

BIOLOGY AND TAXONOMY OF THE NEARCTIC
SPECIES OF TROGODERMA
(Coleoptera: Dermestidae)

BY

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INTRODUCTION

THE GENUS *Trogoderma* is of interest not only because of its taxonomic features, but because of its economic importance. A measure of the latter may be gained from the extent of its treatment in Hinton's *Monograph of the Beetles Associated with Stored Products* (1945). Nevertheless many past investigations on the biological and economic aspects of the genus have been vitiated by the uncertainty surrounding the identification of the species involved. Hence the study of the taxonomy of *Trogoderma* is basic to the study of its other characteristics. The purpose of this paper is to redefine the limits of the Nearctic species of the genus, to redefine their geographical and ecological ranges, and to correlate available biological data with each species. Coincidental to these primary objectives is the necessity of standardizing the nomenclature of the species concerned.

Difficulties in analyzing the taxonomy stem from a combination of several biological features, of which the following may be noticed in particular.

Limited powers of dispersal under natural conditions.—This contributes to the development of geographic variations by limiting gene flow between local populations.

Suitability to dispersal by commerce.—This factor is responsible for several distortions of the natural picture. A large population in an area served by commerce may have come from the chance introduction of but one fertilized female. Such a population will appear quite constant and may thus seem to be specifically distinct from some of its normal varieties. Also commerce may bring together normally allopatric populations of two closely related species. In certain instances this has evidently been responsible for the impression that the two are but individual variations of one species.

Variation in size and proportions under different environmental conditions.—Specimens of *sternale*, *grassmani*, and *simplex* reared in the laboratory with an unlimited supply of food and under optimum temperatures are invariably larger than those taken in the field. Similarly, specimens taken as pests in food stores are larger than those taken under native conditions. With a change in size certain body proportions are also altered. In the past these differences have led to the description of a number of forms which are here regarded as synonyms.

The biology of *Trogoderma*, just as the taxonomy, is open to a profitable review and investigation, in spite of the numerous papers which have been written on the subject. Surprisingly enough, the knowledge of the natural history of a number of these common economic pests of stored products is far less than we might expect, actually much less than for hundreds of species of no economic

importance. As others have already remarked, this is probably because these insects are considered so common and well known that they are generally ignored in the field by collectors.

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HISTORY OF THE GENUS

The name *Trogoderma* is commonly credited to Latreille, and probably correctly so. The earliest reference to the name which the writer has seen is that of Dejean's catalogue in 1821, in which two species, *elongatula* Fabricius and *versicolor* Creutzer, are included in the genus. Dejean, however, credits the name to Latreille. The earlier reference is unknown to me. If neither Dejean's citation nor some earlier citation by Latreille is to be considered valid, then the name should be assigned to Berthold in the 1827 German edition of Latreille, *Natürliche Familien*

Thierreichs. In 1829 Latreille summarized the genus in Cuvier, *Règne Animal*. Subsequently a number of other European authors contributed to the knowledge of the genus.

The first significant American work on the genus appeared in H. F. Jayne's revision of the American Dermestidae in 1883, in which two new species were described and added to the genus, bringing the total recognized Nearctic species to five. Seventeen years later the genus was again revised in a monograph of the family by T. L. Casey, who distinguished eleven additional North American "species" and who, in subsequent years, added yet another nine to the list. Two other taxonomic works, though not on Nearctic *Trogoderma* as a whole, should be mentioned: one a work on the dermestid beetles of New Jersey by Mutchler and Weiss (1927), and the other the monograph of H. E. Hinton (1945) mentioned above. In the latter the description of *Trogoderma* is handled in accord with modern taxonomic practices and permits a clear recognition of those species treated. In the following study nineteen species and subspecies are recognized. Three of these species are undoubtedly recent introductions. One species is transferred from another genus. Five species and two subspecies are described as new.

SPECIES DEFINITION AND IDENTIFICATION

A number of different morphological features lend themselves to the definition and identification of Nearctic *Trogoderma*. Certain of these require a more extensive explanation than is appropriate to the taxonomic section, and these are discussed below.

Characters associated with gross external structures.—Important specific characters in the males involve the structure of the antenna, the shape of the antennal fossa, the sculpture of the floor of the antennal fossa, and the presence or absence of striae on the metasternum and the first abdominal sternite. Differences in vestiture, although often plainly visible when two separate species are placed side by side, are with one exception of limited diagnostic value for lack of a standard of comparison when only one species is available. Hinton (1945) has found the sculpture and shape of the prosternum and the elevated parts of the mesosternum of value in separating some species. Differences are apparently present in these structures, but they are both difficult to use and to define. Differences in punctation of the more conspicuous external surfaces have been used extensively by all previous workers. Although I have felt it necessary to make some use of punctation differences in the key to species, these cannot be depended upon in the absence of supporting characters. In breeding experiments with *grassmani* I have found both smooth and rugosely punctured elytra in the progeny of identically punctured parents.

The hind wings present a special problem from the standpoint of terminology. Characters that are useful in segregating species groups are to be found in the venation, but the identities of the veins involved have not been determined. In the posterior half of the wing are a number of faintly marked veins, the first of which shows marked variations on a group level, being long or short, simple or branched, or wanting altogether. These have been referred to as anal veins for

convenience in the description of the species, but this is not meant to imply that they are known to be homologous with the anal veins of other insects. Additional wing characters are evident in the general shape of the hollow, pigmented spot (stigma) near the middle of the costal margin and in the presence or absence of a pigmented spur extending proximad of that spot. The latter character, however, sometimes varies on a subspecific level.

Patterns of elytral maculation and pubescence.—Unquestionably, an elytral pattern of three, light, transverse maculae is deeply rooted in the phylogeny of the Anthreninae, to which subfamily *Trogoderma* belongs. Such a basic pattern is evident in many species of *Anthrenus*, *Cryptorhopalum*, *Megatoma*, and other

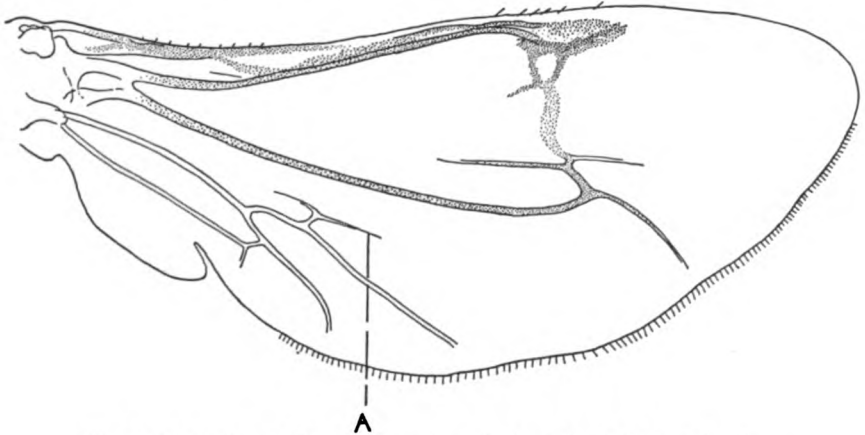


Fig. 1. Hind wing of *Trogoderma sternale sternale*. A, first anal vein.

genera. When present, the subbasal band usually appears crescent-shaped, sometimes almost suggesting a basal circle of light maculation. In a large section of *Trogoderma* all three bands are evident, the subbasal band actually forming in most species a complete circle on each elytron. In addition, a few more or less broken longitudinal lines frequently appear with these transverse bands. These occur with such constancy in widely different species that they also must be considered part of a primitive pattern derived from a progenitor of *Trogoderma*. Although this primitive pattern is not found complete in any contemporary *Trogoderma*, a definitive pattern of elytral maculation may be reconstructed. This will make it possible to understand and describe the peculiar variations existing in the patterns of various species. This definitive pattern, together with terms proposed for the identification of its parts, is illustrated in figure 2. Because it is so evidently basic to the genus, those species without it must be presumed to have lost it by a secondary modification.

The various lines and bands of the pattern maintain their relative positions on the elytron from species to species. The longitudinal lines, if present, follow the longitudinal rugosities that sometimes appear on the elytra, and the loop and submedian and subapical bands occur at nearly the same proportionate distances from the apex or from the base in any one form. The differentiating characters for various species consist in the obliteration of parts of lines and bands

and of the expansion of other lines and bands. The constancy of the position of these lines and bands and of their absence or expansion allows a rather accurate description of the specific differences in spite of the variations which occur.

Variations of the pattern within a species may appear either as progressive changes in a geographic cline (of which the forms of *sternale* provide a good example) or as individual fluctuations in the intensity of the pattern. It is this latter type of variation that has confused most previous authors and led many of them to discard the pattern entirely as a source of specific characters. Once understood it provides an easy reference for the identification of the species.

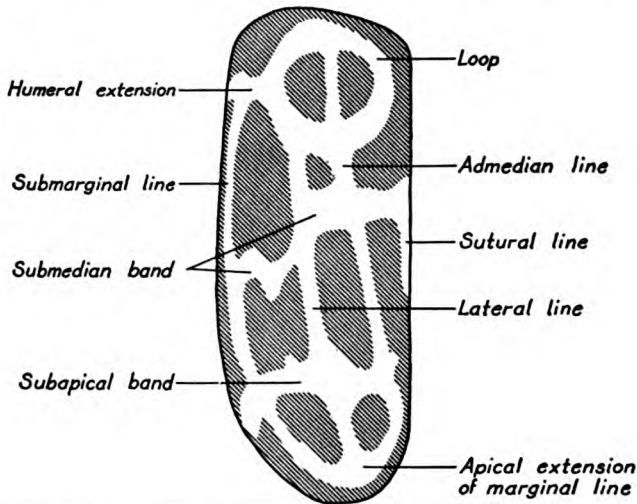


Fig. 2. Schematic representation of generalized pattern of left elytron of *Trogoderma*.

What is most important to observe is the proportionate reduction or expansion of the pattern of a particular species. The pattern of a geographic segregate will rather constantly show the possession of certain characteristic lines, although in any one individual these lines may be greatly expanded or excessively reduced, but always proportionately.

The three illustrations of elytral patterns of *parabile* (fig. 11) represent forms found in almost equal numbers in all series of this species that I have seen. In the heaviest (expanded) pattern the most pronounced lines are the posterior half of the loop and the humeral extension, a small lateral part of the submedian band, and the subapical band. Other thinner lines, which are present and complete in the expanded pattern, disappear as the pattern becomes reduced. For example, the basal half of the loop, the sutural line between the submedian and the subapical bands, and the apical extension of the marginal line frequently disappear. However, in the most reduced form the posterior half of the loop with its humeral extension, a small lateral fragment of the submedian band, and a fragment of the subapical band still remain. These are the parts of the pattern which in the expanded form are the most pronounced or widest.¹

¹ To observe the pattern of maculation clearly, it is helpful to wet the specimen with alcohol. Because the pubescence often masks the maculation underneath, this is sometimes an absolute necessity.

The pattern of light pubescence on the elytra and pronotum usually follows rather closely the pattern of light maculation. In fact in some species in which the elytra are almost or entirely without maculation, such as *boron* and *paralia*, the basic pattern of a loop, a submedian, and a subbasal band is clearly indicated in the pubescence. In some species the light-colored pubescence is broken up into definite patches of white and golden-brown hairs which often show some constancy. However, so far as I have been able to observe, variations of the pattern of color in the pubescence are much greater than variations in maculation, and are seldom of definitive value except on an infraspecific level.

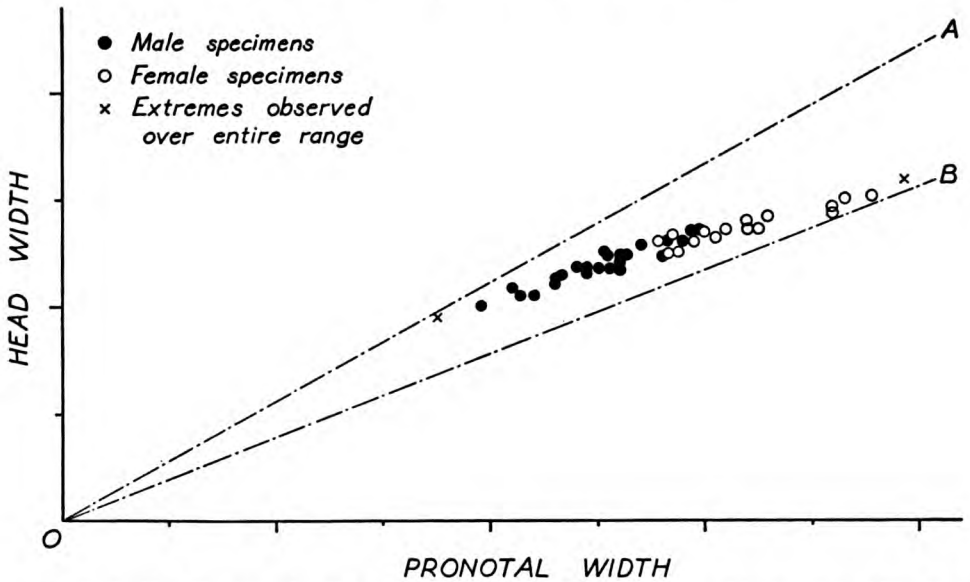


Fig. 3. Scatter diagram showing correlations between head widths and pronotal widths in a single series of forty specimens of *Trogoderma versicolor* (Creutzer) from Douglas County, Kansas.

Specimens of *simplex*, *sternale*, and *grassmani* taken in the desert areas of southeastern California are noticeably smaller than those taken in other parts of their range. In addition they have a preponderance of golden-brown hairs scattered evenly over the elytra and have a tendency toward vagueness in the elytral pattern. Since the same thing is true of all species known to occur in the desert, it is probably the result of an environmental rather than genetic influence.

Characters treated by statistical analysis.—Casey found it convenient to separate several of his species near *versicolor* (= *tarsale*, Casey) on the basis of the proportionate width of the head to the pronotum. However, in a long series of *versicolor*, analysis of this character by means of a simple scatter diagram (fig. 3) shows that although there is a remarkably close correlation between the head width and the pronotal width, the ratio varies directly with the size of the insect. Measurements made on eight² species representing several different sections of

² *Trogoderma sternale* and *T. boron* were studied in addition to those species indicated in fig. 4.

the genus show closely similar correlations. Enough different series were measured to lead to the fairly definite conclusion that separation of species on this character is valid nowhere in the genus. The slight differences between species that do appear (fig. 4) might conceivably be used as taxonomic characters, if the exact size of each specimen is introduced as a factor. However, this would involve considerable computation and is not practicable at this point.

