lb., bran 30 lbs.; freshly cut clover, sprayed with Paris green, 1 lb. to 50 gals. water.

References.—23d Report, State Ent., Illinois; 10th Report, Ill. Farmers' Institute, 1905.

ARMY-WORM

Heliophila unipuncta Haw.

Economic Importance.—Irregularity of outbreaks. Insects mistaken for the army-worm.

Distribution.—Practically cosmopolitan. Occurs throughout the United States and in parts of Canada. A pest in North America only.

Food Plants.—Grasses, especially timothy, wheat, oats, corn, rye, barley; also sorghum, millet, blue-grass, Hungarian grass, crab-grass. Some damage to flax. Caterpillars eat onions, peas, beans, and other garden crops; leaves and green fruits of strawberry. Clover rarely if ever eaten; alfalfa very rarely. Cutworms accompanying army-worms. Moths feed on nectar of

flowers, as clover, apple, honeysuckle; on juices of fallen peaches; on banana skins. Attracted to molasses placed on trees.

Injuries.—Army-worms develop in neglected parts of meadows, and pastures. Feed by night mostly, avoiding bright sunlight. Eat all but the tougher parts of plants. Cause bare patches in meadows. Forced by lack of food to migrate in "armies". May reduce a field of corn to bare stalks, destroy all the green oats or wheat, cut off heads of timothy or small grains. One hundred acres of blue-grass destroyed in five days.

Descriptions.—Eggs; appearance of egg masses. Distinguishing characters of the caterpillar, pupa, and moth.

Life History and Habits.—Three annual generations in this latitude. First generation destructive in southern Illinois (early in June); second in northern Illinois (July); third, rarely injurious. With rare exceptions, only one of these generations is destructive in any one place the same year; reasons for this.

Passes the winter as a partly grown caterpillar or as a moth. Moths flying late in autumn and early in spring. Attracted to lights and to "sugar". Overlapping of generations. Larvæ that have hibernated become active in late March or early April (Illinois); larvæ from eggs of wintered moths appear in May; first brood thus a composite one; effects of this on later broods. Moths occur throughout the season. Second generation of larvæ active in July; third, in September. Egg period about nine days; larval, three to four weeks; pupal, two weeks in summer, three to four weeks in spring.

Armies may number millions of individuals, and will travel and feed in bright weather, unless sunlight is too strong. Worms may be three deep in one of these armies, which may be a half a mile or more in width. Travel three feet in one minute sometimes.

Pupation occurs in the soil, an inch or two below the surface, or under stones or rubbish, etc.

Swarming and migration of the moths.

Natural Enemies.—Chickens, turkeys, ducks, geese. All the insectivorous birds, particularly the robin, blackbirds, meadow-lark, kingbird, catbird, English sparrow, and quail. Shrews, skunks. Toads, frogs. Carabidæ, Cicindelidæ. Tachinidæ. Braconidæ. Chalcididæ. Ichneumonidæ. Sarcophagidæ. Fungous parasite (*Empusa*).

Control.—Watch grass-lands in spring, for local injury; use

of a furrow to surround a colony; killing with arsenicals or by burning. Protection from an army by means of a furrow, with the steep side toward the field to be protected; post-holes a rod apart; kill with kerosene, or by burning, or with earth pound d down. Use of hogs, poultry, and sheep. Burn over fields in winter or early spring. Method of poisoning: use Paris green, 1 lb.; bran, 16 lbs.; with water and a little salt,—to make a bran mash that crumbles readily. Experiments in southern Illinois with this method.

References.—23d Report, State Ent., Ill.; 10th Report, Ill. Farmers' Institute, 1905; Bull. 95, Ill. Exper. Station; Bull. 96, Ohio Exper. Station; Bull. 104, 133, N. Y. Exper. Station; Bull. 157, Ky. Exper. Station.

CORN BILL-BUGS

Sphenophorus

Importance.—Local injury in Illinois.

Distribution.—General in the United States and Canada.

Food Plants.—Larvæ feed on roots of upland grasses, swamp-grasses, or sedges; beetles feed on same plants as their larvæ, and injure corn also.

