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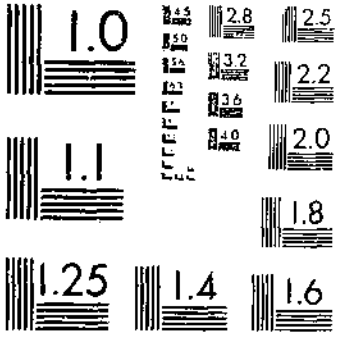

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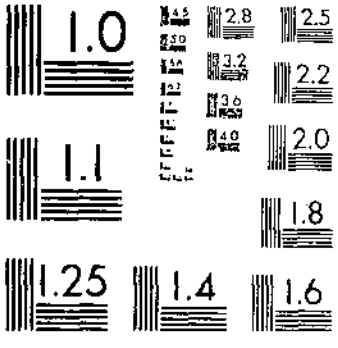

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Biology and Control of the RHODESGRASS SCALE

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UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service
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Biology and Control of the RHODESGRASS SCALE

By HARVEY L. CHADA and E. A. WOOD, JR., *entomologists, Entomology Research Division, Agricultural Research Service* [1]

The rhodesgrass scale (*Antonina graminis* (Maskell)) was first identified in the United States in 1942 by Harold Morrison from specimens of rhodesgrass (*Chloris gayana* Kunth) submitted by Nico Diaz, King Ranch agronomist, Kingsville, Tex. Range, lawn, and golf-course grasses in the gulf coast area of Texas were damaged by the scale, and information on its control was requested. Since there was little information on the biology and control of this pest, a research program was undertaken in 1949 to obtain such data in cooperation with the Texas Agricultural Experiment Station. The results obtained at the Weslaco Substation from 1949 through 1951 are described in this bulletin.

PREVIOUS STUDIES

The rhodesgrass scale was first described by Maskell (*10*)[2] as *Sphaerococcus graminis*, sp. nov., from specimens collected by Koebele at Hong Kong, China; Maskell (*11*) later described it as *Chaetococcus graminis*, sp. nov. Popenoe and Parrott (*13*) first reported the genus *Antonina* Signoret in the United States with several species, including a new species *graminis* Parrott. The homonymy of this name with *graminis* Maskell was recognized by Cockerell, and it was changed in the Fernald Catalogue of the Coccidae (1903) to *parrotti* Cockerell. The scale was described as *Antonina indica* (nov.) by Green (*7*), and his description was more detailed than Maskell's.

The first record of this scale from Hawaii was by Kotinsky (*9*) as *A. boutelouae* Parrott, and later as *A. indica* Green. Timberlake (*20*) described a parasite, *Anagyrus antoninae* Timberlake, from *A. indica* Green in Hawaii. Descriptions of the female and newly hatched larvae of the scale, with a plate showing the several stages, were published by Green (*8, v. 5, pp. 395–396*). The scale was reported on sugarcane in Hawaii by Van Zwaluwenburg (*21*). Schmidt (*19*) found that bees were attracted to scale-infested lawns in Hawaii, where they fed on scale secretions. Sugarcane was reported as a host by Pemberton (*12*), but the insect's economic importance on this host was questionable. Nicotine sulfate and good range management

[1] The authors are indebted to Harold Morrison, Entomology Research Division, for helpful suggestions, including identification of scale specimens.

[2] Italic numbers in parentheses refer to Literature Cited, p. 20.

were recommended for control of the scale in Queensland, Australia (*1*).

Damage to grasses by the scale in Texas and the need for research on its control were emphasized by Thomas.[3] Morrison[4] summarized the information available on the scale and suggested the need for research on this economically important pest. Potes (*14*) reported it to be of economic importance on range grasses in Colombia. Potts and Hensel (*15*) stated that no practical control measures were available in Texas, but biological control was being investigated.

A description of the scale as *A. graminis* (Maskell), along with a list of host plants in Hawaii, was published by Zimmerman (*23, v. 5, pp. 154–157*). Chada et al. (*3*) presented information on its known distribution and hosts and indicated the preferred hosts in the United States. Riherd (*18*) reported on the life history of *Anagyrus antoninae* Timberlake, a parasite of the scale, and described stages in its life cycle. Wene and Riherd (*22*) tested the effectiveness of oil emulsion in controlling scale larvae on lawn grasses.

Several papers on the rhodesgrass scale have been published since 1951. The taxonomy, synonymy, and habits of the scale were discussed by Ferris (*5, v. VI, pt. 2, pp. 289–294*). Richardson (*17*) stated that "parathion should control larvae and young scales" and reported on tests with other insecticides. Parasite establishment in Florida was reported by Questel and Genung (*16*). Dean and Schuster (*4*) discussed scale parasite establishment in Texas. The first report of the rhodesgrass scale in California was from El Centro, Imperial County (*2*).

CLASSIFICATION

The rhodesgrass scale belongs to the order Homoptera, family Pseudococcidae, genus *Antonina*. The synonymy of *Antonina graminis* (Maskell), as recorded in the Ferrisian sense from correspondence with Harold Morrison, is as follows:

Sphaerococcus graminis Maskell 1897
Chaetococcus graminis Maskell 1897
Kermicus graminis Maskell 1899
Antonina indica Green 1908

The synonymy of *A. indica* Green with *A. graminis* (Maskell) has been indicated by Zimmerman (*23, v. 5, pp. 154–157*) and Ferris (*5, v. 6, pt. 2, pp. 289–294*).

DISTRIBUTION

Records of rhodesgrass scale distribution are available from all six terrestrial faunal regions of the world. However, the scale occurs primarily in the tropical and subtropical regions, mainly in the area bounded approximately by the 32d parallels. It has been recorded from Africa, Australia, Canton Island (Phoenix group), Ceylon, Colombia, Cuba, El Salvador, Formosa, Guatemala, Hawaii, India,

[3] Thomas, F. L. SCALE INSECT, ANTONINA GRAMINIS (MASKELL), INJURIOUS TO RHODESGRASS IN TEXAS. 1945. [Tex. Agr. Expt. Sta. unpublished report, Dec. 21, 1945.]