On the other hand, there is a significant taxonomic value in the proportionate length to width of the species. Females of two species, *boron* and *paralia*, can be separated best by this character. It serves as well to verify the taxonomic treatment of a number of other species.

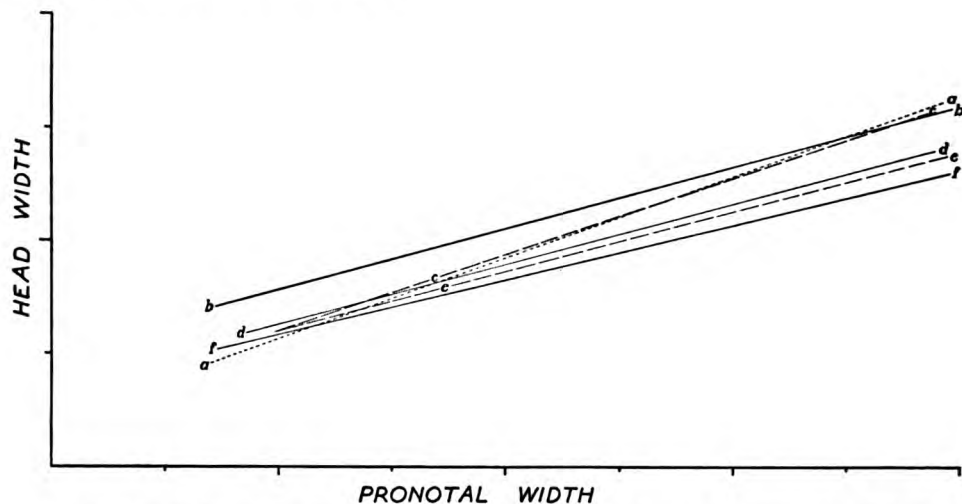


Fig. 4. Straight-line regressions from correlations between head widths and pronotal widths in species of *Trogoderma* (calculated from the entire range of each species considered): a. *ornatum*; b. *versicolor*; c. *sinistrum*; d. *parabile*; e. *simplex*; f. *primum*.

Male genital characters.—Wherever possible, dissections have been made of the male genitalia. The practice is generally not worth the time and effort involved, nor the risk of damage to the specimen, even though discernible specific differences are present. The principal value of the study of the genitalia has been to confirm the conclusions reached through a study of the external morphology.

The structure of the male genital apparatus involves at least two internally recessed abdominal segments and the aedeagus with its associated structures. For purposes of description I am designating the most proximal segment the first periphallic segment. This consists of a more or less completely formed tergite and sternite, and morphologically is the seventh abdominal segment. The eighth abdominal segment is probably represented by the narrow, sclerotized ring that telescopes into the first periphallic segment and that bears on its dorsoposterior margin the membranes forming the anus. It constitutes the second periphallic segment. Capable of being withdrawn into it is the proximal end of a ventral plate, which most probably is the sternite of the ninth segment and corresponds to the U-shaped or V-shaped bar or the "rod" of other beetles. The phallobase

("tegmen" of Sharp and Muir, 1912) consists of two lateral lobes joined proximally to a short apodeme and connected ventrally by a narrow bridge. Distally the aedeagus is a narrow tube with the margin of the gonopore projecting anteriorly as a small terminal hook. Proximally the aedeagus is hinged to the dorsal side of the phallobase by a short, anteriorly directed, Y-shaped apodeme.

Nearly every sclerite of the genitalia has been found to exhibit at least some slight difference at the specific level. However, the most stable and easily compared differences are found in the tergite of the first periphallial segment and in the lateral lobes of the phallobase. In the former, particular differences are observed in the shape of the sclerotized areas and in the character of the marginal (apical) pubescence. The characters of the lateral lobes are found in the relative width and shape of the bridge and in the relative length of the lobes distad of the bridge.

Larval characters.—The treatment of the larval taxonomy of *Trogoderma* is incomplete owing to the lack in collections of the larvae of many species and to the limited numbers of specimens of other species. Hence this study should be regarded as constituting only a tentative analysis of the characters involved. Another difficulty in the study of the larvae is that comparison of equivalent instars is almost impossible, except for the first, because under certain conditions the fourth instar of a species may be mature and ready to pupate, whereas under other conditions the tenth instar may be quite immature. As far as possible the characters used here for description and identification are those found in any instar of more or less mature size. First instar larvae have been available in so few of the species that their comparison has been omitted from the present study.

The head structures of the larvae contain a number of useful characters, but unfortunately for the worker who wants a rapid identification, they require clearing, dissection, and mounting. The number of broad setae of the labro-epipharyngeal margin is particularly valuable in separating some closely related species, such as *sternale* and *grassmani*. In each of the species studied the shape, setal characters, and the like of the antennae show distinct differences.

Besides the peculiar "broad" setae of the labro-epipharyngeal margin, several other types of setae are designated by special names. Some of these types are not altogether distinctive, intergrades being found between them. Nevertheless, the description of the larvae is greatly simplified by recognizing the forms most commonly encountered. Following Rees (1947) the "spear setae" are called "hastisetae" (rather than "pendicle" setae, as they are called by Ferris, 1934). The smooth, terete setae, usually quite small, are named "nudisetae." These are the usual simple setae of most insect larvae. The term "spicisetae" refers to the great variety of large and small setae with a rough, thorny, or laminate surface. This includes the type of hair which Ferris (1934) called a "rat-tail" seta. Some of these indeed bear a resemblance to a rat's tail, but others are quite short and blunt. Some may be covered with scales and appear almost laminated, whereas obviously homologous setae in related species may have the scales represented only by small knobs.

I have seen but have not had an opportunity to study the larvae of some

Australian *Trogoderma* which bear another peculiar type of pubescence, the "mushroom" setae. It is a possibility that two of our related Nearctic species, *fasciferum* and *ballfinchae*, the larvae of which are unknown, may bear this type of setae.

Pupal characters.—Each pupa so far available for study can be identified by characters associated with the "gin-traps" of the abdominal tergites. Of the pupae of six species so far examined, one, *grassmani*, lacks these structures. Hinton (1946) has found them present in another species, *megatomoides* Reitter.

DESIGNATION OF SPERMOTYPES

Progeny bred from the holotype and the allotype of several new species described in this paper have been designated *spermatypes*. This term is used in botanical literature to designate plant specimens grown from the seed of the type of the species, but apparently no comparable word has been used in zoölogy (Frizzell, 1933; Fernald, 1939). The addition of this new term to entomological type nomenclature seems advisable, since specimens so designated would be as serviceable as the holotype in fixing the species. Indeed, the totality of a spermatype series can be an even better reflection of the species than a single type specimen.

I am attempting to maintain living cultures of the spermatypes of the species described. It is possible that these may be of real value in future experimental studies on the taxonomy of the group.

GEOGRAPHIC DISTRIBUTION AND RELATED PROBLEMS

DISTRIBUTION OF THE GENUS

Species of *Trogoderma* are found on every continent from the subarctic to the tropics and with one possible exception, they are distributed rather evenly among the different faunal zones. The following list indicates the number of species recognized at present in each faunal zone, including the changes made here.

Nearctic	14	Australian	58
Neotropical	27	Oriental	5
Palaearctic	11	Uncertain	1
Ethiopian	14		

No recent revision has been made of the Neotropical species, and it is very likely that when one appears, the number of valid species will be greatly reduced. In lieu of good series of Australian specimens for study, no certain conclusions can be drawn from the disproportionately large number of species said to occur there. However, the characters used for their separation by Armstrong (1942) include many which are not specifically constant in our Nearctic species. In general I believe the evidence from geographic distribution leads toward the conclusion that speciation within the genus has been on an intercontinental basis. This conclusion is strengthened by a consideration of the wide range of tolerance of most of the species to climatic and other environmental conditions. If isolating factors have been largely oceanic or major geographic breaks, it is reasonable to expect such a fairly even distribution of the species among the faunal zones.

INTRODUCTION OF SPECIES BY COMMERCE

In *Trogoderma* the technique of plotting the geographic distribution of the various forms has afforded a solution to several problems. However, because the species are so readily distributed by commerce, the suspicion is always present that a plotted distribution is not a reflection of the actual historical segregation of a species. Nevertheless, it is possible, by applying a few simple rules, to determine with a fair degree of accuracy which elements in an area are adventitious. Some helpful criteria for the separation of indigenous from introduced species, together with some examples of the use of these criteria, are the following.

Unnaturally limited distribution.—It is more or less obvious that a distribution limited to large centers of human population would be unnatural in a genus such as *Trogoderma*, the members of which are commonly found as scavengers in bee and wasp nests, bird nests, and the like. *T. parabile*, although widely dispersed in the United States, is usually found in large cities only, and where it is found in more rural areas, it is nearly always as an economic pest of stored foods. Its widest single range of distribution in the United States seems to be in the San Joaquin Valley of California (fig. 5). The likely natural habitats of this area have been rather thoroughly combed for dermestids by Linsley (1942, 1946) and Linsley and MacSwain (1942). However, these authors found *parabile*³ occurring but once in what might be called a "natural" habitat, an English sparrow nest. Linsley and Michelbacher (1943) in a survey of California granaries found it occurring as a pest in at least ten granaries. Although this is described here as a new Nearctic species, it will in all probability eventually be identified with a species indigenous to another faunal region.

Unnaturally separated distribution.—It is not always possible to determine just which factors limit the distribution of a species, but when a species is found to occupy only a small part of a uniform geographic area, there is a good likelihood that it has been quite recently introduced. This is particularly true when the species has but feeble powers of migration, yet is as perfectly adapted to distribution by human activity as are *Trogoderma*. On the other hand, an unnatural distribution may be evident in a wide separation of populations of a species where no barriers to the natural spread of the populations are known to exist. The existence of several forms of *Trogoderma sternale* occurring between Washington, D.C., and New York City is an obvious example of such an unnaturally separated distribution. The species with its various forms is quite plainly indigenous to western North America (fig. 8). Similar examples of such a discontinuous distribution are doubtless to be found in *T. ornatum* (fig. 7), *T. simplex* (fig. 6), *T. boron*, and others.

Absence of geographic polytypy.—*Trogoderma glabrum* (Herbst), according to the description by Hinton (1945), shows several significant elytral and antennal variations in the Eurasian specimens. The remarkable uniformity of series collected in this country is evidence of an introduction of but one of these varieties, perhaps even of a single, gravid female.

On the basis of all available evidence the following lists represent the indigenous and the introduced species of America north of Mexico.

³ Misidentified as *Trogoderma versicolor* (Creutzer).

INDIGENOUS SPECIES

ornatum
sternale
grassmani
paralia
boron
simplex
primum
ballfinchae
fasciferum
sinistrum

INTRODUCED SPECIES

parabile
glabrum
angustum
versicolor (?)

RELATIONSHIPS WITHIN THE GENUS

With so few of the species of the world available for study, it is impossible to reconstruct the phylogeny of the genus. However, it is possible to group the Nearctic species according to their degrees of structural similarity. Arranged in a linear series, these groups are the following:

- | | |
|----------------------|---------------------|
| 1. <i>angustum</i> | 5. <i>paralia</i> |
| 2. <i>primum</i> | <i>boron</i> |
| <i>simplex</i> | <i>parabile</i> |
| 3. <i>fasciferum</i> | <i>versicolor</i> |
| <i>ballfinchae</i> | <i>glabrum</i> |
| 4. <i>ornatum</i> | 6. <i>sinistrum</i> |
| <i>sternale</i> | |
| <i>grassmani</i> | |

Of these *angustum* seems to be the most primitive, possessing an incompletely formed antennal fossa in the adult, and a comparatively simple development of larval setal characters. The group represented by *fasciferum* and *ballfinchae* (group 3) is actually out of place in any such linear arrangement of species. *Simplex* (group 2) and *ornatum* (group 4) are closer to each other than to the species in group 3. However, *fasciferum* and *ballfinchae* possess more characters in common with the groups on either side than with any other group in the series. This judgment is based on the characters of the adults, since the larvae and pupae of these two species are unknown.

Several authors have attempted to delimit *Trogoderma* by segregating some of the species into different genera. However, the genus is monophyletic as it now stands, and the separation of *Entomotrogous*, *Psacus*, *Eurhopalus*, and so on leaves the remaining species in a polyphyletic genus. Either all the groups above must be raised to generic or subgeneric standing, or none of them, if their natural relationships are to be maintained. *Acolpus primus* Jayne (which Casey was never able to examine) obviously belongs in the series together with *simplex*.

LIFE HISTORIES

The life history of *Trogoderma granarium* Everts, the well-known Khapra beetle of Eurasia, is more completely understood than that of any other species of the

genus. A rather full digest of work done on the species has been given by Hinton (1945). The following is a summary of the life history of the species, together with comparable information, where it has been available, on the life histories of Nearctic species.

The optimum temperature for development of *granarium* is 32° to 36° C. Adults do not normally feed, and food is unnecessary for the attainment of full fecundity and longevity. Likewise, *versicolor* does not need to feed as an adult (Norris, 1936). However, the writer has been unable to obtain eggs from adult specimens of *sternale maderae* which have been deprived of food and water.

Larvae of *granarium* normally feed on grain and cereal products, but are capable of developing on dried insects, blood, and the like. Most other species are capable of developing on cereals, but develop more rapidly on pollen or substances of animal origin. Specimens of *parabile* reared on dried horsebeans required about a year at room temperatures to attain maturity, whereas on pollen they completed about three cycles in the course of a year. *T. versicolor* is a common pest of stored grain, rice, seeds, and the like (Hinton, 1945), but in this country, according to a personal communication from R. T. Cotton, it is a very common pest in dried milk factories. Other species recorded as feeding on dried cereal products are *sternale* (Hinton, 1945), *simplex* (Linsley, 1944), and *ornatum* (Hinton, 1945). Recently found infesting granaries and presumably feeding on grain have been *angustum*, *boron*, and *grassmani*.

According to Marson (1924) larvae of *granarium* will live several years without food. Wodsdalek (1917) has shown that mature larvae of *versicolor* can starve for more than five years, and are capable of recuperation at any time when fed. Beyer (1922) found that larvae of the same species which had just hatched could be starved for three months.

There is no record of whether or not *granarium* will feed on its own exuviae. According to Wodsdalek (1917) and Beyer (1922) larvae of *versicolor* do not attack each other and do not eat their own skins or skins of other individuals of the same species, even when starving. However, partly eaten exuviae of *sternale maderae* have been found in mud-dauber wasp cells inhabited by the larvae. Larvae of *sternale maderae*, *simplex*, and *grassmani* individually reared on pollen in small glass tubes about the size of a lead pencil (corresponding in size to some wasp and bee nests in which these species are found in nature) have been observed eating their own exuviae.