Injury.—Under three conditions: (1) in swamp land broken up from grass in spring and planted to corn the same year; (2) in such land poorly cultivated where the swamp grasses are not kept down; (3) in old timothy sod, broken in spring and put into corn at once. *S. parvulus* develops in timothy bulbs, the beetle going to blue-grass, corn, or wheat to feed, but doing little damage ordinarily. *S. ochreus* bores into the stalks or buds of corn, sometimes doing great damage. Characteristic leaf-punctures of the bill-bugs.

Descriptions.—Distinguishing characters of the more important bill-bugs. Structure and use of the beak.

Life Histories.—Winter as beetles on the ground under rubbish, or in other sheltered situations, usually in fields in which they have developed. Apparently single-brooded. Injure corn before the middle of July. Eggs laid in May and June in roots or stems. Larvæ occur throughout summer. Beetles emerge in late summer and in fall.

Control.—Replant, as late as possible. Early fall-plowing.

References.—Bull. 79, Ill. Experiment Station; 22d and 23d Reports, State Ent., Ill.; 10th Report, Illinois Farmers' Institute, 1905.

CORN EAR-WORM

Heliothis obsoleta Fab.

Economic Importance.—Damage in Illinois. In the South, known as the cotton boll-worm, bud-worm, or tassel-worm.

Distribution.—Cosmopolitan.

Food Plants.—Some eighty species. Injurious in truck gardens to potatoes, beans, peas, cucurbits, etc. Injury to ornamental plants.

Injuries.—Worst injury to corn, cotton, tomato, and tobacco. Sweet corn subject to more injury than field corn, as it is planted earlier. Characteristic injury to ears of corn.

Descriptions.—Characters of eggs, larvæ, pupæ, and adults.

Life History and Habits.—Three generations in Illinois. Winters as a pupa in the soil, within six inches of the surface. Moths emerge in April or May, and lay eggs on tomatoes, peas, corn, etc. Second generation of caterpillars feeds on tassel, silk, and soft ears of corn. Cannibalistic habit. Third generation of larvæ in autumn on hard corn. Pupates in September and October.

Natural Enemies.—Tachinidæ. Kingbird, catbird.

Control.—Plowing after the corn is cut, to destroy the pupæ. Corn as a trap crop, in the South.

References.—23d Report, State Ent., Ill.; 10th Report, Illinois Farmers' Institute, 1905; Farmers' Bulletins 47, 191, 212, U. S. Department of Agriculture; Bull. 24, 50, U. S. Bureau Entomology.

CHINCH-BUG

Blissus leucopterus Say

Economic Importance.—The chinch-bug and the Hessian fly have done more damage than any other insects in the United States. Injury to corn, wheat, and oats in Illinois in 1887 by chinch-bug estimated at \$11,840,000; in 1871, in seven states (Illinois, Indiana, Wisconsin, Iowa, Missouri, Kansas, Nebraska), \$30,000,000. In 1887, its damage in these states, with that in Ohio, Kentucky, and Minnesota, aggregated \$60,000,000.

Distribution.—Probably came from Central America. Guatemala, Panama, Cuba, Mexico, New Mexico, California. General distribution: Texas north to Manitoba and east to Atlantic Ocean. Florida to Cape Breton. Paths of distribution.

Food Plants.—Originally native grasses. Injurious chiefly to wheat, barley, rye, and corn. Attacks Hungarian grass and

millet; timothy, in absence of other food. Oats, seldom. Crab-grass, pigeon-grass, etc. Sorghum, broom-corn.

Injuries.—Saps and kills plants. In spring affects wheat or oats, migrating at harvest-time to corn. Sometimes affects young corn instead of small grains. Successive hot dry summers indicate the approach of a chinch-bug period. Moist weather unfavorable to development of chinch-bug; reasons for this.

Descriptions.—Eggs: form, color, size, number, deposition. Characters of the chinch-bug in the five stages of its development. Means of distinguishing the chinch-bug from other bugs mistaken for it. Short-winged race of the chinch-bug.