[4] Morrison, H. MEMORANDUM ON ANTONINA GRAMINIS (MASK.). 1946. [U.S. Bur. Ent. and Plant Quar. unpublished report, Jan. 8, 1946.]

Japan, Johnston, Kwajalein (Marshalls), Madagascar, Mariana Islands, Mauritius, Mexico, Nicaragua, Palau, Philippine Islands, Puerto Rico, South China, Sumatra, United States, and Venezuela.

In the United States the numbers of infested counties by States through 1951 were as follows: Alabama 1, Florida 21, Louisiana 25 (parishes), Mississippi 3, and Texas 62. In addition, the first scale infestation in California was found on St. Augustine grass on October 3, 1957. Infestations were also recently recorded from Arizona and New Mexico. There are reports of infestations from Georgia and Maryland, but the source is uncertain. The scale probably has its widest distribution in the United States.

There is no definite information on when or how the rhodesgrass scale was introduced into the United States. G. F. Ferris [5] believed that it was native to southeastern China, based on his coccid-collecting experiences in China and because it was first described from there. He considered that possibly it was introduced into Texas about 1925. However, from recent information regarding scale habits, dispersion, and distribution, it is believed to have been there for many years, but not collected or recognized. Attention was focused on it when it was found infesting the recently introduced rhodesgrass.

HOST PLANTS

Hosts of the rhodesgrass scale in the United States are members of the grass family Gramineae, and 69 hosts were recorded through 1951. In addition, 13 hosts were reported from 8 foreign countries. Recorded hosts in the United States are as follows:

Subfamily Festucoidea
- Tribe Agrostidae
  - *Sporobolus asper* (Michx.) Kunth — tall dropseed
  - *Sporobolus poiretii* (Roem. & Schult.) Hitchc — smutgrass
  - *Sporobolus texanus* Vasey — Texas dropseed
- Tribe Chlorideae
  - *Bouteloua curtipendula* (Michx.) Torr — side-oats grama
  - *Bouteloua filiformis* (Fourn.) Griffiths — slender grama
  - *Bouteloua hirsuta* Lag — hairy grama
  - *Buchloe dactyloides* (Nutt.) Engelm — buffalograss
  - *Chloris ciliata* Swartz — fringed chloris
  - *Chloris cucullata* Bisch — hooded windmillgrass
  - *Chloris gayana* Kunth — rhodesgrass
  - *Cynodon dactylon* (L.) Pers — bermudagrass and coastal bermudagrass
  - *Dactyloctenium aegyptium* (L.) Beauv — crowfootgrass
  - *Eleusine indica* (L.) Gaertn — goosegrass
  - *Leptochloa filiformis* (Lam.) Beauv — red sprangletop
  - *Trichloris pluriflora* Fourn — fourflower trichloris
- Tribe Festuceae
  - *Arundo donax* L — giant reed
  - *Dactylis glomerata* L — orchardgrass
  - *Eragrostis curvula* (Schrad.) Nees — weeping lovegrass
  - *Eragrostis lehmanniana* Nees — Lehmann lovegrass
  - *Eragrostis oxylepis* (Torr.) Torr — red lovegrass
  - *Eragrostis replans* (Michx.) Nees — creeping lovegrass
  - *Eragrostis trichodes* (Nutt.) Wood — sand lovegrass

[5] Correspondence dated Dec. 6, 1949.

Subfamily Festucoidea—Continued	
Tribe Festuceae—Continued	
Festuca arundinacea Schreb	Alta tall fescue and Ky.–31 tall fescue
Pappophorum bicolor Fourn	pink pappusgrass
Tridens albescens (Vasey) Woot. & Standl	white tridens
Vaseyochloa multinervosa (Vasey) Hitchc	texasgrass
Tribe Hordeae	
Agropyron smithii Rydb	western wheatgrass
Tribe Phalarideae	
Phalaris tuberosa var. *stenoptera* (Hack.) Hitchc	hardinggrass
Tribe Zoysieae	
Hilaria belangeri (Steud.) Nash	curly mesquite
Subfamily Panicoideae	
Tribe Andropogoneae	
Andropogon caucasicus Trin	Caucasian bluestem
Andropogon littoralis Nash	seacoast bluestem
Andropogon nodosus (Willem.) Nash	angletongrass
Andropogon saccharoides Swartz	silver bluestem
Andropogon sericeus R. Br	silky bluestem
Elyonurus tripsacoides Humb. & Bonpl. [ex Willd.]	Pan American balsamscale
Saccharum officinarum L	sugarcane
Sorgastrum nutans (L.) Nash	indiangrass
Sorghum halepense (L.) Pers	johnsongrass
Sorghum sudanense (Piper) Stapf	sudangrass
Sorghum vulgare Pers	sorghum
Trachypogon secundus (Presl) Scribn	crinkleawn
Tribe Paniceae	
Brachiaria ciliatissima (Buckl.) Chase	fringed signalgrass
Cenchrus pauciflorus Benth	field sandbur
Cenchrus setigerus Roxb	birdwoodgrass
Digitaria decumbens Stent	pangolagrass
Digitaria runyoni Hitchc	dune fingergrass
Digitaria sanguinalis (L.) Scop	crabgrass
Echinochloa colonum (L.) Link	jungle-rice
Echinochloa crusgalli (L.) Beauv	barnyardgrass
Eremochloa ophiuroides (Munro) Hack	centipedegrass
Panicum antidotale Retz	blue panicgrass
Panicum fasciculatum Swartz	browntop panicgrass
Panicum hallii Vasey	Hall's panicgrass
Panicum maximum Jacq	guineagrass
Panicum nodatum Hitchc. & Chase	sarita panicgrass
Panicum purpurascens Raddi	paragrass
Panicum texanum Buckl	Texas panicgrass
Panicum virgatum L	switchgrass
Paspalum dilatatum Poir	dallisgrass
Paspalum monostachyum Vasey	gulfdune paspalum
Paspalum plicatulum Michx	brownseed paspalum
Pennisetum ciliare (L.) Link	buffelgrass
Rhynchelytrum roseum (Nees) Stapf & Hubb	natalgrass
Setaria sp	bristlegrass
Setaria geniculata (Lam.) Beauv	knotroot bristlegrass
Setaria macrostachya H. B. K	plains bristlegrass
Setaria verticillata (L.) Beauv	bur bristlegrass
Stenotaphrum secundatum (Walt.) Kuntze	St. Augustine grass

Rhodesgrass, johnsongrass, bermudagrass, and St. Augustine grass are preferred hosts of economic importance. Most of the other grasses are only occasionally and lightly infested.