Voelkel (1924) has shown that the length of the incubation period of the egg, the duration of the larval, pupal, and quiescent stages of the adult, and the total number of instars of *granarium* vary according to the temperature. At a temperature of 10° C. the life cycle was approximately 147 days, but at 34.3° C. it was approximately 35 days. Under optimum conditions the larvae molt four to seven times, but under adverse conditions they may molt up to fifteen times. Doubtless other conditions, such as quality and quantity of food, relative humidity, and so on, influence the duration of life and number of instars. Wodsdalek (1917) has shown that *versicolor* larvae, which lived three and a half years under adverse conditions, molted up to thirty-two times. However, at room temperatures in Wisconsin he found (1912) that larvae fed on dried insects and fish took about

five months to develop, molting eight to twelve times, most of the molts averaging 14 days. It seems evident that in nature most of our Nearctic species habitually produce but one generation a year.

Females of *granarium* emerge later than the males and ordinarily undergo one to three more molts than the male. Morison (1925) found that under optimum conditions the male molts four and the female five times. This is apparently true of all species to a certain degree. Under identical conditions females of *simplex* have been found to average ten instars, males seven to eight instars. It has been observed that in cultures of *sternale*, *parabile*, and *grassmani* males invariably appear 3 or 4 days to a week before the females.

Voelkel (1924) found that temperature has a significant effect on the length of life of adults of *granarium*, and has a certain effect, though not as significant in extent, on the number of eggs laid by the adults. At all temperatures mated females lived longer than mated males, and virgin females longer than mated females. No comparable data are available for other species.

According to Rahman and Sohi (1939), 78 per cent of one-day-old larvae of *granarium* are unaffected by light, the remainder being negatively phototropic. After the second day the majority are negatively phototropic, and after the fourth instar, all are negatively phototropic until pupation. A majority of adult males and about half of the adult females are negatively phototropic at all times. During oviposition more adult females are negatively phototropic than at other times. Beyer (1922) has shown that *versicolor* is negatively phototropic throughout its larval life and most of its adult life. The female becomes indifferent to light several hours or a day after the end of its oviposition period and finally becomes positively phototropic. The adult male also becomes positively phototropic during the last days of its life.

The adults of *granarium* mate only during the night (Voelkel, 1924). This is not true of *simplex*, *sternale maderae*, and *grassmani*, and is questionable in the case of *parabile*.

These comparisons show a rather close similarity between the known life histories of members of the genus. No data are available on the tolerance of different species to ranges of relative humidity, and except for *granarium*, no data are available on optimum temperatures. It is probable that significant differences between species and even between geographic forms of some of the species will eventually be found in these characteristics. The ability of *sternale maderae*, for example, to live in open bird nests as well as in bee or wasp nests probably represents a difference in tolerance to ranges of relative humidity, or ranges of temperature, or both, as against those species which are confined to bee or wasp nests.

The pupal stage of all species of *Trogoderma* is passed in the last larval skin. Hinton (1946) has described the protective function of the gin-traps of the pupa in *Dermestes*. Presumably the gin-traps of *Trogoderma* pupae serve the same end.

After molting the adult emerges from the pupal skin and, without leaving the larval skin, forces the pupal skin into a wad at the posterior end of the larval skin. The adult then passes a quiescent period in the larval skin, the length of which varies according to the temperature. At optimum temperatures the

quiescent adult stage lasts 12 to 24 hours in both sexes of *granarium* (Voelkel, 1924). Quiescent adults of *simplex*, *sternale maderae*, and *grassmani* have been observed to reënter the last larval skin when removed from it, and Wodsdalek (1912) and Beyer (1922) have observed the same behavior in *versicolor*. If the beetle, after being removed, reënters the larval skin with its head at the posterior end, it immediately leaves, reorients itself, and enters it again.

Preceding copulation a practically identical behavior pattern was observed in *sternale maderae*, *grassmani*, and *simplex*. Males in a closed petri dish appeared to be actively stimulated to sexual activity only when their mouthparts came in contact with the setae on the dorsal surface of the female. Unmated males and females seemed to move entirely at random, apparantly ignoring one another even when only a few millimeters apart. However, when the mouthparts, or possibly the antennae, of a male came in contact with any part of the dorsal surface of a female, the male immediately became intensely active and attempted to copulate. To achieve copulation, the male first oriented himself at about a 130° horizontal angle to the female, though not invariably. Then extruding the genitalia, the male stroked the pygidium of the female with the phallobase until the female ovipositor was extruded and copulation ensued. Whenever the male lost this initial contact with the female pygidium, his genitalia withdrew. The male would then directly return to the dorsum of the female, pursuing the female if necessary, apparently attempting to regain the stimulus offered by the contact of his mouthparts with the dorsal setae. The stimulus found, the process would be repeated. With an unreceptive female, an active male was observed to continue this behavior more than forty-five minutes. Ordinarily the entire process, including copulation, lasted not more than two and a half minutes.

Of four species available, *sternale maderae*, *grassmani*, *simplex*, and *parabile*, it was found that females would respond to sexual stimuli only from males of the same species. On the other hand, males of the first three, and in some instances males of *parabile*, were stimulated to sexual activity by coming into contact with the dorsum of a female of any of the other species.

NATURAL HABITATS

Trogoderma are ordinarily found as scavengers, living wherever there is a supply of food stuff of a high protein content and an environment suitable for their life and growth. The more common habitats are bird and mammal nests, tent caterpillar nests, spider webs, and old wasp and bee nests provisioned with spiders, insects, or pollen. In Colorado large numbers of *sternale plagifer* have been found in the tunnels of *Anthophora* bees, particularly where these tunnels have been re-used by the wasp, *Chlorion elegans*, which provisions its nest with tree crickets (see Fernald, 1906). Nests of birds and mammals are usually replete not only with old feathers or hair, but with the remains of many other insect inhabitants of the nests. Only dried foods are ordinarily eaten, but three species have been reported to feed upon living eggs. De Lepiney (1930, 1933) has found *versicolor* in Morocco eating the live as well as dead eggs of the gypsy moth, *Lymantria dispar*. Auten (1925) found the larvae of *ornatum* in Ohio under bark, feeding on the eggs of spiders and even eating into the egg capsules containing young spiders. Linsley

(1946) says that *sternale* in the webs of the black widow spider appears actually to enter undamaged egg sacs and to feed on the eggs as well as on insect remains and other debris in the web. On the other hand, Linsley and MacSwain (1942) could find no evidence that *simplex*, living in old used cells of *Anthophora*, ever attacked living insects. However, they were sometimes responsible for the death of bees by prematurely cutting into cells and exposing the occupants to the external environment, mold, parasites, predators, and the like. Large numbers of *boron* have been reared by W. F. Barr in Idaho from hackberry leaf galls which were made by psyllids, the dermestids feeding on the dead remains of psyllids which failed to mature, and perhaps also on their cast skins. This species has also been found in Colorado in *Sceliphron* wasp nests.

Other factors than a food supply apparently influence the geographic and ecological distribution of the various species. I have seen no records of *Trogoderma* from dry carcasses of dead animals in nature. Temperature and humidity are probably factors which permit *sternale maderae* and *parabile* to live in open bird nests, whereas in the same geographic area *simplex* is found only in the nests of wasps and bees. *Sternale maderae* also occurs in wasp and bee nests, but the only known occurrence of *simplex* in native habitats outside of wasps' and bees' nests is one occurrence in the nest of a tent caterpillar and one occurrence in a palm log in the burrows of bostrichids. Many potential habitats, such as the nests of many wild bees, *Vesputa* nests, and the nests of many mammals, have never been carefully investigated from the standpoint of dermestid populations.

Even less is known of the natural history of the adults. They are often taken on flowers or by beating or sweeping shrubs. However, the species that have been bred in the laboratory are apparently not obliged to feed on nectar nor to fly in order to breed successfully. The experiments on phototropism already referred to suggest that adults are found away from oviposition sites only after oviposition or at least only after initial oviposition. This undoubtedly accounts for the rarity of adults in outdoor collections, especially since the life span of the adult is so short. Records are too scanty to indicate whether or not adults that do fly to flowers have specific flower preferences.

ECONOMIC IMPORTANCE

Hinton (1945) and others have given a rather full treatment of the economic importance of various species of *Trogoderma*, which does not need to be repeated here. Nearctic species already known to be in some degree economically important are the following: *ornatum*, *sternale*, *versicolor*, and *glabrum*. Besides these, five other Nearctic species appear to be economically important or to have potential economic significance.

Parabile (misidentified as *versicolor*) has already been referred to as a pest of granaries in California. It has also been taken in Fresno, California, infesting dried horsebeans together with an infestation of *Dermestes maculatus* Degeer. Probably the larvae of *Trogoderma* would be unable to penetrate the tough seed coat of the horsebeans by themselves. At the same locality *parabile* has been found infesting stored prunes. In the prunes there was also an infestation of the silvanid, *Oryzaephilus surinamensis* (Linnaeus), not in large enough numbers to provide

insect remains for the numerous dermestids, but apparently providing ingress for the dermestids by breaking the outer integument of the prunes. No prunes were found with dermestid damage which did not also show either some mechanical damage to the skin or the work of the silvanids. The species has been found in Tucson, Arizona, infesting dried chili powder, and also as a pest in a house.

Another potentially important pest is *boron*, which apparently is a pest of granaries in the Midwest and Pacific Northwest. It has been found once in Idaho infesting an insect collection, and in Illinois infesting nuts and shelled corn.

As an economic pest, *simplex* appears to be of very minor importance. It has been collected in a farm granary at Salina, Utah, together with *sternale plagifer* and *grassmani*, and at Bozeman, Montana, in oatmeal. Nevertheless, Linsley and Michelbacher (1944), in a survey of one hundred and twenty-eight infested granaries in ninety-seven California localities, failed to turn up a single infestation of this species, although it has been established that the species will consume grain (Linsley, 1944). At Burness and at Del Rey, California, it was found infesting a raisin storage in 1931, but most likely feeding upon the remains of some other pest. Occasionally it is found infesting insect collections, although it has never yet been reported as a serious pest.

Trogoderma angustum may not be established in this country, but it is a potential economic pest. It has been taken in Ithaca, New York, as a pest in a granary. Its two other known occurrences in this country were infestations of insect collections.

Aside from the single instance of its association with *simplex* mentioned above, *grassmani* has never been reported as an economic pest.

GENERIC NOMENCLATURE AND DESCRIPTION

Trogoderma Berthold [Latreille?]

Trogoderma [Dejean, 1821, Cat. Col., p. 46] Berthold, 1827, in Latreille, Nat. Fam. Thierr., p. 352; Latreille, 1829, in Cuvier, Règne Animal, 4:511; Hope, 1840, Col. Man., 3:143; Erichson, 1846, Nat. Ins. Deutschl., 3:446; Sturm, 1847, Deutschl. Fn., 19:94; Lacordaire, 1854, Gen. Col., 2:467; Jacquelin du Val, 1857-1859, Gen. Col. d'Eur., 2:256; Thomson, 1862, Skand. Col., 2:206; Mulsant and Rey, 1867, Ann. Soc. Linn. Lyon (n.s.), 15:121; Reitter, 1880, Verh. zool.-bot. Ges. Wien, 30:71 (Best.-Tab. 3); Jayne, 1882, Proc. Amer. Philos. Soc., 20:361; Casey, 1900, Jour. N.Y. Ent. Soc., 8:151; Ganglbauer, 1892-1899, Käf. Mitteleur., 4(1):34; Sumakov, 1907, Rev. Russe Ent., 7:15; Dalla Torre, 1911, Junk Col. Cat., 33:67; Arrow, 1915, Ann. Mag. Nat. Hist. (8) 15:429; Scheerpeltz and Winkler, 1930, Tierwelt Mitteleur., 5 (Abteilg. 12):121; Armstrong, 1942, Proc. Linn. Soc. N.S. Wales, 67:321; Armstrong, 1945, *ibid.*, 70:47, 49; Rees, 1934, U.S.D.A. Misc. Pub. 511:11; Hinton, 1945, Monog. beetles assoc. with stored prod., 1:375; Hinton, 1946, Trans. Roy. Ent. Soc. Lond., 97(19):480.

Macroprion Hope, 1840, Col. Man., 3:109.

Eurhopalus Solier, 1849, in Gay, Hist. fis. Chile, Zool., 4:372.

Psacus Pascoe, 1866, Jour. Ent. Lond., 2:446.

Asidora Mulsant and Rey, 1867 (1868), Ann. Soc. Linn. Lyon (n.s.), 15:122.

Globicornis, Guérin-Méneville, 1868, Rev. Zool. Paris, p. 138 (non *Globicornis* Latreille, 1829).

Acolpus Jayne, 1882, Proc. Amer. Philos. Soc., 20:360; Casey, 1900, Jour. N.Y. Ent. Soc., 8:145;

Dalla Torre, 1911, Junk Col. Cat., 33:71 (new synonymy).

Eucnocerus Sharp, 1902, Biol. Centr.-Amer. Col., 2(1):648; Casey, 1916, Mem. Col., 7:190.

Entomotrogus Ganglbauer, 1904, Käf. Mitteleur., 4(1):33; Lepesme and Paulian, 1939, Soc. Zool. Fr., 64:159.