Life History and Habits.—Hibernates as adult, among roots of grasses, under dead leaves, boards, rail fences, rubbish, under bark, in corn shocks, etc. Bugs issue from winter quarters in April, fly about, and infest wheat mostly, though bugs issuing later (May) sometimes lay eggs in oats or young corn. Egg period ten days or three weeks. From hatching to adult stage, six weeks. As the small grains ripen and harden, the bugs leave the grain fields and invade corn fields. At this time the bugs migrate on foot, though many of them are capable of flying. Cast skins often mistaken for dead bugs. Corn often black with the bugs. Outer rows attacked first. Eggs, for second generation laid on corn or on wild grasses. Two generations a year, with a partial third generation in Kansas and possibly southern Illinois also. In autumn the bugs crawl or fly to shelter for the winter.

Natural Enemies.—Fungous and bacterial diseases. Experiments with *Sporotrichum*. Predaceous insects: *Triphleps*, *Agonoderus*, *Chrysopa*, Coccinellidæ, ants. Bird enemies: quail, prairie chicken, catbird, meadow-lark, wren, brown thrush, red-winged blackbird. Birds eat comparatively few, however. Habits and importance of *Eumicrosoma benefica*.

Control.—Difficulty of protecting wheat in spring from the chinch-bug. Destruction of bugs in spring by burning over grass lands. Clean farming to lessen numbers of bugs. Use of gasoline torch. Method of making the dusty furrow; disadvantages. The Illinois method: Repellent barriers, trap-holes, and a spray when necessary. Preparation of the ground for the repellent; post-holes, 20 feet apart, 18 inches or more in depth. Comparison of repellents used: gas-tar; road oil No. 7; crude creosote; crude carbolic acid. Maintenance of the barrier. Killing bugs in the post-holes. Cost of method. Practicability of

killing bugs by spraying in a few outer rows of corn at harvest-time, and in young corn in spring. Use of "Black Leaf 40", $\frac{1}{4}$ ounce with 1 ounce soap solution to a gallon of water. Three ounces soap to 1 gallon water. Cautions. Kind of sprayer to use.

Necessity of community cooperation against the chinch-bug. Mode of organization. Campaigns conducted by the State Entomologist of Illinois.

References.—Circulars by State Ent., Ill.; 16th, 17th, 19th, 20th, and 23d Reports, State Ent., Ill.; Bull. 69, 77, 106, Ohio Exper. Station; Bull. 51, Mo. Exper. Station; Bull. 15, 18, U. S. Division of Entomology; Farmers' Bull. 132, U. S. Dept. Agriculture.

WHEAT INSECTS

HESSIAN FLY

Mayetiola (Cecidomyia) destructor Say

Economic Importance.—Ranks with the chinch-bug in destructiveness. Destroys annually in the United States at least 10 percent of the wheat crop. Injury in Illinois often amounts to several millions of dollars; in 1910, to \$600,000 in one county.

Distribution.—Europe, Western Asia, North Africa, New Zealand. Now occurs practically throughout the wheat belt of the United States and Canada. Introduction into this country, possibly in 1776. First attracted attention in Long Island in 1779; origin of the common name. Slowly distributed by flight and by the wind. Tends to oviposit in the nearest fields. Transportation in straw occasionally.

Food Plants.—Confined to wheat, barley, and rye. No good evidence as yet that it develops on any other plants. No varieties of wheat are "fly-proof", though some resist the injury better than others, by having stiffer stems or by tillering more freely.

Injuries.—Young infested plants have "bunchy" or erect leaves, no internodes; leaves broader and darker green than normal, often bluish green; easily killed by frost; tillers show the same effects. Plants attacked early are often killed; plants attacked later, after tillers are formed, may develop some unaffected stalks. Infested plants turn yellow and then brown. In summer the straw breaks at the joints where the larvæ have been working; or, sometimes, at the surface of the ground. Frequently less grain ripens than was sown. In young plants,

larvæ at or below the surface of the ground cause a swelling of the base of leaf and culm.

Descriptions.—Egg, larva: three stages; function of the “breast-bone”. Puparium, or “flaxseed”. Pupa. Characters of adults.