DAMAGE AND NATURE OF INJURY

Reliable damage data for the rhodesgrass scale are not available because of the closely interrelated effects of scale infestation, drought, and overgrazing, or close mowing, usually all in operation at the same time. King Ranch reported a loss of 100,000 acres of rhodesgrass pasture attributed to scale infestation between 1945 and 1949. How much of this loss was due directly to scale infestation is not known. Overgrazing and drought, common on rangelands of southern Texas, contribute significantly to losses attributed to the rhodesgrass scale. Losses on lawns and golf courses are directly associated with close mowing and lack of water. An estimated 13,608 scales per square yard were observed on bermudagrass golf greens, but with daily watering and adequate fertilization satisfactory growth was maintained.

A survey to determine rhodesgrass scale damage to rangelands in southern Texas was made in 1951. Ten locations at random were selected in each of six counties. Five 1-square-foot areas were examined at each location at least 50 feet from the edge of the pasture. The counties infested and the average numbers of scales per square foot were Cameron 6, Willacy 3, and Hidalgo 1. The infestations were mostly in irrigated pastures. No infestations were found in the native, brushy, dryland pastures in Kenedy, Kleberg, and Nueces Counties. The infestations observed were not heavy enough to cause damage.

Infested plants are weakened by the removal of plant juices. The scales are attached to the host by their mouth parts throughout most of their life, except for a short period during the first instar. Under heavy infestation the plants turn brown and die.

DESCRIPTION OF STAGES IN LIFE CYCLE

Eggs were observed by dissecting adult female scales. The eggs are cream colored, oblong, and average 498 by 183 microns. During the fall and winter the average number of eggs per female is 170 and during the spring and summer 150.

First-instar larvae (fig. 1*a*) are oblong-oval, cream colored, with the median area tinged with purple, and they are active. They have three pairs of legs, six-segmented antennae, two long caudal appendages, and long styletlike mouth parts. Average body measurements are 830 by 235 microns.

Second- and third-instar larvae are saclike and show little resemblance to the first instar. They become sessile on the host, legs and appendages are lost with the first molt, and antennae are reduced to stubs. The body is enclosed in a felted waxy sac, and it resembles that of the adult, except for size.

The adult (fig. 1*b d*) is also saclike. Appendages are lacking, except for small two-segmented antennae and long styletlike mouth parts. The body is broadly oval to subcircular, dark purplish brown, and averages 3 by 1.5 mm. The ectoderm is smooth and soft, with the caudal extremity strongly chitinized. Mouth parts, as in the second and third instar, remain inserted in the host throughout life. The body is enclosed in a felted waxy sac, which turns yellow with age, but openings at the anterior and posterior ends expose the body. A

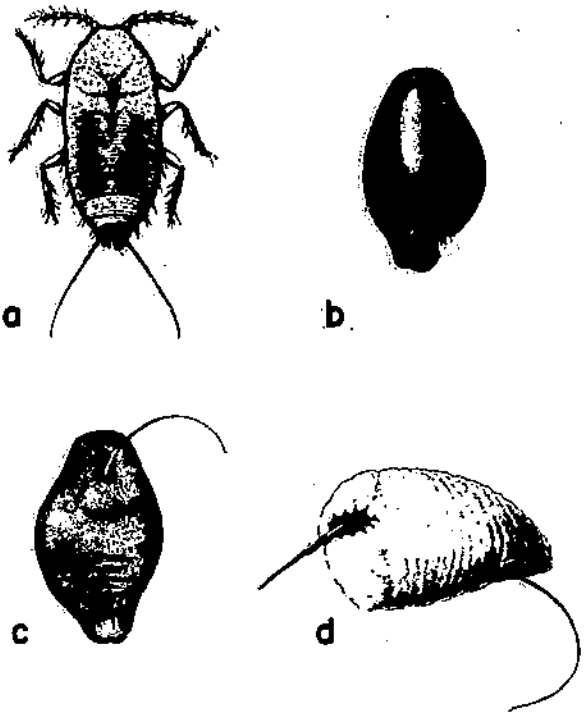

FIGURE 1.— Larval and adult stages of the rhodesgrass scale: *a*, Larva; *b* and *c*, dorsal and ventral views of adult scale without waxy sac covering; *d*, adult with waxy sac covering showing mouth parts (ventral) and excretory tube (terminal). (From Green (*8*).)

white, waxy, tubular filament, which is excretory in function, protrudes from the anal end, and the mouth parts extend from the anterior end of the body.

LIFE HISTORY AND HABITS

Adult scales are parthenogenetic and reproduce ovoviviparously; reproduction continues in an individual for an average of 50 days. Males have never been observed or reported. Newly born larvae remain on the body of the female under the waxy sac for several hours, then emerge from the sac, become very active, and run over the plant. The normal movement is upward, and many can be found at the leaf tips. However, "settling down," or establishment, occurs on the crown or at the lower nodes of erect-growing plants or at the nodes of prostrate-growing plants (figs. 2 and 3). Being positively thigmotropic, the larvae wedge themselves beneath a leaf sheath at a node, insert the mouth parts in the plant, and begin a sessile existence. As soon as this occurs, the excretory tube and felted waxy sac covering are secreted, and the first molt takes place within 10 days.