Adult male.—Body subparallel to narrowly ovate, moderately to strongly convex, moderately densely clothed with recumbent to erect hairs; hairs simple, not strongly scalelike, although light-colored hairs of dorsum occasionally somewhat flattened and ensiform. Head with front more or less vertical; plane of clypeus forming somewhat obtuse angle with plane of front; median ocellus distinct. Antenna 11-segmented or rarely 9- to 10-segmented; club 3- to 9-segmented, symmetrical, pectinate, or flabellate; segments of club, except terminal segment, usually quadrate to strongly transverse; terminal segment subequal in length to preceding two or three segments, never greatly enlarged. Pronotum punctate over entire surface; lateral margins more or less straight and slanting obliquely downward when viewed from side (only rarely a little sinuate), strongly or moderately convex with margins moderately or strongly and abruptly flanged when viewed from front. Elytra subequal in width to pronotum, smooth or feebly rugose. Epipleuron well developed and usually extending to or slightly beyond first abdominal sternite. Scutellum moderately large, more or less equilaterally triangular, about two to four times as broad as median ocellus. Hind wings as in figure 1, except for variations in stigma and first anal vein. Prosternum with anterior margin strongly or weakly deflexed and subtransverse at middle, thence oblique or arcuately rounded to sides; lateral extension of prosternum gradually narrowed or at least never appreciably longer at sides than above middle of procoxa, sides rounded or acutely angulate; posterior process moderately narrow and long and received in mesosternal sulcus, finely carinate along margins and with or without median carina. Hypomeron with antennal fossa quite variable in size and depth, but usually very distinct; posterior oblique margin of fossa elevated and more or less carinate at least as far as middle of fossa, usually for entire length of fossa. Mesosternal disc completely divided by deep and usually broad median sulcus. Metasternal episternum broad and not extending to caudal margin of hind coxa. Externally visible part of epimeron large and extending mesally about halfway across caudal margin of episternum. Legs with only front pair strongly retractile. Coxae large and with front pair feebly projecting; hind coxae extending laterally nearly halfway across caudal margin of episternum to meet mesal projection of epimeron. Tibiae without distinct teeth. Tarsi with basal segment slightly longer to twice as long as second. Abdomen with first sternite with or without sublateral discal carinae. First periphallie segment simple, without median hooks or spines and without lateral processes on sternite. Second periphallie segment narrowly ringlike, not divided into distinct tergite and sternite, dorsum a little expanded. Ventral plate broad, apically rounded, proximally acutely angulate or with narrow, short, proximal process. Small sclerotized plate present between ventral plate and bridge of lateral lobes. Phallobase with lateral lobes broad or narrow, connected ventrally at middle by narrow bridge. Aedeagus with variable Y-shaped apodeme at base.

Adult female.—Antennal club 3- to 6-segmented, symmetrical or serrate. Pronotum without lateral flanges. Antennal fossa usually somewhat more shallow than in male and proportionately narrower, posterior diagonal carina usually lower than in male.

*Pupa*⁴.—Pupal instar always enclosed in last larval cuticle so that only its middle dorsal surface exposed; last larval cuticle split so that median longitudinal fracture extends to or beyond posterior margin of sixth abdominal segment; abdomen without urogomphi; gin-traps present or absent, when present three in number, on abdominal segments 1-2, 2-3, and 3-4; posterior jaw of each gin-trap with numerous acute tubercles arranged in two, three, or four rows; anterior jaw serrate; depression beneath posterior jaw without a sclerotized transverse ridge or with a transverse ridge present but only weakly sclerotized.

Mature larvae.—Second and third thoracic and abdominal acrotergites with row of several series of very fine, appressed spicisetae; thoracic tergites with two or more rows of large, erect spicisetae and with or without row of spicisetae on posterior margin; smaller spicisetae variously arranged on tergites; short hastisetae inserted on tergites posteriorly of submedian row of large spicisetae, hastisetal tufts becoming progressively larger and denser posteriorly. First segment of antenna short with few to numerous nudisetae, rarely with one to many spicisetae, and with two sensory pores; second antennal segment one to three times as long as first, with or without setae, with a single sensory pore about middle and with two apical sensory

⁴ Drawn in large part from Hinton (1946), pupae of most genera being unavailable for comparison.

pores at base of short accessory papilla; third segment one to two and a half times as long as first, with two subbasal sensory pores and one apical sensory pore and with one or several distal sensory papillae. Middle setal series of labro-epipharyngeal margin with broad and slender setae, typically two broad inner and two slender outer setae, or with broad setae only. Epipharynx with distal sensory papillae in a single, sharply defined, compact group near distal margin of epipharynx; a median pair of sensory cups, a proximal transverse series of eight to twenty-four sensory cups; epipharyngeal rods slender, tapering posteriorly, diverging lateroposteriorly. Mandible distally rounded, inner cutting edges rounded; retinaculum present.

Type of genus.—*Anthrenus elongatulus* Fabricius, 1801, designated by Hope, 1840, 3:143.

Adults of *Trogoderma* are most readily separated from other Nearctic dermestids by characters found in the antennae and in the antennal fossae. All Nearctic species have an antennal club of four or more segments, and the club is widest at about the ninth or tenth segment (apparently true for all members of the genus except for the Eurasian *granarium*, in which the female club is 3-segmented and the number of antennal segments is sometimes reduced to nine or ten). In the closely related *Megatoma* the antennal club is composed of three considerably elongated segments. In *Cryptorhopalum* the club is 2-segmented, whereas in *Thaumaglossa* there is only one enlarged terminal segment. The antennal fossa of *Trogoderma* is large and does not exactly conform to the shape of the antenna, yet is more or less closed behind by a narrow, knifelike carina. *Megatoma*, on the other hand, lacks the posterior carina enclosing the hind margin of the fossa, whereas *Cryptorhopalum*, *Anthrenus*, and others have a small fossa which is enclosed behind by a much wider ridge and which more or less exactly conforms to the shape of the antenna.

Some exotic genera are much more difficult to separate from *Trogoderma*. The palearctic *Phradonoma*, said to differ from *Trogoderma* only in having the outer margins of the front tibiae toothed, is only questionably distinct. However, the separation of such groups is outside the scope of this study.

No information is available on the comparison of pupae of *Trogoderma* with other Nearctic Megatomini. Similarly the larvae of too few species of Megatomini have been studied to conclude which characters are of real significance at the generic level.

KEY TO SPECIES OF ADULT TROGODERMA

1. Elytral pubescence unicolorous; elytra immaculate, evenly dark brown.....2
 Elytra with pattern indicated either by areas of lighter and darker pubescence or by varied maculation3
2. Elytral pubescence closely appressed; female antennal club compact, arrangement of segments on pedicels not appreciably eccentric in either male or female.....*sinistrum*
 Elytral pubescence subdecumbent; female antennal club not compact, pedicels more or less visible, arrangement of segments on pedicels decidedly eccentric (fig. 13); male antenna flabellate (as in *fasciferum*, fig. 13).....*ballfinchae*
3. Elytra with a single antemedian band of light maculation, base of elytra rarely tending to be somewhat light as well.....4
 Elytra with more than one band of light maculation, or with no bands of light maculation, the pattern indicated by light and dark pubescence.....5
4. Male antennae strongly flabellate, female antenna pectinate; punctures on disc of pronotum separated by one-fourth to three-fourths diameter; antennal fossa completely margined behind by knifelike carina.....*fasciferum*
 Segments of antennae at most slightly eccentrically placed on pedicels (fig. 13); punctures

- on disc of pronotum contiguous; antennal fossa margined behind by a low, subacute ridge along median third, indistinctly margined along lateral two-thirds.....*primum*
5. Form long and narrow, ratio of width to length greater than 1:2.1; antennal fossa with low and subacute carina on median two-thirds of posterior diagonal margin, open behind on lateral third; pattern of elytron as in figure 12 (subbasal band not forming loop, submedian band well behind middle, apical pale spot present or absent); female with 3-segmented antennal club*angustum*
 Form relatively shorter, ratio of width to length 1:2.0 or wider; antennal fossa more or less completely closed behind by acute posterior diagonal carina; pattern of elytron typically with basal loop of light maculation and with submedian band at or just behind middle; antennal club of female with four or more segments.....6
6. Elytra entirely black, or black with small indefinite piceous markings on humeri and apical margins only (loop, submedian band, and subapical band indicated by light, mostly gray hairs)7
 Elytra with loop and submedian and subapical bands more or less distinctly indicated by light maculae8
7. Ratio of width (across humeri) to length (of pronotum and elytra) ranging from 1:1.81 to 1:1.98; segments of male antennal club rather loosely joined, eccentrically placed on pedicels*paralia*
 Ratio of width (across humeri) to length (of pronotum and elytra) ranging from 1:1.60 to 1:1.75; male antenna compact and symmetrical (similar to that of *versicolor*, fig. 13)*boron*
8. Antennal cavity coarsely and confluent punctate on all surfaces except for small smooth area near prosternal suture, punctures two or three times as large as facets of eye; female antennal club 5- or 6-segmented; basal loop of elytron never penetrated nor bisected by admedian line*simplex*
 Antennal cavity finely punctate with punctures about as fine as facets of eye, or shining and minutely striate; female antennal club 4-segmented, seventh segment of antenna somewhat enlarged or not; basal loop of elytron penetrated or bisected by admedian line or not9
9. Inner margin of eye with shallow to deep, arcuate emargination at middle; male antenna with third segment about half as wide as second, four terminal segments of club not serrate, compact; each side of metasternum marked with a fine stria.....10
 Inner margin of eye entire or only very slightly sinuate; male antenna with third segment narrow or subequal in width to second, four terminal segments serrate or not, compact or loose; metasternum marked with striae or not.....11
10. Inner margin of eye distinctly emarginate; configuration of male antennal club as shown in figure 13; admedian line of elytron evident, connecting loop and submedian band; lateral line usually present as short spur from loop; sutural line often present behind submedian band (fig. 12).....*versicolor*
 Inner margin of eye only shallowly emarginate to slightly sinuate; configuration of male antennal club as shown in figure 13; neither admedian line nor lateral line evident between loop and submedian band (fig. 12).....*glabrum*
11. Male antennal club not serrate, segments compactly or loosely joined; elytron with loop, submedian and subapical bands well marked, but with intervening lateral and admedian lines evanescent or absent.....12
 Male antennal club distinctly serrate and segments loosely joined so that pedicels are visible; anterior loop of elytron well marked, or partly evanescent, or represented only by posterior margin, but if loop well marked then admedian line connecting loop and submedian band also well marked and lateral lines usually present between loop and subapical band....13
12. Margins of male antennal club subparallel (fig. 13); club 8-segmented, eleventh segment bluntly rounded at apex; light hairs of pronotum almost entirely golden yellow.. *parabile*
 Male antennal club subclavate (fig. 13); club 5- or 6-segmented; eleventh segment acutely pointed at apex; light hairs of pronotum nearly evenly divided between golden yellow and white*glabrum*

13. Third segment of male antenna approximating second and fourth segments in length and width; segments of club decidedly eccentric or pectinate (fig. 13); loop of elytron bisected by admedian line, light areas forming both loop and admedian line being about same proportionate width so that if admedian line evanescent or continued only part way into loop, then loop extremely thin or evanescent (fig. 12).....*ornatum*
 Third segment of male antenna minute, about half either second or fourth segments in length and width; segments of club only moderately eccentric (as *sternale*, fig. 13); loop of elytron not bisected by admedian line, or if bisected by admedian line, then loop very pronounced, and admedian line and lateral line usually coalesced between loop and submedian band14
14. Basal half of loop always absent; pattern of elytral maculation as shown in figure 12
grassmani
 Loop always somewhat indicated on basal half; pattern and variations of elytral maculation as shown in figure 9.....*sternale*

KEY TO KNOWN MATURE LARVAE OF TROGODERMA

1. Setae of acrotergite of each abdominal segment long or short, but all extending across antecostal suture2
 Setae of acrotergites relatively short, anteriormost setae of acrotergite not extending across antecostal suture5
2. Setae of acrotergites short, not more than one-third as long as length of sclerotized part of abdominal tergites; setae of basal segment of antennae about half as long as second segment*angustum*
 Setae of acrotergites long, on abdominal segments one to four at least one-half as long as tergite; setae of basal segment of antennae as long or longer than second segment of antenna3
3. One or two setae inserted on second segment of antenna.....*sternale*
 No setae present on second antennal segment.....4
4. First segment of antenna approximating second in length; basal sensory pores of apical segment situated at about basal fourth; outer setal series of labro-epipharyngeal margin consisting of five to eight setae*grassmani*
 First segment of antenna about half as long as second; basal sensory pores of apical segment situated distad of basal third; outer setal series of labro-epipharyngeal margin of eight to eleven setae.....*ornatum*
5. Second segment of antenna at least three times as long as first or third segments; posterior margin of third thoracic and each abdominal tergite bearing no setae more than half as long as large spicisetae of disc of tergite; each tergite with numerous, short, somewhat blunt spicisetae near mid-line (fig. 18)*simplex*
 Second segment of antenna less than twice as long as either first or third segments; posterior margin of third thoracic tergite and usually first two abdominal tergites bearing a row of large spicisetae approximating in size those of disc of tergites; thoracic and abdominal tergites without such short, blunt spicisetae as those described for *simplex*.....6
6. Proximal sensory pore of terminal antennal segment situated directly on basal margin of segment; basal segment of antenna bearing nine to eleven setae, sometimes including spicisetae*versicolor*
 Proximal sensory pore of terminal antennal segment not on basal margin of segment, usually at about basal fourth or fifth; basal segment of antenna with few or many nudisetae, never (?) any spicisetae.....7
7. Posterior margin of at least first three abdominal tergites bearing a row of four to eight large spicisetae which approximate in size those of submedian row of tergites; eight or fewer nudisetae on basal segment of antenna, these inserted largely on medial side of segment*parabile*
 Posterior margin of first three abdominal tergites with no more than two spicisetae equal in size to large spicisetae of disc, usually with none; twelve or more nudisetae on basal segment of antenna, these inserted more or less evenly around entire circumference of segment*boron*

NOMENCLATURE, DESCRIPTION, AND DISCUSSION OF SPECIES⁵*Trogoderma angustum* (Solier)

(Figs. 12, 17)

Eurhopalus angustus Solier, 1849-1851, in Gay, Hist. fis. Chile, Zoologia, 4:374.*Trogoderma angustum*, Reitter, 1880 (1881), Verh. nat. Ver. Brünn, 19:39; Dalla Torre, 1911, Junk Col. Cat., 33:67.

Adult male.—Color of head black, pronotum black to piceous with lateral margins brownish and with or without lateral basal brownish spots; elytra dark to light piceous transversed by three, light, reddish-brown maculae; undersurfaces black; legs light to dark brown. Pubescence of dorsal surfaces coarse, suberect, consisting of blackish, golden-brown, and white hairs; pubescence of undersurfaces moderately coarse, recumbent, almost entirely white except for golden-brown hairs of tibiae and tarsi. Head with punctures about as coarse as facets of eye, separated by less than half a diameter on front and by as much as one diameter on vertex, each puncture with a granule in center; surface between densely and minutely granulate-punctate; pubescence of evenly distributed black hairs and white hairs with a very few golden-brown hairs. Antenna 11-segmented, extending in repose to base of pronotum or slightly beyond, piceous with second and third segments light brown, moderately densely set with short, fine, erect setae; segment three minute; segments four to eight slightly eccentric; segment eleven somewhat shorter than nine and ten combined. Eyes medially rounded. Pronotum with punctures of disc simple, one to two and a half times as large as facets of eye, becoming somewhat larger and denser toward sides; surface between very minutely and densely punctate-granulate, more coarsely so on sides; hairs of pronotum predominately white, or with more black hairs on disc and white hairs largely disposed in patches on lateral basal angles. Elytra with punctures of disc shallow, one and a half to two times as large as facets of eye, separated by one to two diameters, simple or with slightly raised margins; surface between indistinctly, microscopically wrinkled; maculation as illustrated; light pubescence coinciding with light maculation and consisting almost entirely of white hairs. Epipleura extending slightly beyond middle of first abdominal sternite, transversely flattened along most of length. Prosternum moderately striate-punctate on disc, confusedly punctate toward sides; process long with sides parallel to blunt apex; median carina extending length of process, narrower than lateral carinae. Antennal fossa half as wide as long, extending to base of pronotum and moderately deeply excavated; posterior diagonal ridge low, subacute, extending to angle of the floor of fossa and of the acutely deflected anterolateral wall of fossa; floor of fossa finely, densely punctate. Mesosternal disc with raised part on either side of sulcus almost three times as long as wide, sides parallel. Metasternum without oblique discal striae; median anterior projection strongly, triangularly produced between mesocoxae, narrowly margined. Ratio of width between procoxae to mesocoxae about 1:1.6. Abdomen without oblique striae on first sternite. Length (of pronotum and elytra) ranging from 2.2 mm. to 3.0 mm. Ratio of width (across humeri) to length varying from 1:2.1 to 1:2.3.