Life History and Habits.—Winters in the flaxseed stage, as a rule. Two principal broods (spring and fall) and in some years four. Flies emerge from late May to late June (southern Illinois); a large percentage remain in the stubble as flaxseeds at harvest. Influence of moisture on development. Eggs laid in grooves on upper surface of leaf; egg period, four days to two weeks. Larvæ go down under sheath of leaf and fix themselves on the stem. In spring, eggs laid mostly near the first joint. Larvæ often erroneously called the “eggs” of the fly. Flies that emerge from the stubble lay their eggs on volunteer wheat. Flies of fall generation lay eggs on young crop of wheat in September and early October. Will oviposit even in frosty weather. Adults said to live but three days at most, apparently without feeding.

Natural Enemies.—Influence of parasites on the Hessian fly. Chalcididæ. Proctotrypidæ.

Control.—1. Sow on new ground, not in wheat the preceding year. Do not sow wheat on infested stubble.

2. Prepare a good seed-bed, finely pulverized and compact.

3. Use good seed; test it.

4. Select varieties, other things equal, with a hard straw and which tiller freely.

5. Burn stubble after harvest; method of doing this; often impracticable where clover or timothy are with wheat. Plow stubble under, if possible, after harvest, and roll.

6. Burn chaff, screenings, and other waste from infested fields.

7. Destroy volunteer wheat, by plowing, disking, or otherwise, before larvæ have matured. Plow and roll when three or four inches high. Use of trap strips of wheat. Rotation.

9. Late sowing: In an average year, northern Illinois, September 20; central Illinois, September 30; southern Illinois, October 10. Sowing “after the first hard frost”. Importance of co-operation in late sowing in a community. One who sows wheat too early raises Hessian flies for his neighbors.

References.—Circ. 146, Ill. Experiment Station; 14th, 15th, and 17th Reports, State Ent., Ill.; Circ. 70, U. S. Bureau of Ento-

mology; Bull. 16, U. S. Division of Entomology; Bull. 107, 119, 136, 177, Ohio Exper. Station; Bull. 103, 111, Ky. Exper. Station; Bull. 62, Mo. Exper. Station; Bull. 194, Cornell Exper. Station.

CLOVER-SEED INSECTS

The problem of raising a good crop of red-clover seed is primarily entomological. The methods about to be given have enabled many Illinois farmers during the last five years to double their yield of clover seed.

High prices of clover seed are due primarily to the fact that comparatively few farmers know how to raise seed profitably. Even successful seed-growers who know the right methods seldom understand precisely how these methods operate to produce good results.

Average yield of seed in the black soil of the corn belt, 1.5 bu. per acre; largest yields, 9 bu. (Indiana), 10 bu. (Idaho). Red clover practically a biennial on prairie soil, though many plants will live for more than two years; a perennial in the north-western states and on the Pacific slope.

Pollination.—Red clover can not pollenize itself. Cross-pollination is performed chiefly by bumblebees. Examples of the many experiments that prove this. Brief account of the life history of bumblebees. Red clover does not set much seed in the June crop, as a rule, because there are not enough bumblebees to pollenize the flowers, the only winged bumblebees at that time being the comparatively few queens that have survived the winter. In midsummer, however, there are ordinarily enough bumblebees to pollenize the second crop. Average number of these bees in a clover field in bloom; rate at which the flowers are pollenized. Experiments made by us in raising bumblebees artificially. Boys on the farm should be instructed not to kill bumblebees wantonly.

Every year there is some seed in June; now and then a bushel or a bushel and a half to the acre in this or that locality. This unexpected yield of seed in June is due, so far as has been ascertained, to pollination by honey-bees of the long-tongued variety (Italian). Circumstances under which honey-bees can pollenize red clover.

A negligible amount of pollination is probably performed accidentally by minute insects that commonly occur in clover heads, such as *Euthrips* and *Triphleps*.

The structure of the blossom of red clover. Mechanism of

cross-pollination. Reasons for the failure of artificial pollination by the brush-machine.

Rules for Raising Clover Seed.—1. Pasture *to sheep in spring, after the clover has made a good start, turning them off in early June. A good method where many sheep are raised, though the next method is better adapted to the conditions in Illinois.