Molting takes place under the felted waxy sac enclosing the scale. Consequently, it was not possible to observe the process after the first instar, and data on the length of the second and third instars could not be definitely ascertained. However, by dissecting the felted

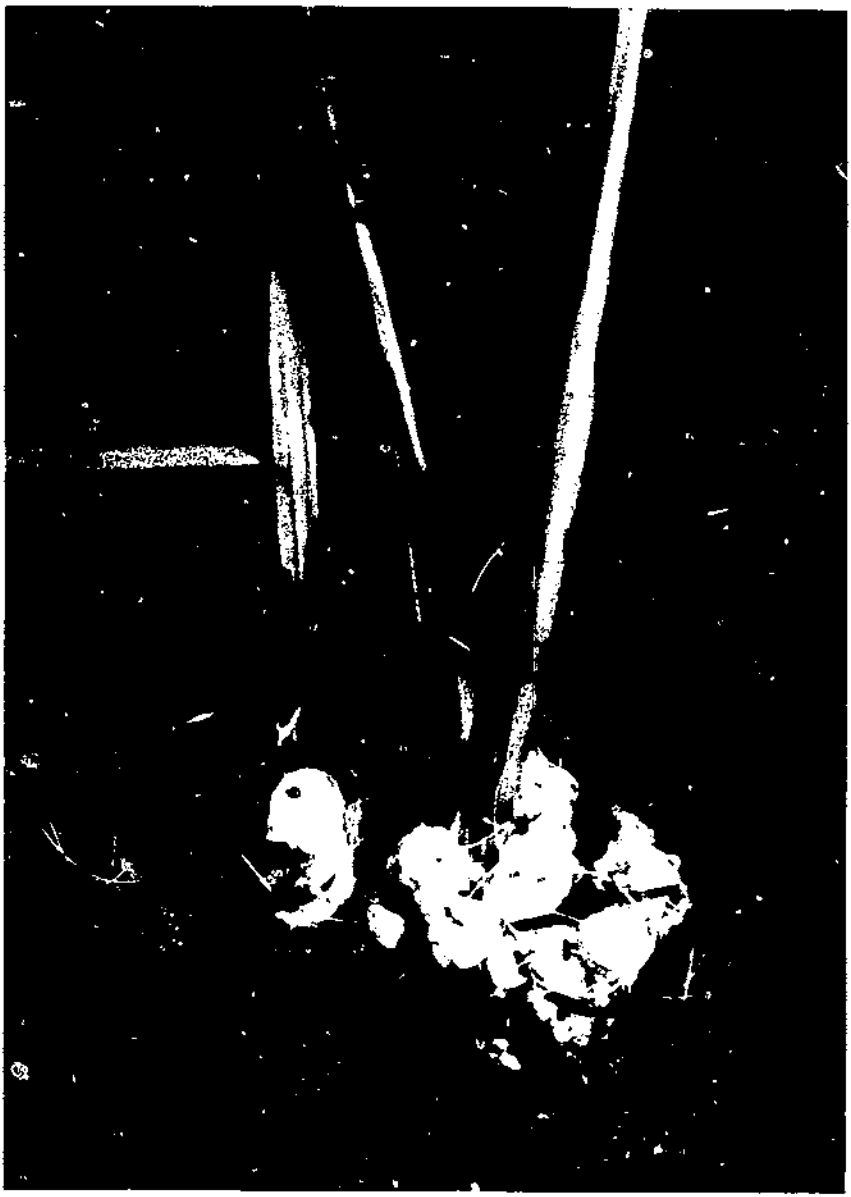

FIGURE 2.—Rhodesgrass scale [illegible] Notice long terminal [illegible]

months, and the other generations during the spring, summer, and fall average 2 months each.

The rhodesgrass scale is primarily a crown-infesting species, but there is also colony establishment at nodes away from the crown during the summer. The development of new colonies at nodes above the crown, especially on erect-growing plants, appears to be due to overcrowding in the more favored locations. The average percentage of scales below the first node, or on the crown, throughout the year was 85.4. During the winter 98.5 percent were on the crown, whereas during the remainder of the year 81.6 percent were on the crown. During the winter, living scales were found only in protected places on the crown and roots. Larvae lived up to 5 days and adults to 6 weeks without food.

SEASONAL HISTORY

The rhodesgrass scale lives throughout the year in southern Texas. Reproduction continues during the winter, but at a reduced rate. Only a few first-instar larvae are found on the adult under the felted waxy sac. With a rise of temperature in the spring, scales become more abundant and populations increase rapidly until a peak is reached about July 1. During July and August populations decrease markedly. With cooler weather in September and October populations again increase to another peak about November 1. After that they gradually decrease as cool weather sets in, and they remain low until the temperature rises again the following spring.

DISPERSION

Motility in the rhodesgrass scale is confined to a few days during the first larval instar; there are no winged forms. Most of the dispersion, therefore, is brought about by means other than the activity of the scale itself. Laboratory experiments showed that the larvae are carried by air currents. Glick (*6*) reported finding many wingless insects, including coccids, as high as 5,000 feet in the air, and he concluded that they could be carried great distances by air currents. The constant strong winds blowing out of the south in the gulf coast area of Texas may affect scale dispersion.

Transportation of bermudagrass and St. Augustine grass sod and of cuttings from infested to noninfested areas for pasture and lawn establishment is a factor in scale dispersion. Most St. Augustine grass lawns in Texas are established from sod grown in the infested gulf coast area. Living scales have been collected from such sod and from cuttings that were shipped.

Dispersion apparently is accomplished by first-instar larvae "hitchhiking" on animals. Active larvae transfer from host plants to animals in pastures and then drop off to establish new colonies in other pastures.

Transportation facilities, especially railway cattle cars and cattle trucks, serve as means of dispersion. Both scale-infested litter and animals with larvae on them are transported. In newly infested areas infestations were invariably found first along railroad rights-of-way and main traveled highways.

EFFECTS OF CLIMATE ON THE SCALE

Temperature is the most important climatic factor affecting scale development. Temperatures over 100° and under 32° F. have adverse effects.