Adult female.—Antenna extending in repose to about middle of lateral margin of prothorax; club 3-segmented. Antennal fossa moderately deeply excavated, a little more than half as wide as long. Length (of pronotum and elytra of the only two specimens available to writer): 2.8 mm. Width (across humeri): 1.2 mm.

Mature larva.—Acrotergites of thorax and abdomen very weakly sclerotized; fine spicisetae of acrotergites short, not more than one-third as long as length of sclerotized part of abdominal tergites, but all extending across antecostal suture; no setae inserted anteriorly of row of large submedian spicisetae on disc of abdominal tergites and only hastisetae inserted posteriorly of submedian spicisetae; no spicisetae inserted on posterior margin of abdominal tergites. An-

⁵ In the synonymical bibliographies which follow only those references are included (1) to the original publication of the name of the species; (2) to the original publication of each name which has been placed in synonymy; (3) to each taxonomic treatment related to the Nearctic occurrence of the species; and (4) to biological references to the species where the writer is reasonably certain of the correct identification.

tennae with nudisetae only; setae of basal segment about half as long as length of second segment; second segment with two or three nudisetae; accessory papilla ovate or subquadrate, not extending much beyond base of terminal segment; configuration of antenna and approximate location of sensory pores as figured (fig. 17). Outer setal series of labro-epipharyngeal margin 8 to 10. Proximal series of epipharyngeal sensory papillae 8.

Type locality.—Chile.

Recorded distribution.—Santa Rosa and Copiapo, Chile.

Distribution of specimens examined.—NEW YORK: Ithaca, 1945, "in grain" (R. M. Schuster); MAINE: Lewiston, April 27, 1926, "ex specimens in museum" (F. E. Pomeroy). In addition to these, several specimens were examined which were found infesting an insect collection recently purchased and brought up from Chile by the California Academy of Sciences.

Adults of this species are easily separated from all other species treated in this paper by their elongate form, peculiar elytral pattern, and punctation of the head and pronotum. Of the Nearctic species, only *primum* has a similarly incomplete or weak posterior diagonal margin of the antennal fossa and is liable to be confused with this. But *primum* has a proportionately shorter form, only one distinct band of light maculation on the elytra, and an entirely different punctation of the head and pronotum.

Larvae are easily distinguished from the others described here by the short setae of the acrotergites, and by the lack of large spicisetae on the posterior margins of the abdominal tergites. The former, even though all short, all extend across the antecostal suture. Pupae of this species are unknown.

Little is known of the biology of this species. It has been found as an economic pest in a granary but once, but apparently it will consume grain. Otherwise it is known as a pest only rarely in insect collections.

Trogoderma primum (Jayne), new combination

(Figs. 12, 13, 14, 15)

Acolpus primus Jayne, 1882, Proc. Amer. Philos. Soc., 20:361; Casey, 1900, Jour. N.Y. Ent. Soc., 8:145; Dalla Torre, 1911, Junk Col. Cat., 33:71.

Adult male.—Color of head and pronotum black; elytra dark brown transversed by a single, moderately narrow, light brown to reddish-orange band; undersurfaces piceous black to dark brown, legs brown. Pubescence of dorsal surfaces coarse, suberect; hairs bicolorous, piceous black and whitish; pubescence of undersurfaces moderately fine, recumbent, bicolorous, whitish with few intermingled golden-brown hairs; pubescence of legs mostly golden brown. Head with punctures two to three times as large as facets of eye, closely contiguous (but distinct and rarely confluent) over entire surface; pubescence mostly whitish with a few scattered dark hairs. Antenna 11-segmented, extending in repose to middle of lateral length of pronotum or nearly to base of pronotum, but not attaining base, light to dark brown, densely set with very short, fine, suberect puberulence; segment three minute; segments four to eleven eccentrically placed on pedicels; segment eleven shorter than segments nine and ten combined; configuration as illustrated. Eyes medially straight to rounding, not at all emarginate. Pronotum with punctures of entire surface three to four times as coarse as facets of eye, shallow, contiguous (but not confluent); hairs mostly dark except for whitish hairs disposed along lateral margins in an anterior and a posterior band, in a median anterior patch, and in a patch on basal lobe. Elytra with punctures not more than twice as coarse as facets of eye, separated on disc by two to three diameters, becoming closer toward base; each puncture with anterior margin moderately to strongly raised above surrounding area; surface between smooth and shining; whitish pubescence disposed in narrow band at basal margin, in wider band coinciding with light-colored band of maculation at basal third, and over entire apical third thinly intermingled with dark hairs; maculation as illustrated, but rarely including a narrow light area

along basal margin. Epipleuron with both margins separately defined at least as far as posterior margin of first abdominal sternite, transversely shallowly concave along entire length. Hind wings with short proximal spur on stigma; first anal vein weak, but extending nearly to margin of wing. Prosternum deeply, coarsely, confluent punctate to granulate; posterior process with sides parallel to apex; median carina low and narrower than lateral carinae, or absent. Antennal fossa approximately three-fifths as wide as long, extending at least four-fifths of distance to base of pronotum, shallowly excavated; surface with moderately shallow contiguous or confluent punctures which are twice as coarse as punctures of eye; posterior diagonal margin with low subacute ridge along median third, more or less open behind or margined by indistinct carina along lateral two-thirds. Mesosternal disc with raised part on either side of sulcus about twice as long as wide, sides subparallel. Metasternum without oblique discal striae; median anterior projection narrowly, irregularly rounding to subacutely angulate, strongly margined. Ratio of width between procoxae to width between mesocoxae varying from 1:1.7 to 1:2.2. Abdomen with discal striae of first sternite present, diverging obliquely outward from inner margin of coxal cavity and extending from one-third to nearly full length of sternite. Genital segments as illustrated. Length: 2.1 mm. to 2.4 mm. Ratio of width (across humeri) to length (of pronotum and elytra) ranging from 1:1.78 to 1:1.96.

Adult female.—Antenna not extending much beyond middle of lateral length of pronotum; antennal club 6-segmented; configuration as illustrated. Antennal fossa approximately one-half as wide as long. Length: 2.3 mm. to 2.9 mm.

Type locality.—Texas. Lectotype in the Academy of Natural Sciences of Philadelphia.

New records.—TEXAS: Brownsville, May 8 to August 8, various years (J. N. Knull); May 7, 1904 (H. S. Barber); June 26, 1895 (Townsend); Cypress Mills (Chittenden); San Diego (E. A. Schwarz); Victoria, June 21, 1913 (J. D. Mitchell); OKLAHOMA: Woods County, May 9, 1911 (R. D. Bird).

This species has been collected on flowers of snapdragon and at lights. Other details of its biology and stages other than the adult are unknown.

What the final generic assignment of this and the two previous species will be must depend on a study of the genus over its total range. It is unquestionably close to *variegatum* (Solier), which Hinton places in *Trogoderma*. It is certainly as close to the type of the genus as is *simplex*, which it resembles in many ways. Apparently it differs from *variegatum* principally in the character of its elytral maculation, and from it, may eventually prove to be but subspecifically distinct. From *simplex* it can be easily distinguished by the character of its elytral maculation, and by its dense pronotal punctation.

Trogoderma simplex Jayne

(Figs. 5, 14, 15, 16, 18)

Trogoderma simplex Jayne, 1882, Proc. Amer. Philos. Soc., 20:362, pl. 2, figs. 51, 52; Casey, 1900, Jour. N.Y. Ent. Soc., 8:151; Dalla Torre, 1911, Junk Col. Cat., 33:70.

Trogoderma pollens Casey, 1900, Jour. N.Y. Ent. Soc. 8:153; Dalla Torre, 1911, Junk Col. Cat., 33:69 (new synonymy).

Trogoderma ajax Casey, 1924, Mem. Col., 11:186 (new synonymy).

Adult male.—Color of head and pronotum black; elytra piceous black to black with variable reddish to ochereous maculae; undersurfaces black; antennae light brown to piceous; legs light to dark piceous. Pubescence of dorsal surfaces coarse, suberect, consisting of blackish, golden-brown, and white hairs; pubescence of ventral surfaces of medium coarseness, recumbent, cinereous, or pale golden brown. Head with punctures on anterior part of front and clypeus shallow, twice as coarse as facets of eye, separated by one-half to one-fourth diameter or occasionally contiguous, and on posterior half of front and on vertex about equal in coarseness to facets of eye, separated by one to two diameters or occasionally much sparser; pubescence of mixed golden-brown and dark hairs, rarely with all golden-brown hairs or rarely with a few

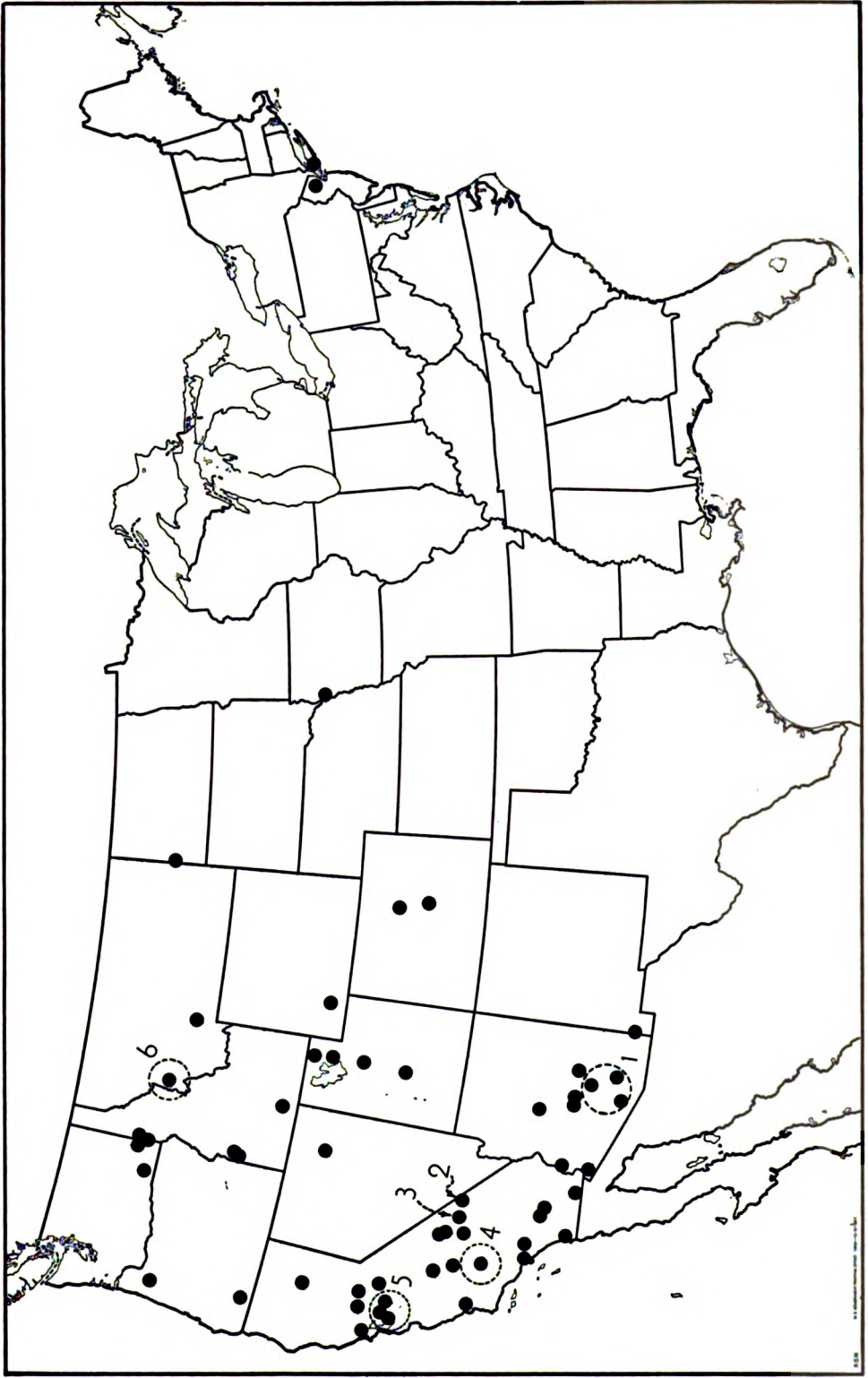


Fig. 5. The known distribution of *Trogoderma simplex* Jayne. The numbers designate localities from which area samples have been described in the text.

scattered whitish hairs. Antenna 11-segmented, extending in repose to a point about two-thirds distance of lateral margin of thorax toward base; surface of segments four to eleven clothed with very short, dense, suberect puberulence; segment three minute, segments four to eleven slightly eccentrically placed on pedicels; segment eleven approximately as long as segments eight, nine, and ten combined. Eyes with medial margins straight, not at all sinuate nor emarginate. Pronotum with surface shining and smooth; punctures on disc simple, about one and one-half times as coarse as facets of eye, separated by one to two and a half diameters, becoming coarser and having elevated rims on lateral margins; pubescence of dark, golden-brown, and white hairs in variable pattern, usually with light hairs more numerous at sides and base and with cluster of white hairs on basal lobe, but sometimes with white hairs covering nearly entire pronotum. Elytra with punctures of disc simple or with anterior margins microscopically raised above surrounding surface, about twice as coarse as facets of eyes, separated by one to two diameters; surface between smooth and shining; maculation with variations described in the "area samples" following, but typically with a basal loop, a submedian band, a subapical band, and an admedian line between loop and submedian band; pubescence variable with light pubescence usually disposed in patches on light-maculate areas, rarely with golden-brown hairs scattered over entire elytron. Epipleuron extending barely to hind margin of metepimeron or slightly beyond, transversely flattened for most of length. Hind wings without proximal spur on stigma; first anal vein extending nearly to margin of hind wing and unbranched or with one or two short costally directed branches. Prosternum coarsely and confluent punctate to coarsely granulate; posterior process of moderate width, sides straight and gradually tapering to apex; median carina of process raised, slightly wider than lateral carinae. Antennal fossa half to slightly less than half as wide as long, shallowly excavated; anterolateral wall slightly concave to strongly convex, rarely so strongly convex as to reduce excavated area to half usual width; entire surface very finely pubescent and (with exception of small, minutely striate and shining area near prosternal suture) covered with large, shallow punctures two to three times as coarse as facets of eye; punctures contiguous to confluent, sometimes so confluent as to give surface granulate appearance; posterior diagonal wall raised with margin extending as knife-like carina full length of fossa. Mesosternal disc with elevated part on either side of sulcus usually longer than wide, roughly triangular or rhomboidal. Metasternum not marked with oblique discal striae; median anterior projection moderately to strongly margined and moderately narrowly rounded. Ratio of width between procoxae to width between mesocoxae varying from 1:1.7 to 1:2.5. Abdomen without lateral discal striae on first sternite. Tergite of first periphallie segment with short, unsclerotized area across middle of distal margin. Lateral lobes of phallobase relatively broad, strongly incurved at apices; bridge narrow, strongly arcuate. Length (of pronotum and elytra): 2.2 mm. to 3.5 mm. Ratio of width (across humeri) to length (of pronotum and elytra) varying from 1:1.61 to 1:1.87.