2. Clip the clover twice: in the middle of May and the last of June, in an average season in central or northern Illinois. In a wet season, when the clover grows rapidly, three clippings may be necessary. Clip before the growth is so heavy that the clippings will smother the new growth, or use next method.

3. Cut the June hay crop early, when one-third or one-half of the field is fresh in bloom. This early-cut clover will cure perfectly, notwithstanding statements to the contrary. Clover cut in July is woody and makes poor fodder, and the following new growth can not be expected to yield much seed. It is possible to get a good hay crop and a good seed crop in the same year, if one wishes to do so. The plowing under of clover from time to time, for the sake of the nitrogen, is highly important, but does not form a part of the present subject.

4. Cut (or pasture) red clover in the latter part of its first year's growth to destroy the heads that flower prematurely, or to prevent their formation. In some moist seasons a paying crop of clover hay may be obtained in the first year. Cut the clover a few weeks after the oats are harvested, and early enough to allow a good growth before frost comes.

5. Destroy volunteer clover. This may conveniently be done when the hay crop or seed crop is cut, cutting at the same time the clover that grows wild on the borders of the field or the sides of the road.

The reasons for these methods will appear after the habits of the seed-insects have been discussed. These seed pests are of three species. They are abundant in Illinois in every field where clover is grown (unless they have been guarded against), and often destroy fifty to seventy-five percent of the possible yield of seed. The two worst pests are so small that they escape notice, and the third—the seed-caterpillar—though comparatively large, is not often seen on account of its habits.

CLOVER SEED-MIDGE

Dasyneura leguminicola Lintn.

Flies of first generation most abundant May 25, in central

Illinois, in an average season; in other words, at the time when the green clover-heads are most numerous. How to find and recognize the midges; oviposition; egg period. Habits of the larvæ. Appearance of infested heads. A simple means of determining the amount of infestation in a clover field. Larvæ become full grown and begin to leave the clover heads by June 20—an important date, from the standpoint of control. Pupate in the soil. Second generation of adults on the wing in early August, to lay eggs on the seed crop. Third, and most abundant generation, flying in September, and laying eggs in first-year clover.

Control.—If the clover has been pastured or clipped, there are no green heads in which the midges can lay their eggs the last of May.

If the hay crop has been cut before June 20, the larvæ are still in the clover heads, and are killed by the drying of the hay; so there will be no flies to lay their eggs on the young heads of the seed crop. If the hay crop is not cut until July, the larvæ will have gone into the ground by that time, and there will be an abundance of flies in August to lay their eggs on the seed crop.

The flies that emerge from the ground during the last of May are from larvæ that have passed the winter in the clover field on the roots of the plants. These larvæ are from eggs laid the preceding autumn on green heads that formed during the first year of the clover's growth. It is evident, therefore, that the clover should be prevented from forming heads in its first year, and that these heads, if formed, should be destroyed by cutting, as in method No. 4.

Volunteer clover should be destroyed because it harbors the clover pests, affording them food at times when the cultivated clover is not available.

SEED-CHALCID

Bruchophagus funebris How.

Adults of first generation most abundant about the middle of June, laying eggs in flowers that have been fertilized and have begun to wither; never in green heads or in seeds that are hard. Characters of the adult chalcids; habits, including oviposition. The egg. The larva eats out the inside of a developing seed. Infested seed compared with healthy seed. The adult eats its way out, leaving only the shell of the seed. Most of these empty shells are blown away with the chaff, when the seed

is hulled; a few are carried over with the sound seed. An immense loss of seed is due to this pest, the presence of which is unsuspected by most farmers. The second generation of adults is most abundant in the middle of August and lays eggs on the seed crop. The third generation occurs in autumn, and oviposits in premature heads of first-year clover, also in volunteer clover. The insect passes the winter inside the seed, on the ground, chiefly as a larva.