High Temperature

During July, August, and September 1950, populations dropped from an average of 2,966 to 29 scales per square foot of bermudagrass turf, a reduction of 99 percent. The soil temperature at 12 noon 1 inch below the surface at Weslaco, Tex., during this period averaged 123.3° F., with a range of 90° to 149°. Similar readings taken at 2 p.m. averaged 134.1°, with a range of 102° to 155°. The average maximum air temperatures for July, August, and September were 95.7°, 97.8°, and 96.1°, respectively. Laboratory studies showed that temperatures near 100° retarded development of the scale and that 108° for 24 hours was fatal.

Low Temperature

Cold temperatures during October, November, and December 1950 also reduced scale populations. From October 1 to December 14 populations dropped from an average of 2,203 to 158 scales per square foot of bermudagrass turf, a reduction of 93 percent. Average air temperatures for these months were 65.6°, 56.0°, and 50.3° F., respectively.

On December 6 and 7 temperatures dropped to 33° and 24°, resulting in a scale mortality of 40 percent. After a week of freezing temperatures ending on February 3, 1951, with a low of 19° on February 3, mortality for the period was 91 percent.

In laboratory exposure tests 28° for 24 hours was fatal to all stages of the scale. Exposure to 32° for 24 hours did not kill the scales, but subsequent reproduction was greatly reduced. Based on field and laboratory data and observations, the optimum temperature for scale development is between 85° and 90°.

It is apparent from these data that temperatures near or below freezing would limit scale development. Distribution then would be limited to tropical and subtropical regions where temperatures drop to freezing for only short periods. The 32d parallels roughly include the area around the world where such conditions occur, and the general scale distribution is confined to this area.

Moisture

Moisture affects the scales indirectly through its effect on the host plants. The scales thrive under moisture conditions that promote good plant growth, even with high temperatures. Under drought conditions the scales soon kill the plants and then die themselves.

CONTROL

Cultural Control

Damage by the rhodesgrass scale is affected by conditions that weaken the plant, such as overgrazing, drought, and low fertility. It was observed that the combination of heavy grazing and scale infestation would kill rhodesgrass, whereas the same grass equally infested in a fenced area and not grazed was not materially affected. Likewise, closely cut bermudagrass golf greens were killed by scale infestations, but the same grass several inches tall on the border of the green and similarly infested was not killed. Similar observations were recorded in Queensland, Australia, and irrigation, fertilization, and controlled grazing to restore vigor were recommended (*1*). Cultural control on ranches in southern Texas, except for controlled grazing, is of little value because of adverse climate and other factors. Frequent irrigation, fertilization, and controlled mowing (not shorter than 1½ to 2 inches) aided greatly in preventing damage to lawns.

Biological Control

The only recorded parasite of the rhodesgrass scale is *Anagyrus antoninae*. However, no information was available on its effectiveness in controlling the scale in Hawaii.

In January 1949 Riherd (*18*) undertook biological control investigations on the scale at Weslaco, Tex., in cooperation with the U.S. Department of Agriculture. None of the hymenopterous parasites reared from other scales on johnsongrass parasitized this scale. On March 7, 1949, he received a shipment of *A. antoninae* from Hawaii for colonization studies. After repeated liberations in various locations, a few of these parasites were recovered in the irrigated Rio Grande Valley area along the banks of irrigation canals and lakes. However, under dry range conditions, such as at the King Ranch, colonization was unsuccessful.

In later work Dean and Schuster (*4*) liberated this parasite in cages covering rhodesgrass that was heavily infested with the scale in a drought area on the King Ranch. At the same time several parasite liberations were made on similarly infested rhodesgrass outside the cages. After repeated liberations a low percentage of parasitization was recorded from the caged locations, but no parasites were recovered from the adjoining uncaged locations or from several other locations on the ranch. They also reported parasite recoveries from humid locations in the lower Rio Grande Valley. Low relative humidity was considered an important limiting factor in parasite establishment on dry rangelands.

This parasite was collected in Hawaii from an area of high rainfall with a warm, uniform annual climate. The southern Texas area is semiarid with long periods of drought, and annual temperatures fluctuate from freezing to around 110° F. These climatic conditions probably will preclude the establishment of this parasite as a means of practical control in Texas. Under humid conditions in areas where this parasite was liberated it has become established and has provided excellent control of the scale.

Host Resistance

Differences in susceptibility of grasses to rhodesgrass scale infestations were recognized early in these investigations. Studies were made on the resistance of some of the economically important range grasses of southern Texas in an attempt to find resistant varieties that could be recommended to growers.

During 1950 several range grasses were potted and grown in the insectary, where they were manually infested with scale larvae over a 3-month period. Rhodesgrass, johnsongrass, and fringed signalgrass became heavily infested, but King Ranch bluestem, angletongrass, and Diaz bluestem were free of infestation.

For subsequent manual infestation studies large numbers of scale larvae were required, and incubators for their production were devised. Johnsongrass crowns heavily infested with scales were placed in 60-pound lard cans, and the lids were sealed with paraffin. Three 1-inch holes were made in the side of each can, to which glass tubes were fitted for collecting the positively phototropic larvae. There were approximately 5,000 larvae in 0.1 cc. when measured in a small graduated cylinder. The estimated numbers of larvae used in infesting plants in subsequent tests were based on volume measurement.

Seeds of 10 grasses were planted in duplicate 8-inch pots in the insectary on March 6, 1951. When the grasses were about 10 inches high, each was infested with larvae, and population counts were made on June 26. The unit of measurement employed in this and all subsequent resistance tests was one culm plus a part of the plant that pulled away when the sample was taken. Results of this test are presented in table 1.

Scale populations of consequence developed only on rhodesgrass, buffelgrass, and guineagrass. Scale infestations were recorded for the first time on angletongrass and Caucasian bluestem. The definite resistance of some of the grasses, especially the bluestems, was apparent.