Adult female.—Antennae extending in repose no farther than middle of lateral length of pronotum; surface clothed with short pilosity and longer fine setae; terminal club consisting of five or rarely six compactly joined and symmetrically placed segments. Antennal fossa about one-third as wide as long, extending nearly to base of prothorax; anterior diagonal wall concave to convex; posterior oblique margin with carina low but distinct for entire length; floor of fossa sculptured as in male. Length (of pronotum and elytra): 2.4 mm. to 4.4 mm.

Pupa.—Gin-traps present; posterior margin of fourth abdominal tergite sclerotized or not, but if sclerotized then sclerotized area less than a fourth as wide as sclerotized area of anterior jaws of gin-traps and not serrate posteriorly; anterior jaws of gin-traps strongly and more or less regularly serrate; teeth roughly equal in length to distances between apices; posterior jaws of gin-traps rather strongly concave with margin bearing row of large tubercles rather regular in size and arrangement below, and three or four series of much smaller tubercles above; series of smaller tubercles expanded laterad of posterior jaw into wide tuberculate band extending across integument nearly to margin of tergite; setae in posterior depression of gin-trap 36 to 50.

Mature larva.—Acrotergites of thorax and abdomen strongly sclerotized; fine spicisetae of acrotergites short with anteriormost not extending across antecostal suture; disc of each thoracic and abdominal tergite with row of large submedian spicisetae; row not quite extending to

mid-line but with more or less dense patch of short, blunt, somewhat stout, suberect spicisetæ occupying area near mid-line (fig. 18); posterior margin of thoracic and first four or five abdominal tergites with row of moderately stout spicisetæ of medium length. Antenna with nudisetæ only, or more rarely with some spicisetæ; setæ of basal segment less than half as long as length of second segment; second segment three times as long as first or third segments, and bearing one to five setæ; accessory papilla subquadrate, rarely extending to base of terminal segment; configuration of antenna and approximate location of sensory pores as figured. Outer setæ of labro-epipharyngeal margin 10 to 16. Proximal series of epipharyngeal sensory papillæ 13 to 18.

Type locality.—Western states. Lectotype in the Academy of Natural Sciences of Philadelphia.

In his original description of the species Jayne distinguished it from other *Trogoderma* by the small antennal cavity formed by the strongly convex anterolateral wall of the cavity. This character does not hold, however, for all forms of the species, and is at best a possible subspecific character. Besides the characteristic pubescence and maculation of its various geographic forms, the configuration of the male antenna and the sculpture of the antennal fossa are sufficient to identify the species. Only in *primum* and *simplex* is the floor of the antennal fossa covered with large, contiguous, or confluent punctures and from the former, *simplex* is easily separated by the punctation of the pronotum, which is not confluent, and by the elytral maculation.

The larvae are most readily separated from those of other species treated here by the presence of dense clusters of short, blunt spicisetæ along the mid-line of each thoracic and first four or five abdominal tergites. Ordinarily no hastisetæ nor longer spicisetæ are intermingled with them, so they stand out in sharp contrast to the other setæ of the tergite. The elongated form of the antennæ also affords a quick identification of the larva when it is mounted on a slide.

Apparently this species is indigenous to North America from the Rocky Mountains west to the Pacific coast. The easternmost extension of its natural range seems to be in the eastern foothills of the Colorado Rockies, but it has been introduced at Sioux City, Iowa; Beach, North Dakota; Long Island, New York; and the state of New Jersey.

The species is highly polymorphic, and the problems connected with its infraspecific forms are still far from a complete solution. Characters associated with its geographic variants are found in the pattern of the vestiture, in the structure of the anterolateral wall of the antennal fossæ, and in physiological responses connected with reproduction. Specimens from Contra Costa County, California, will not interbreed with specimens from Tucson, Arizona, under laboratory conditions in which mating readily occurs with pairs from one locality or the other. Any specimen from Contra Costa County may easily be distinguished from any specimen from Tucson or its vicinity by wide differences in vestiture. Furthermore, the Contra Costa specimens all have a more or less strongly convex anterolateral wall of the antennal fossa, whereas the wall is uniformly concave in the Tucson specimens. These differences would easily establish the two forms as good species, except that every possible morphological intermediate exists in an apparently evenly graded cline between the two areas. Unfortunately, living adults for breeding experiments have so far been available only from Contra Costa County and Indio, California, and Tucson and Florence, Arizona. Speci-

mens from the last three named localities are morphologically close and behave the same when an attempted cross-mating is made with *Contra Costa* individuals. Until breeding pairs are available from intermediate localities, the true taxonomic picture will not be established.

There are two conceivable taxonomic explanations. One suggestion is that an actual but unrecognized dividing line exists between the forms, separating them into allopatric species (or at least good subspecies), the failure to recognize them as species arising from the highly polymorphic nature of one or both forms which may at times superficially resemble each other, but which actually remain more or less completely separated by a sexual barrier. A second possible interpretation, and the one that I am tentatively adopting because it seems to offer a better explanation for the distribution of the forms outside the areas of Arizona and California discussed above, is that the sexual differences between the more remote geographical forms are, like the morphological differences, quantitative and gradual. If this theory is true, it will eventually be found that the ease or difficulty with which experimental cross-matings can be achieved varies proportionately with the distances from which the members of a pair are taken.

However, the analysis of the evidence has to depend on series taken from natural habitats where there has been little likelihood of recent introduction, since, as with most *Trogoderma*, accidental dispersal by commerce may greatly distort the geographic picture. The localities from which six such series have been taken are indicated on the accompanying map (fig. 5), and these steps of the cline are described below as unnamed varieties. Specimens taken from intermediate localities agree for the most part as progressive stages between the points selected for description. There are exceptions to the trends, but these exceptions consist either of unique specimens or series too short to indicate a true varietal difference, or of series taken in a situation suspiciously suggesting a recent introduction, such as in an insect collection of a museum.

Area sample No. 1 (Tucson and Florence, Arizona): Pubescence of basal half of elytral loop of one or two very small patches of light-colored, mostly white hairs, or of black hairs only; humeral extension almost entirely white; posterior half of loop entirely white or of patches of white separated by patches of golden brown; basal half of loop not evident in maculation, or indicated only by a small patch of light maculation; posterior half of loop light-maculate to suture; admedian line not evident; submedian band narrow or broken; subapical band narrow laterally, gradually expanding toward suture. Anterolateral wall of antennal fossa concave.

Specimens from southwestern New Mexico and central and southern Arizona agree rather closely with this form, except for two specimens from the Pinal Mountains, Gila County, Arizona (D. K. Duncan), which have a much more pronounced pattern of elytral maculation and which may be part of a distinct montane variation. One specimen from Tempe, Arizona, is similar, except for a pronounced admedian line between the loop and the submedian band.

Area sample No. 2 (Furnace Creek, Death Valley, California): Pubescence of basal half of elytral loop of black hairs sparsely intermingled with a few white hairs; pubescence of humeral extension and posterior half of loop usually of mostly white hairs, occasionally with a large number of intermingled golden-brown hairs; basal half of loop not indicated in maculation; posterior half of loop light-maculate only on lateral half of elytron and indicated medially

only by light-colored pubescence; admedian line not evident; submedian band narrow or broken; subapical band narrow laterally, abruptly expanded toward suture. Anterolateral wall of fossa concave.

This form differs principally from that of the first locality in the reduced pattern of the elytral loop. Specimens from Palm Springs, Indio, Coachella, Claremont, and Los Angeles, California, seem to fall roughly between this form, the form described under Area sample No. 1, and those to be described under Area sample No. 4.

Area sample No. 3 (Panamint Mountains and Panamint Valley, California): Pubescence of basal half of loop of black hairs or of a few scattered white hairs; humeral extension and posterior half of loop of sparse or dense white patches, occasionally of mostly golden-brown hairs, although sutural quadrant nearly always white; loop not indicated in maculation except at lateral posterior quadrant; admedian line not evident; submedian band narrow or broken or limited to small lateral spot of light maculation; subapical band usually reduced to sutural spot of light maculation. Anterolateral wall of fossa medially convex, laterally obliquely flat or concave.

In addition to the characters described above, most of the specimens of the series examined are considerably smaller than average specimens of *simplex* and may have a preponderance of golden-brown hairs scattered evenly over the elytra. However, as has been pointed out previously, these characteristics seem to be common to all species of *Trogoderma* taken in the deserts, possibly the result of a limited food supply. This form differs principally from those of Area sample No. 2 in the more convex shape of the anterolateral wall of the antennal fossa; otherwise it might be considered nearly identical with it. Two specimens from Lone Pine, Inyo County, California, are nearly identical, as are two specimens from the Santa Rosa Mountains, California, but a single specimen from near-by Independence, California, appears to belong to a quite different form in having a complete elytral loop and a distinct admedian line. Four specimens from Little Lake, Inyo County, California, are of a rather different form, with a widely suffused area of light maculation between the loop and the submedian band, as well as an unusual arrangement of white and golden-brown pubescence. It is entirely possible that a number of forms are to be traced in the mountainous, semiarid, and desert regions of eastern California and of Nevada. However, collections from these areas are too limited at present to form any sound basis of judgment.

Area sample No. 4 (20 miles east of Bakersfield, California): Pubescence of basal half of loop of black hairs with a few scattered white hairs; white hairs forming somewhat denser patch along sutural quadrant; humeral extension of golden-brown hairs with large or small patches of white; loop usually indicated in maculation only at lateral posterior quadrant, although occasionally complete on posterior half with basal part indicated by a few light-maculate spots; admedian line only occasionally evident; submedian band broken; subapical band reduced to small spot near suture or continued across elytron. Anterolateral wall of fossa slightly to moderately strongly convex.

Rather wide differences are apparent in the elytral maculation of specimens from this locality, but the uniformity of the pattern of pubescence and of the shape of the antennal cavity is no less than expected for any particular local

population. A progression toward the northern California form is clearly seen in the more convex anterolateral margin of the antennal fossa and in the greater preponderance of golden-brown hairs in the lateral posterior quadrant of the loop.

Area sample No. 5 (Alameda, Contra Costa, and San Joaquin counties, California): Pubescence of basal and sutural parts of loop of dense patches of white with a few scattered golden-brown hairs; pubescence of humeral extension and posterior half of loop preponderately golden brown with a few, small, interspersed patches of white; loop usually more or less completely indicated in maculation except lateral basal quadrant; admedian line always evident in maculation; lateral line sometimes evident and sometimes fused with admedian line to form wide, suffused, light line between loop and submedian band; submedian band nearly always entire, covered with dense but narrow patches of white pubescence; subapical band entire, usually covered with white pubescence; apical part of submarginal line often indicated by light maculation and a few scattered light hairs. Anterolateral wall of fossa slightly to strongly convex.

This form is marked by a predominance of white patches of pubescence on the light-maculate areas of the elytron except for the golden-brown lateral posterior quadrant of the loop, by a strongly pronounced pattern of elytral maculation, and by the convex anterolateral wall of the antennal cavity. A good series has been taken about four miles south of Antioch, Contra Costa County, in nests of *Osmia*. Another good series from Penryn, Placer County, reared from nests of mud-dauber wasps by A. T. McClay, differs from these just described in no significant detail. Specimens from various localities in the San Joaquin Valley of California, however, are all intermediate between these and the form just previously described.

Other California localities indicated on the map but not discussed above present special problems. Two specimens collected in the California coast range five miles north of San Luis Obispo are more like the southern Arizona form than any other. Likewise the Arizona form is apparent, though not so unexpectedly, in one specimen taken in San Diego County (F. E. Blaisdell). Specimens from Shasta County, California, as well as those from Medford and McMinnville, Oregon, seem rather like those described in *Area sample No. 5*, but may represent further geographic varieties. The writer has not seen series sufficiently long to justify a description.

Area sample No. 6 (Ravalli County, Montana): Pubescence of basal quadrant of loop black with two or three small patches of white; sutural quadrant with one or two slightly larger patches of white; basal half of loop mostly golden brown with scattered white hairs or small patches of white; humeral extension mostly white; basal half of loop light-maculate on lateral two-thirds; admedian line faintly indicated; submedian band entire or broken and covered with white pubescence; subapical band wide or narrow or subobsolete. Anterolateral margin of antennal fossa moderately to strongly convex.

This form differs from the preceding variety, although it has a similar convex anterolateral margin of the antennal fossa, in having much smaller patches of white pubescence on the basal and sutural quadrants of the loop and in not having those same sections of the loop light-maculate. Only three specimens have been seen from Ravalli County (each collected by W. L. Jellison); these were taken from the cells of the bee *Diadasia* and very probably represent an indigenous population.