Control.—Use the methods already given. If the clover has been pastured or clipped, there will be no heads for the chalcids to lay their eggs in, in the middle of June; consequently no second generation will develop in that field to infest the seed crop, the chalcids entering from other fields being few in number. If the hay crop is cut when fresh in bloom, the crop is taken out of the reach of the chalcid, and the second generation prevented from developing in that field. The June chalcids in a field are from eggs laid in premature heads in the same field the preceding autumn. Thus the importance of Rule No. 4 is evident.

CLOVER SEED-CATERPILLAR

Enarmonia interstinctana Clem.

The adults are small brown moths with silvery markings. They are most abundant when green clover-heads are most numerous, laying their eggs in these. Thus the periods of maximum abundance coincide with those of the seed-midge. First generation of moths most abundant in the last of May; second, late in July; third, late in August and early in September. Appearance of infested clover-heads; the caterpillar eats out the bases of the florets; characters of the caterpillar. Winter is passed chiefly in the pupal stage; sometimes in the larval stage.

Control.—Use the same methods as for seed-midge and seed-chalcid.

Reference on Clover Insects.—Bull. 134, Illinois Experiment Station. This contains many references on the subject.

TRANSMISSION OF DISEASES BY INSECTS

Present importance of the subject.

MALARIA

Laveran, 1880. Development of *Plasmodium* in erythrocytes. Terms used: schizont, melanin, merozoite, gametes, macro-

gamete, microgametocyte, microgamete, oökinete, oöcyst, sporoblast, sporozoite. Types of malaria: tertian, quartan, æstivo-autumnal. Effects of the disease on the human system. Experiments proving the transmission of malaria by mosquitoes of the genus *Anopheles*. Comparison of *Culex* and *Anopheles* in their several stages. Preventive measures.

YELLOW FEVER

Historic account. The disease not understood until 1900. Pioneer work of Dr. Charles J. Finlay. The U. S. Yellow Fever Commission: Major Walter Reed, Dr. James Carroll, Dr. Jesse W. Lazear, Dr. A. Agramonte. Brilliant work of this Commission in Cuba in 1900. The harmlessness of fomites. Transmission of yellow fever by the transfusion of human blood. Experiments that prove that the disease is transmitted solely by a mosquito, *Aedes calopus* (*Stegomyia fasciata*). Influence of climate and season upon the habits of this mosquito. The specific cause of yellow fever is as yet undetected. Control of the disease in Havana by Major W. C. Gorgas. Yellow fever in New Orleans. Control of fever in the Canal Zone by Col. Gorgas.

TYPHOID FEVER

Transmission of *Bacillus typhosus*. Infection of water, milk, etc. Agents of transmission. Proof that the disease may be transmitted by flies, particularly *Musca domestica*. Habits and life history of the house-fly. Methods of control. Other intestinal diseases transmitted by flies.

PLAGUE

History of the disease. Three types: bubonic, septicæmic, pneumonic. Primarily a disease of rats, transmitted among rats and to man by several species of fleas. Experiments that prove this. Plague in San Francisco; its suppression by Dr. Rupert Blue. Transmission by ground-squirrels.

TRYPANOSOMIASIS

Structure of a typical trypanosome. The hosts of trypanosomes. Tsetse flies. Nagana. Bruce's experiments on nagana, which is caused by *Trypanosoma brucei* and carried by *Glossina morsitans* chiefly. Preventive measures. Human trypanosomiasis; symptoms, mortality. *T. gambiense* and *G. palpalis*. Prevention.

FILARIASIS

Studies by Manson, Bancroft, and others. Habits of *Filaria bancrofti*. Transmission by *Culex*. Effects on the human system.

OTHER DISEASES

Cholera transmitted by flies. Dysentery also. Tuberculosis possibly, under certain conditions. Ophthalmia. Dengue. Kala-azar. Researches on *Simulium* in relation to pellagra. Investigations of Rosenau and Brues on the transmission of poliomyelitis (infantile paralysis) by the stable-fly (*Stomoxys calcitrans*).

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Most of the literature on the economic entomology of the United States is contained in the following serial publications: Bulletins of the U. S. Bureau of Entomology; Reports of State and of Government Entomologists; Bulletins and Reports of the State Experiment Stations; *Insect Life*; *The Journal of Economic Entomology*.

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