TABLE 1.—*Resistance of grasses to manual rhodesgrass scale infestation in insectary tests, 1951*

Grass	Total number of larvae per pot	Number of infestations per pot	Average number of scales developing per culm
Rhodesgrass	20,000	4	35
Buffelgrass	15,000	3	12
Guineagrass	15,000	3	4
Angletongrass	20,000	4	.7
Slender grama	15,000	3	.6
Caucasian bluestem	15,000	3	.02
Diaz bluestem	20,000	4	0
King Ranch bluestem	16,200	4	0
African bluestem	15,000	3	0
Dallisgrass	15,000	3	0

TABLE 2.—*Resistance of grasses to natural rhodesgrass scale infestation when grown in replicated plots under irrigated and dryland conditions at San Benito, Mission, and Raymondville, Tex., 1950–51*

Grass	Average number of scales per culm at					
	San Benito		Mission		Raymondville	
	1950	1951	1950	1951	1950	1951
Irrigated:						
Rhodesgrass	5	12	5	9	13	7
Guineagrass	1	.9	2	.1	3	.6
Blue panicgrass	.3	2	.3	.1	.7	.2
Angletongrass	0	0	0	0	0	0
King Ranch bluestem	0	0	0	0	0	0
Dryland:						
Rhodesgrass	12	7	2	11	14	5
Guineagrass	1	1	.1	.5	1	1
Blue panicgrass	.2	.5	.02	.2	.7	.5
Angletongrass	0	0	0	0	0	.01
King Ranch bluestem	0	0	0	0	0	0

Scale population counts were made in naturally infested grass plots maintained by the Texas Extension Service and the Central Power and Light Company at San Benito, Mission, and Raymondville, Tex. There were four replications, and the grasses were grown under both irrigated and dryland conditions. Infestation data in these plots are presented in table 2.

The heaviest infestation occurred on rhodesgrass and guineagrass, with a light infestation on blue panicgrass. No scales were found on King Ranch bluestem, and the 0.01 scale per culm on angletongrass was of little consequence. There was no significant difference between the infestations under irrigated and dryland conditions.

Observations on natural scale infestations were made in 43 other grass plots grown under irrigated and dryland conditions at San Benito, and 17 were infested. Only Alta tall fescue, bermudagrass, and switchgrass had possible damaging populations, but they were light as compared with those developing on rhodesgrass.

Scale infestation counts were made on several grasses grown in the field on ranches in southern Texas. All the grasses except those at Kingsville were irrigated. Infestation data are presented in table 3.

Rhodesgrass had the heaviest infestation; the other seven grasses were practically free of infestation. One scale was found on angletongrass where it was growing close to heavily infested rhodesgrass. The two irrigated fields at Brownsville were planted in 1937 and 1938, and although heavily grazed for 13 years, they remained in excellent condition. There was no scale infestation in them, whereas johnsongrass and bermudagrass in pastures and roadsides bordering the fields were heavily infested.

Rhodesgrass always had the heaviest infestation among the grasses observed under both manual and natural infestation, whereas several

TABLE 3.—*Resistance of grasses to natural rhodesgrass scale infestation when grown in the field at several locations in southern Texas, 1950–51*

Grass	Location	Average number of scales per culm	
		1950	1951
Rhodesgrass	Mercedes	5	13
	Donna	1	0
	Combes	7	----
Fourflower trichloris	Combes	.04	----
Dallisgrass	Mercedes	.1	0
	Donna	0	0
Hardinggrass	San Benito	0	0
Angletongrass	Mercedes	0	0
	Brownsville	0	0
	Combes	0	0
	San Benito	0	0
	Kingsville	0	----
Diaz bluestem	Kingsville	0	
King Ranch bluestem	do	0	
Coastal bermudagrass	Mercedes	0	

other grasses, particularly the bluestems, were only lightly infested or not infested. Infestation was never found on King Ranch, African, or Diaz bluestems, and they were considered immune. Therefore, ranchers and farmers using any of the range grasses, except rhodesgrass, bermudagrass, johnsongrass, and St. Augustine grass, would escape damage from the scale. In southern Texas, rhodesgrass is the only one of these four grasses that is planted and only on a small acreage. Most of the other seeded grasses are bluestems, which are relatively free of scale infestation. Bermudagrass and johnsongrass occur naturally on ranges, and St. Augustine grass is used mainly for lawns. On the basis of these data the use of resistant or tolerant varieties on rangelands is recommended in the area infested by the rhodesgrass scale.

Control With Insecticides

The literature prior to these studies contained little information on the control of the rhodesgrass scale with insecticides. In Queensland, Australia, nicotine-soap solution was recommended, but no data were presented on its effectiveness (*1*). Wene and Riherd (*22*) killed first-instar larvae with a 1.6-percent oil emulsion at the rate of 150 gallons per acre, but its effectiveness was lost in 3 days, and the adult scales were not killed.

The following statement appeared in the Queensland [Australia] Agricultural Journal (*1*): "In view of the protective covering and sheltered position, control of this insect is difficult and is normally necessary only when growing conditions are poor. Owing to the wide distribution of the species, eradication must be considered impossible."

It was apparent early in these investigations that control of the scale with insecticides would be difficult. The main infestation is

located on the crown of the host, where the scales are hard to reach with insecticides; unless the adults are killed there, reinfestation takes place readily. All stages but the first larval instar are well protected. The larval and adult bodies are covered with wax, and the adult is surrounded by a waxy sac. During the entire life cycle, except for a few days in the first larval instar, the scale is attached to the host by its mouth parts. It was indicated that conventional sprays for controlling other scale insects would be of little value. Therefore, exploratory tests with insecticides were necessary before intensive tests could be made. Most of the insecticides used were first screened in the laboratory.

Preliminary translocation and toxicity studies were conducted in the laboratory and insectary with systemic insecticides and infested plants growing in nutrient solution or soil.