No small doubt surrounds the varietal status of specimens from the remaining western localities. Three specimens taken in Bozeman, Montana (D. J. Pletsch), are decidedly unlike any of the varieties previously described, but having been found infesting a commercial product, may easily have been introduced from almost anywhere. The specimens from Utah seem to be rather similar to those from Ravalli County, but have a slightly concave anterolateral wall of the antennal fossa. Single specimens from Hansen, Twin Falls, and Caldwell, Idaho, are individually quite different from one another, and one or more probably represent introductions. A series from Moscow, Idaho, was taken infesting an insect collection, and is thus of questionable significance. A large series has been taken at Sioux City, Iowa (C. N. Ainslie), and interestingly enough, seems to include elements of all the varieties previously described, suggesting multiple introductions and subsequent crossbreeding. However, it is well to be cautious at this point, because not many *Trogoderma* at all have been taken from Iowa or throughout the northern states of the Great Plains except in the large metropolitan districts, so that native populations which may be present remain virtually unknown. Larvae of this species have been found in *Anthophora* bee nests near Morrison, Jefferson County, Colorado, but a sufficient number of adults has not yet been reared to afford a description of the normal varietal pattern.

The eastern localities in which *simplex* has been found unquestionably represent introductions; it is in fact a question whether the species has become established at any of these points. Three specimens from Long Island, New York (Schaeffer collection), seem to belong to the variety described under Area sample No. 1, whereas a single specimen examined from New Jersey (Schaeffer collection) compares most closely to specimens taken in the central San Joaquin Valley of California.

The normal habitat of this species appears to be the nests of bees and wasps. Unlike *sternale* it has not, to my knowledge, ever been taken in the nests of birds or spiders, although it has been found once by E. G. Linsley in the nest of the California tent caterpillar, *Malacosoma californica*. The nests of Hymenoptera in which it has been found are the following: *Anthophora linsleyi* Timberlake, *A. bomboides stanfordiana* Cockerell, *A. pacifica* Cresson, *A. occidentalis* Cresson, *Chlorion (Isodontia) elegans* (Smith), *Diadasia* sp., *Osmia lignaria* (Say) (Linsley, 1946), *Sceliphron caementarium* (Drury), *Ancistrocerus tuberculocephalus sutterianus* (Saussure), *Xylocopa orpifex* Smith (Linsley, 1943), and *Chrysis (Pyria) clara* Cresson. At Indio, California, in 1928, F. A. Thackery found this species in a palm log containing the giant bostrichid, *Dinapate wrighti* Horn, where it may have been feeding on the remains of the bostrichid or perhaps on material stored by bees nesting in the burrows of the log. Adults have been observed on flowers of two plants, *Prosopis* sp., and *Eucnide urens*.

Trogoderma fasciferum Blatchley

(Figs. 12, 13)

Trogoderma fascifera Blatchley, 1914, Can. Ent., 46:67; Blatchley, 1922, *ibid.*, 54:29.

Trogoderma flabellata Blatchley, 1922, Can. Ent., 54:28 (new synonymy).

Adult male.—Color of head, pronotum, and elytra black; elytra transversed by single, wide, irregular, antemedian, ochereous-red band; color of undersurfaces piceous black; legs brown.

Pubescence of dorsal surfaces subrecumbent, moderately coarse, uniformly dark piceous; pubescence of undersurfaces recumbent, fine, light brown. Head with punctures two to three times as large as facets of eye, closely contiguous (but distinct and rarely confluent) over entire surface. Antennae 11-segmented, densely covered with extremely minute, recumbent, cinereous puberulence; first three segments light piceous, segments four to eleven dark brown; segment three minute; segments four to eleven flabellate; configuration as illustrated. Eyes with medial margins straight, not at all sinuate nor emarginate. Pronotum with punctures two to three times as coarse as facets of eye, separated on disc by one-fourth to three-fourths diameter, but becoming confluent toward sides; surface between shining and smooth. Elytra with punctures of disc twice as coarse as facets of eye, separated by one-half to two diameters, somewhat more closely set toward base, each puncture with anterior margin distinctly raised above surrounding area; surface between smooth and shining; maculation as figured. Epipleura extending just behind metepimera, transversely shallowly concave along entire length. Prosternum deeply, coarsely, confluent punctate; posterior process rather narrow with sides arcuate on basal half, thence nearly parallel to apex; median carina of process distinct, as narrow as marginal carinae, but raised well above them. Antennal fossa about three-fifths as wide as long, extending practically to base of prothorax, deeply excavated; anterolateral wall concave but somewhat horizontally inflated along middle; posterior diagonal margin raised, knifelike, and extending full length of fossa; floor (of cavity) glabrous, shining, and finely, rugosely striate. Mesosternal disc with elevated part on either side of sulcus obovate, about twice as long as wide. Metasternum having each side marked with a short, well-defined stria extending obliquely from posterior margin of mesocoxal cavity; median anterior projection with strongly raised and wide margin. Ratio of width between procoxae to width between mesocoxae about 1:2.1. Abdomen with lateral discal striae of first sternite distinct, diverging obliquely outward from inner margin of coxal cavity and extending to posterior half of segment. Length (of pronotum and elytra): 3.1 mm. Width (across humeri): 1.8 mm.

Adult female.—Antenna serrate from the fourth segment (Blatchley, 1914).

Type locality.—Lake Istokpoga (west shore), Florida. Type specimen in collection of Purdue University, Lafayette, Indiana.

Recorded distribution.—FLORIDA: Hog Island, Dunedin, Caxambus.

New record.—FLORIDA: Marion County, April 2, 1930 (H. I. Keck).

Although I have not seen the types of Blatchley's species and have had only the above recorded male available for study, after finding what appears to be a strictly homologous situation in the closely related *ballfinchae*, there is little doubt in my mind that *flabellata* is a synonym of this species. Blatchley's descriptions clearly show the evident relationship; what he supposed were males of *fasciferum* because of their pectinate antennae (no females then being known in the genus with such antennae) were in reality females, *flabellata* being the male of the species.

***Trogoderma ballfinchae* new species^o**

(Fig. 13)

Adult female.—Color of head, pronotum, and elytra uniformly dark brown; undersurfaces dark brown; legs somewhat lighter brown. Pubescence of dorsal surfaces suberect, slightly coarse, uniformly light brown; pubescence of undersurfaces fine, recumbent, light brown. Head with punctures two to three times as large as facets of eye, closely contiguous (but distinct and rarely confluent) over entire surface. Antenna light brown, 11-segmented, extending in repose to about middle of lateral length of prothorax; surface densely clothed with fine, short, suberect hairs; segments four to ten pectinate; configuration as illustrated. Eyes not emarginate nor appreciably sinuate along medial margins. Pronotum with punctures two to three times as coarse as facets of eye; punctures on disc separated by one-fourth to three-fourths diameter

^o Named for Miss Anna Loy Ballfinch, educator of Tucson, Arizona, who has given the author great help and encouragement in his work.

but becoming confluent toward sides; surface between shining and smoth. Elytra with punctures of disc twice as coarse as facets of eye, separated by one-half to two diameters, somewhat more closely set toward base; each puncture with anterior margin distinctly raised above surrounding area; surface between mostly smooth and shining but minutely wrinkled toward base. Epipleuron extending to about middle of first abdominal sternite, transversely shallowly concave along entire length. Prosternum deeply, coarsely, confluent punctate; posterior process rather narrow with sides more or less parallel to tip; median carina of process low, as narrow as marginal carinae, interrupted and irregular. Antennal fossa two-fifths as wide as long, extending nearly to base of prothorax, shallow with rather flat floor except for deeper excavation along prosternal suture; floor (of cavity) with very shallow, confluent punctures three to four times as coarse as facets of eye, glabrous; posterior diagonal margin low but distinct and knifelike, extending nearly to apex of fossa. Mesosternal disc with elevated part on either side of sulcus obovate, about twice as long as wide. Metasternum having each side marked with short, indefinite stria extending obliquely from posterior margin of mesocoxal cavity; median anterior projection with strongly raised and wide margin. Ratio of width between procoxae to mesocoxae about 1:2.3. Abdomen with lateral discal striae of first sternite present, diverging obliquely outward from inner margin of coxal cavity and extending to posterior half of segment. Length (of pronotum and elytra): 4.0 mm. Width (across humeri): 2.2 mm.

Holotype female (in collection of U.S. National Museum): Oracle, Arizona, July 11 (Hubbard and Schwarz). A damaged male paratype (in collection of the University of Kansas): Bill Williams Fork, Arizona, August (F. H. Snow).⁷

The male of this species has not been described, because no undamaged specimen was available for study. However, the specimen examined seemed to differ from the female in no significant detail except the size of the antennal fossae and the possession of flabellate antennae.

Nearly every character links this species with the Florida *fasciferum*. The flabellate male and the pectinate female antennae, the presence of striae on the metasternum and the first abdominal sternite, the configuration of the prosternum and its median carina, and the absence of the peculiar type of elytral pattern found in most other representatives of the genus are convincing evidence for the common genetic origin of both these species. *Ballfinchae* is easily separated from *fasciferum* by its lack of any elytral maculation.

Trogoderma ornatum (Say)

(Figs. 6, 12, 13, 15, 16)

Megatoma ornata Say, 1825, Jour. Acad. Nat. Sci. Phila., 5:186.

Trogoderma tarsale Melsheimer, 1844, Proc. Acad. Nat. Sci. Phila., 2:116; Casey, 1900, Jour. N.Y. Ent. Soc., 8:153; Dalla Torre, 1911, Junk Col. Cat., 33:70.

Trogoderma pallipes Ziegler, 1845, Proc. Acad. Nat. Sci. Phila., 2:269; Reitter, 1880 (1881), Verh. nat. Ver. Brünn, 19:38; Dalla Torre, 1911, Junk Col. Cat., 33:69.

Trogoderma ornatum, LeConte, 1854, Proc. Acad. Nat. Sci. Phila., 7:110; Casey, 1900, Jour. N.Y. Ent. Soc., 8:152; Dalla Torre, 1911, Junk Col. Cat., 33:69; Casey, 1916, Mem. Col., 7:186; Mutchler and Weiss, 1927, N.J. Dept. Agr. Circ., 108:11, 23, pl. 3, fig. 4, pl. 4, fig. 2 (*sternale* in part?); Hinton, 1945, Monog. beetles assoc. with stored prod., 1:395.

Trogoderma pusilla LeConte, 1854, Proc. Acad. Nat. Sci. Phila., 7:111; Reitter, 1880 (1881), Verh. Nat. Ver. Brünn, 19:38.

Trogoderma serrigera Casey, 1900 (non Sharp, 1877), Jour. N.Y. Ent. Soc., 8:153.

Trogoderma serriferum Dalla Torre, 1911, Junk Col. Cat., 33:70 (new synonymy).

Trogoderma procera Casey, 1916, Mem. Col., 7:185 (new synonymy).

⁷ Since this study was completed, the author has identified as belonging to this species a male specimen that was intercepted June 24, 1950, by a border agricultural inspection at Nogales, Arizona. This indicates an indefinite extension of this species into Mexico.

Trogoderma parvula Casey, 1916, Mem. Col., 7:186 (new synonymy).

[*Eucnocerus anthrenoides* Sharp, 1902, Biol. Centr.-Amer., Col. 2 (1):649; and *Eucnocerus dispar* Sharp, *ibid.*, Tab. xix, figs. 15, 15a, 15b, have been synonymized with this species, but I feel, on the basis of the Nearctic distribution of *ornatum* and on the basis of specimens similar to *ornatum* which I have examined from the Canal Zone, that the identification should be questioned.]

Adult male.—Color of dorsal and ventral surfaces black with reddish maculations on elytra and occasionally on pronotum; antennae and legs piceous to light brown. Pubescence of dorsal surfaces coarse, suberect, consisting of black, golden-brown, and white hairs; pubescence of ventral surfaces moderately fine, recumbent, cinereous. Head with punctures on front simple or shallow and umbilicate, one and a half to two times as coarse as facets of eye and separated by one-fourth to one-half diameter, on vertex as small as facets of eye and separated by one to two diameters; pubescence of black, golden-brown, and white hairs, light-colored hairs more commonly distributed in patches on either side of vertex. Antenna 11-segmented, extending in repose to base of prothorax or very slightly beyond, densely set with fine, short, erect hairs; segments three to ten pectinate; segment three equal in width to segment four; segment eleven eccentrically placed on pedicel; configuration as illustrated. Eyes with medial margins straight or nearly so, not at all emarginate. Pronotum with surface shining and smooth; punctures on disc simple, one to two times as coarse as facets of eye, separated by one-half to three diameters, becoming a very little denser toward sides; pubescence with light hairs in patches on lateral and basal margins and on basal lobe and with black hairs predominating on disc, sometimes with light hairs forming two transverse bands across disc; maculation, when present, similar to pattern formed by light pubescence. Elytra with punctures of disc slightly coarser and denser than those of pronotum; surface between smooth and shining, sometimes becoming subrugose; maculation as illustrated, or with pattern somewhat evanescent, but in latter case with admedian line indicated as plainly within basal loop as between loop and submedian band; pubescence variable but with light hairs more or less confined to areas of light maculation. Epipleuron ending somewhat behind posterior margin of metasternal epimeron, transversely flattened posteriorly, very slightly concave anteriorly. Hind wings with well-marked proximal pigmented spur on stigma; first anal vein short, less than half as long as second. Prosternum coarsely punctate; punctures confluent or with strongly elevated and confluent margins; posterior process relatively broad, sides subparallel; median carina distinct or somewhat evanescent, narrower than lateral carinae. Antennal fossa three times as long as wide, extending full length of lateral margin of prothorax, deeply excavated; anterolateral margin somewhat concave; posterior diagonal margin raised as knifelike carina and on same level as anterior margin; floor of fossa striate and microscopically punctate, striations more or less longitudinal (i.e., at right angles to posterodiagonal margin). Mesosternal disc with elevated part on either side of sulcus subquadrate to trapezoidal, usually about as wide as long. Metasternum not marked with oblique discal striae; median anterior projection very broad, obtusely rounded, more or less strongly margined at sides. Ratio of width between procoxae to width between mesocoxae varying from 1:2.2 to 1:3.0. Abdomen with short, fine, lateral, discal striae on first sternite, usually shorter than length of trochanter. Tergite of first periphallie segment evenly rounded apically; setae extending around apical margin and arranged at middle in about three series. Lateral lobes of phallobase narrow, subparallel; bridge moderately arcuate, narrow. Length (of pronotum and elytra): 1.9 mm. to 2.5 mm. Ratio of width (across humeri) to length (of pronotum and elytra) varying from 1:1.7 to 1:1.9.

Adult female.—Antenna extending in repose to about apical third of lateral margin of prothorax, rather densely clothed with short, fine setae; club 4-segmented; segment seven a little expanded; segments three to six subequal in width. Antennal fossa moderately excavated, about one-third as wide as long; posterior diagonal margin carinate; carina low but extending length of fossa; floor of fossa confluent punctate on lateral half, smooth or finely striate on median half. Length (of pronotum and elytra): 2.1 mm. to 3.6 mm.