In early studies with schradan it was apparent that translocation was taking place, because aphids, *Rhopalosiphum maidis* (Fitch), were dead in 18 hours on plants growing in 0.1-percent solution. Also, scales did not become established on plants growing in this solution for several days when infested with scale larvae. However, there was little superficial change in the appearance of scales on treated and untreated plants. Under microscopic examination scales on treated plants were found to be dead. Consequently, after examining a large number of scales from treated and untreated plants, criteria were established for use in determining scale mortality in subsequent insecticide tests as follows: (1) If the scale body was shriveled, dried, and darkened when the waxy sac was removed, it was dead. (2) If the scale had a normal living appearance and active larvae were present, it was alive. (3) If honeydew was produced when the scale was teased with a needle, even though larvae were not present, it was alive. (4) In the absence of larvae and honeydew, normal-appearing scales were punctured with a needle. If the body content was viscid, the scale was dead; if it was fluid, it was alive.

In systemic insecticide translocation studies scale-infested plants were grown in nutrient solution containing various concentrations of insecticides. Scale mortality counts were made 30 days after treatment. Among the several insecticides tested, demeton, schradan, and Geary E–20/86 gave the best control, and residual toxicity to the scales generally was good. The data are presented in table 4.

In addition to these tests, parathion at 0.2-, 0.1-, and 0.01-percent concentrations in nutrient solution was tested for systemic action and scale control. Control after 30 days was 76, 21, and 86 percent, respectively. However, it was apparent that mortality was due to fumigation rather than systemic action, because only scales and aphids on the lower part of the plant were killed. When insecticides with true systemic action were used, scales and aphids at the top or growing tip of the plant were killed first, because of more rapid translocation to these parts. Parathion in nutrient solution caused severe phytotoxicity, and there was little residual toxicity. In field tests parathion sprayed on infested plants killed scale larvae but not the adults. Richardson (17) reported being able to kill scale larvae and newly established scales on St. Augustine grass lawns with weekly applications of parathion dust or spray, but he gave no data on mortality of adults infesting crowns of the plants. Because of these

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TABLE 4.—*Control of the rhodesgrass scale on paragrass with systemic insecticides in nutrient solution and their residual toxicity in laboratory tests*

Insecticide and concentration (percent)	Control in 30 days	Residual toxicity
Demeton:	*Percent*	
0.1	100	Good.
0.04	100	Do.
0.02	100	Do.
0.013	100	Do.
Schradan:		
0.166	100	Do.
0.1	100	Do.
0.01	100	Do.
0.001	62	Fair.
0.0001	49	Poor.
Geary E–20/86:[1]		
0.1	100	Good.
0.01	42	Poor.
0.001	6	None.
0.0001	0	Do.

[1] *O,O*-Diethyl Se-2-(ethylthio)ethyl phosphoroselenate.

findings, parathion was not considered practical for controlling the scale on rangelands.

Further tests with these and other insecticides as soil drenches were carried on in the insectary. Infested rhodesgrass, johnsongrass, and paragrass were grown in 1-foot-square flats. The insecticides in various concentrations in water were applied at 500 and 1,000 cc. per flat when the soil was rather dry, and scale mortality was determined 30 days after treatment. Demeton gave the best control and showed good residual toxicity to the scales. These data are presented in table 5.

From tables 4 and 5 it is apparent that demeton and schradan offered the best possibility for controlling the rhodesgrass scale in the field.

Tests were conducted in the laboratory with white oil 95, Soltrol 140, and Soltrol 140–DDT for effectiveness in controlling the adult scales on heavily infested johnsongrass crowns. The oils were sprayed at the rate of 2.3 cc. per crown and were sufficient to produce runoff. Data on the results are presented in table 6.

Both white oil 95 and Soltrol 140 in 50-percent concentrations were effective in controlling adult scales, but lower concentrations had no effect. The addition of 5-percent DDT to 25-percent Soltrol 140 oil resulted in fair control at low concentrations. In these tests all scales were exposed and runoff applications were excessive. In the field most of the scales would be protected on the crown. Because of the heavy excessive applications necessary to effect control and the high cost, the use of oils for scale control was considered impractical.

Laboratory and insectary tests showed that systemic insecticides offered the best possibility for controlling the rhodesgrass scale. Infested johnsongrass sprayed with a runoff application of 0.1-percent

schradan resulted in 9-percent control, because the spray did not reach the seat of the infestation on the crown. Consequently, most of the field tests were with schradan and demeton as soil drenches.

Preliminary experiments with various concentrations of insecticides showed that at least one-half gallon of liquid per square yard (55½ gallons per 1,000 square feet or 2,400 gallons per acre) was necessary to take the toxicant to the root zone, and that most effective control was obtained when the plants were in a vigorous growing condition; little translocation took place when plants were dormant. Most of the field tests were conducted with this rate of application and stage of plant growth.

Demeton, schradan, sodium selenate, and sodium fluoroacetate were the systemic insecticides tested as drenches for scale control in heavily infested bermudagrass turf. Results of these tests are given in table 7.

A 25-percent demeton wettable powder distributed evenly over the turf and then washed in with one-half gallon of water per square yard gave good control of the scale and had excellent residual toxicity. Both demeton and schradan emulsions also gave good control, and at higher dosages residual toxicity was good. On the basis of laboratory,

TABLE 5.—*Control of the rhodesgrass scale on various grasses with systemic insecticides applied as soil drenches and their residual toxicity in insectary tests*

Host	Insecticide	Concentration	Control after 30 days	Residual toxicity
		1,000 CC. PER SQUARE FOOT		
		Percent	*Percent*	
Rhodesgrass	Demeton	0.1	99	Good.
		.01	70	Do.
		.001	0	None.
Johnsongrass	American Cyanamid 3885.[1]	.1	90	Poor.
		.01	7	None.
		.001	4	Do.
	American Cyanamid 3901.[2]	.1	58	Poor.
		.01	0	None.
		.001	0	Do.
Paragrass	Geary E-20/86	.1	34	Poor.
		.01	0	None.
		500 CC. PER SQUARE FOOT		
Rhodesgrass	Demeton	0.1	73	Good.
		.01	34	Do.
	Schradan	.1	21	Do.
		.01	10	None.
		.001	11	Do.

[1] *O,O*-Diethyl *S*-acetylureidophosphorodithioate.
[2] *O,O*-Dimethyl *S*-(2-oxo-2-ureidoethyl)phosphorodithioate.

TABLE 6.—*Control of the rhodesgrass scale on johnsongrass with various oils and oil-DDT at 2.8 cc. per crown in laboratory tests*

Treatment	Concentration	Contro
	Percent	*Percent*
White oil 95+Triton X-100	50	100
	25	9
	12	0
	5	0
	3	0
	1	0
Soltrol 140+Triton X-100	50	100
	25	0
	12	0
	5	0
	3	0
	1	0
Soltrol 140+DDT+Triton E-1956	1.25	78
	1	65
	.75	56
	.5	64
	.25	64
	.125	19

TABLE 7.—*Control of the rhodesgrass scale in bermudagrass turf with systemic insecticides applied as soil drenches and their residual toxicity in field tests*

Insecticide	Rate of application per square yard		Control after 30 days	Residual toxicity
	Drench	Toxicant		
	Gallons	*Grams*	*Percent*	
Demeton:				
Suspension	½	7.26	100	Excellent.
		3.63	100	Do.
Emulsion	½	3.63	87	Do.
		1.81	89	Do.
		.73	31	Fair.
		.36	34	Do.
		.24	33	Do.
Schradan emulsion	⅙	2.91	87	Good.
		1.45	92	Do.
		.73	27	Fair.
		.36	44	Do.
		.18	42	Do.
Sodium selenate emulsion	1	2.25	23	Poor.
Sodium fluoroacetate emulsion	½	1.9	99	Do.
		.2	13	Do.
		.02	3	Do.

insectary, and field tests, demeton and schradan used as soil drenches offered the best possibility of controlling the rhodesgrass scale with insecticides.

Control with an emulsion containing 2.25 grams of sodium selenate per square yard was poor, and it had little residual toxicity. Much higher dosages would be necessary to effect satisfactory control.

An emulsion containing 1.9 grams of sodium fluoroacetate per square yard gave good control, but residual toxicity was poor. Extremely toxic residues left in plants after use of this insecticide as a systemic would preclude its practical use for scale control.

Residual toxicity is an important consideration in selecting an insecticide to control the rhodesgrass scale, because reinfestation occurs readily in the absence of a toxicant. Demeton had a residual toxicity for 151 days when applied at 3.6 grams in one-half gallon of water per square yard of St. Augustine grass turf and for 96 days at 1.8 grams. The results of these tests are given in table 8.

TABLE 8.—*Residual toxicity to the rhodesgrass scale of different dosages of demeton when applied in one-half gallon of water per square yard to St. Augustine turf in field tests*

Dosage (grams)	Percent control after				
	27 days	62 days	96 days	151 days	175 days
3.6	87	100	100	100	41
1.8	89	100	100	37	12
0.18	13	0	0	0	0

Control of the rhodesgrass scale with insecticides has limited application. The high dosages and rates of application of demeton and schradan necessary to effect control would limit their use to small areas such as lawns and golf greens. A dosage of 3.6 grams of demeton or schradan in one-half gallon of water per square yard is equivalent to 403 grams in 55½ gallons per 1,000 square feet, or 38.7 pounds in 2,400 gallons per acre. Costs of such applications on rangelands would be prohibitive. Most of the other insecticides tested did not show much promise of controlling the scale.

SUMMARY

The biology and control of the rhodesgrass scale *Antonina graminis* (Maskell) were investigated at the Weslaco Substation of the Texas Agricultural Experiment Station from 1949 through 1951.

The rhodesgrass scale occurs in tropical and subtropical regions. World-distribution records are confined mainly to the area bounded by the 32d parallels. In the United States it was recorded from Alabama, Arizona, California, Florida, Louisiana, Mississippi, New Mexico, and Texas, with possible infestations in Georgia and Maryland. The largest infested area was in Texas.

Through 1951, 69 hosts were recorded in the United States, all members of the grass family Gramineae, and 13 hosts were reported from 8 foreign countries. Rhodesgrass (*Chloris gayana* Kunth), johnsongrass (*Sorghum halepense* (L.) Pers.), bermudagrass (*Cynodon dactylon* (L.) Pers.), and St. Augustine grass (*Stenotaphrum secundatum* (Walt.) Kuntze) are preferred hosts of economic importance. Most of the other hosts are only lightly infested.

Range, lawn, and golf-course grasses are damaged by the scale, but it is difficult to establish damage data due to the scale alone because of the interrelation of other factors, such as drought and overgrazing, or close mowing, usually all in operation at the same time. Heavily infested grasses turn brown and die because of the removal of plant juices by the scale.

Adult scales are parthenogenetic and reproduce ovoviviparously; the reproductive period in an individual averages 50 days. Males have never been observed or reported. There are three larval instars. Only the first is active, and it has well-developed legs and antennae. The second and third instars and the adult are sacklike, are surrounded by a felted waxy sac, and lead a sessile existence.

The life cycle ranges from 60 to 70 days, and there are five generations annually. The winter generation is longer than the other generations. Major infestation occurs on the crown; 85 percent of the scales are found there. In Texas the scales live throughout the winter, but the reproductive rate during this period is greatly reduced. The largest populations occur about July 1 and November 1.

Dispersion is accomplished by the larvae being windborne or carried about by grazing animals, or by larvae and adults being transported on grass cuttings or sod.

Temperatures near 100° F. retard scale development, and 108° for 24 hours is fatal. A temperature of 32° also retards development, and 28° for 24 hours is fatal to all stages. Optimum temperature for development is between 85° and 90°.

Cultural control and biological control of the rhodesgrass scale have not proved practical. The use of resistant or highly tolerant grasses is recommended. King Ranch, African, and Diaz bluestems are immune to the scale, and angletongrass is only lightly infested.

Control with insecticides, except on lawns and golf greens, is impractical. The scale can be controlled with systemic insecticides, but the cost is excessive. Systemic insecticides such as demeton and schradan at 3.6 grams in at least one-half gallon of water per square yard as a soil drench give the best control on lawns and golf greens.

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