Mature larva.—Acrotergites of thorax and abdomen strongly sclerotized; fine spicisetae of acrotergites long, on abdominal segments one to four at least half as long as sclerotized part of tergite, all extending across antecostal suture; disc of each abdominal tergite with few to

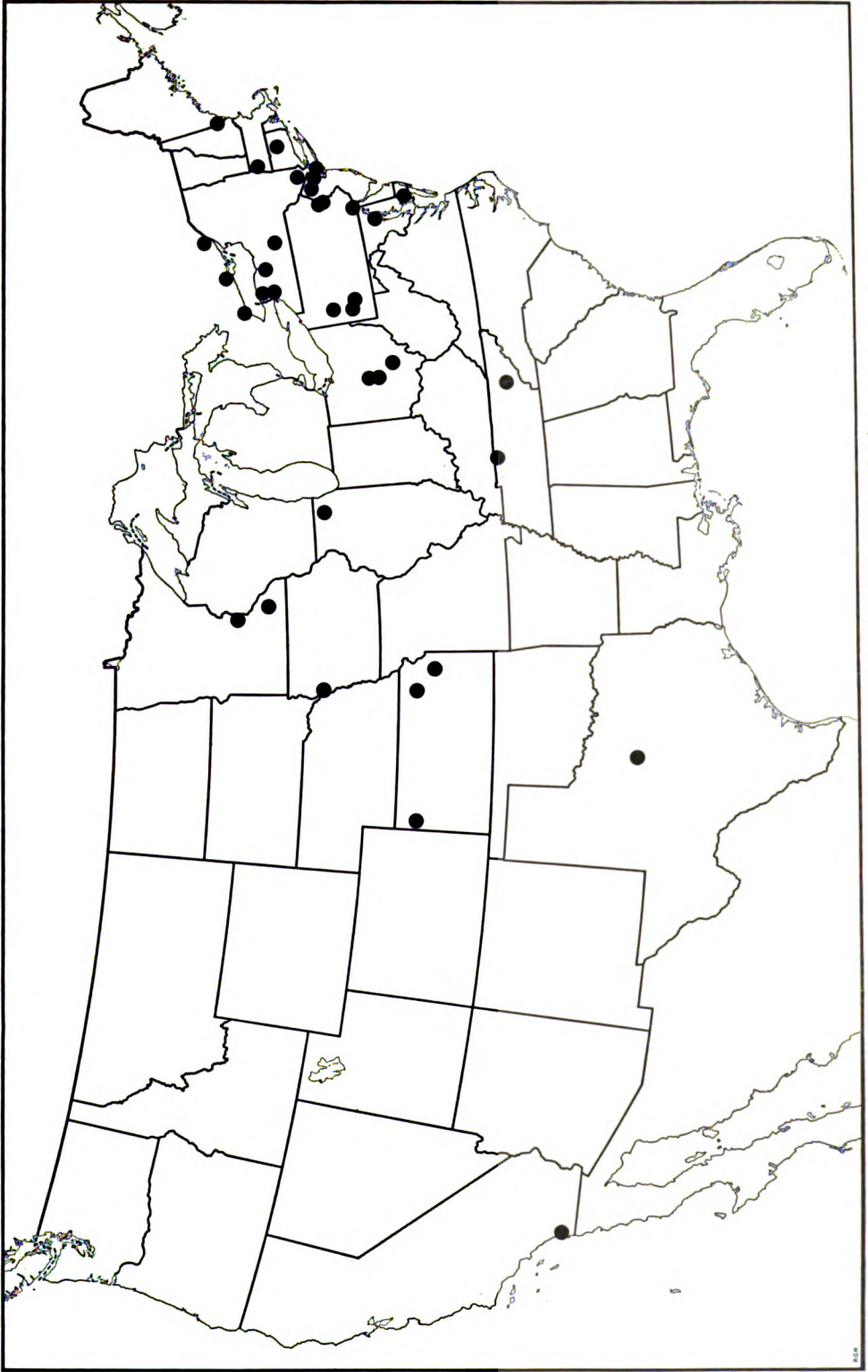


Fig. 6. Nearctic distribution of *Trogoderma ornatum* (Say).

many small slender spicisetae in addition to submedian row of large spicisetae, some anterior of large submedian spicisetae; posterior margin of each abdominal tergite with numerous spicisetae appreciably more slender and (in fully developed instars) shorter than submedian spicisetae. Antenna with nudisetae only; most setae of basal segment as long as length of second segment; no setae present on second segment; accessory papilla ovate, extending but little over base of terminal segment; basal sensory pores of terminal segment between basal third and basal half; configuration of antenna as figured. Outer setal series of labro-epipharyngeal margin plus or minus 8 to 11. Proximal series of epipharyngeal sensory papillae plus or minus 14.

Type locality.—Iowa (?).

Distribution.—For the distribution of Nearctic specimens, see figure 6. The species is also recorded from Hawaii and from Central America. However, it is questionable whether the Hawaiian and Central American forms are identical with that described above. A few specimens which I have examined from Hawaii and from Panama seem to be similar to each other but at least subspecifically distinct from this form. There seems to be as well a large geographic gap between the forms. The specimens found in central Texas and southern California most probably represent introductions by commerce.

Diagnosis.—The long setae of the thoracic and abdominal acrotergites immediately identify the mature larva as belonging to the *sternale* group. The larvae are separated from *sternale* and *grassmani* with difficulty, principally by those antennal characters used in the key. Adult males are easily distinguished from all others by antennal characters; females less readily. The latter may be distinguished by the exceptionally broad separation of the mesocoxae and by the elytral maculation. Typically the loop of the elytron is completely bisected by the admedian line, and the admedian line is about as pronounced inside the loop as between the loop and submedian band. When the loop is thin or broken, the admedian line may not completely bisect the loop, but it is still as pronounced inside the loop as behind it. When in *sternale* the loop is bisected completely by the admedian line, the admedian line outside the loop is correspondingly much wider and usually coalesced with the lateral line.

The biology of this species has been well summarized by Hinton (1945) and needs not be repeated here. The ability of this species to live out of doors in spiders' nests and to feed on living spiders' eggs suggests that biologically as well as structurally it is quite similar to the various forms of *sternale*.

Trogoderma sternale Jayne

(Figs. 1, 7, 8, 13, 14, 15, 16, 18)

Adult male.—Color of dorsal and ventral surfaces black to brown with reddish to pale brown maculae on elytra and occasionally on pronotum; antennae and legs piceous to light brown. Pubescence of dorsal surfaces coarse, suberect, consisting of black, golden-brown, and white hairs; pubescence of ventral surfaces moderately fine, cinereous to golden brown. Head with punctures on front shallow, one to two times as coarse as facets of eye, separated by less than one-half diameter, becoming confluent on sides and clypeus, becoming a little sparser and smaller on vertex; surface between smooth or microscopically wrinkled or granulate; color of pubescence variable but light pubescence usually evenly distributed over surface. Antenna 11-segmented, extending in repose not quite as far as or slightly beyond base of prothorax, densely set with fine, short, erect hairs; segment three minute, half as wide as segments two or four; segments four to ten eccentrically placed on pedicels; segment eleven about one-

eighth longer than segments nine and ten combined. Eyes with medial margins straight or very slightly sinuate, not emarginate. Pronotum with surface shining and smooth or microscopically granulate; punctures on disc simple or rarely crateriform, one or two times as coarse as facets of eye, separated by one to three diameters, becoming somewhat coarser and denser toward sides; pubescence variable, usually with light hairs in dense patch on each lateral basal margin and on basal lobe and forming two transverse light bands across disc; integument immaculate or with light maculations in two vague transverse bands and on basal lobe. Elytra with punctures of disc somewhat coarser than those of pronotum, simple or crateriform; surface shining and smooth or somewhat rugose; maculation widely variable (see fig. 8), but with loop always indicated by at least posterior half and median basal quadrant, not bisected by median line, or if bisected, then admedian line much wider between loop and submedian band; pubescence variable with light hairs usually confined to areas of light maculation. Epipleura ending a little beyond hind margin of metasternal epimera. Hind wings with or without a proximal pigmented spur on stigma; first anal vein short, less than half as long as second anal vein. Prosternum coarsely and confluent punctate; posterior process long and narrow with sides subparallel; median carina distinct, broad, much wider than lateral carinae, or sometimes evanescent except at tip. Antennal fossa about three times as long as wide, extending full length of lateral margin of pronotum, moderately deeply excavated; anterolateral margin concave; posterior diagonal margin raised as knifelike carina extending full length of fossa but sometimes becoming considerably lower than anterolateral margin at lateral third; floor of fossa finely striate; striations more or less longitudinal on anterolateral half, becoming transverse or confusedly striate-granulate on posterior half. Mesosternal disc roughly trapezoidal, as long as wide to a little longer than wide. Metasternum not marked with oblique discal striae; median anterior projection moderately broad, obtusely rounded, moderately to weakly margined at sides. Ratio of width between procoxae to width between mesocoxae varying from 1:2.0 to 1:2.8. Abdomen with or without discal abdominal striae. Tergite of first peripheral segment evenly rounded with setae extending around apical margin, usually in a single series. Lateral lobes of phallobase narrow, subparallel; bridge relatively transverse and wide. Length (of pronotum and elytra): 1.9 mm. to 2.5 mm. Ratio of width (across humeri) to length (of elytra and pronotum) varying from 1:1.7 to 1:2.2.

Adult female.—Antenna extending in repose no farther than middle of lateral length of pronotum; club 4-segmented; segment seven somewhat enlarged or not; segments compact or loose, symmetrically arranged on pedicels. Antennal fossa about one-fourth as wide as long, ending somewhat before base of prothorax, moderately shallow; posterior diagonal margin with carina low but distinct and usually extending full length of fossa; floor of fossa striate on medial half, punctate-striate on lateral half. Length (of pronotum and elytra): 1.9 mm. to 3.4 mm.

Pupa.—Gin-traps present; posterior margin of fourth abdominal tergite visibly sclerotized; sclerotized area about half size of sclerotized areas of anterior jaws of gin-traps, usually feebly serrate; anterior jaws of gin-traps feebly serrate with teeth less than half as long as distances between apices, or with teeth longer but very irregular in size, some short, some long; posterior jaws of gin-traps nearly transverse or slightly concave with tubercles tending to be irregular in size and consisting of an irregular row of large tubercles below one or two series of irregularly arranged smaller tubercles; integument on either side of posterior jaw not tuberculate; setae in posterior depression of gin-trap 10 to 22.

Mature larva.—Acrotergites of thorax and abdomen strongly sclerotized; fine spicisetae of acrotergites long, on abdominal segments one to four at least half as long as sclerotized part of tergite, all extending across antecostal suture; disc of each abdominal tergite with numerous, small, very slender spicisetae in addition to submedian row of large spicisetae, some anterior of large submedian spicisetae; posterior margin of each abdominal tergite with numerous spicisetae appreciably more slender and (in fully developed instars) shorter than submedian spicisetae. Antenna with nudisetae only; setae of basal segment at least as long as length of second segment; one or two setae present on second segment; accessory papilla ovate, extending well over base of terminal segment; basal sensory pores of terminal segment located on or about basal third; configuration of antenna as illustrated. Outer setal series of labro-epipharyngeal margin 9 to 14. Proximal series of epipharyngeal sensory papillae 12 to 20.

This species is not likely to be confused with any other treated here except *ornatum*. Although *grassmani* is closely related, it is easily recognized by an entirely distinct elytral pattern, one in which the basal half of the loop is always wanting. Males of *sternale* and *ornatum* may be distinguished by the pectinate antennal club of the latter, and by the third antennal segment, which is minute in *sternale*, but as large as the second or fourth segments in *ornatum*. The elytral pattern affords the most useful characters for separating the females. Typically, in *ornatum* the loop is more or less completely bisected by the admedian line, which is as pronounced within the loop as it is between the loop and the submedian band. Rarely the admedian line only partly bisects the loop, but in such cases the admedian line is very thin between the loop and the submedian band. In all subspecies of *sternale* the admedian line is quite pronounced between the loop and the submedian band. Where it is relatively reduced, as in *sternale deserti*, it does not show at all inside the loop.

Sternale is a highly polymorphic western species. In the United States there exist at least six recognizable geographic forms, which are treated here as subspecies. The species extends into Mexico, but how many and which of the described Mexican species are to be synonymized with it I am unable to say at present.

Trogoderma sternale sternale Jayne

Trogoderma sternale Jayne, 1882, Proc. Amer. Philos. Soc., 20:363, pl. 2, fig. 50; Casey, 1900, Jour. N.Y. Ent. Soc., 8:153; Dalla Torre, 1911, Junk Col. Cat., 33:70; Linsley and Michelbacher (in part), 1943, Jour. Econ. Ent., 36 (6):830; Hinton, 1945, Monog. beetles assoc. with stored prod., 1:395 (includes females of *simplex*?).

Trogoderma simulans Casey, 1900, Jour. N.Y. Ent. Soc., 8:153 (new synonymy).

Trogoderma variipes Casey, 1900 (non *variipes* Blackburn, 1892), Jour. N.Y. Ent. Soc., 8:153; Dalla Torre, 1911, Junk Col. Cat., 33:70.

Trogoderma caseyi Arrow, 1915, Ann. Mag. Nat. Hist. (8) 15:429 (new synonymy).

Adult.—Admedian line not penetrating loop, long and pronounced between loop and submedian band; loop complete; lateral line absent; no lines evident between submedian band and subapical band; subapical band more or less transverse.

Type locality.—California. Lectotype in the Academy of Natural Sciences of Philadelphia.

This form extends along the Pacific coast from southern California to British Columbia, and inland along the Sierra Nevada Mountains. A complete series of intergrades between this and *sternale maderae* has been found in Sacramento, Contra Costa, and Stanislaus counties, California. However, a large series from Carmel, California, and its vicinity, collected over a period of years by L. S. Slevin, shows no specimens resembling *sternale maderae*. Likewise all the specimens from Oregon, Washington, and British Columbia are more or less uniformly of this type. Along the southern part of its range, the admedian line seems to become shorter and less pronounced.

Trogoderma sternale maderae new subspecies

Trogoderma sternale, Linsley and Michelbacher (in part), 1943, Jour. Econ. Ent., 36 (6):830; Linsley, 1946, Pests and Their Control, July.

Adult.—Admedian line partly penetrating loop, long and strongly pronounced between loop and submedian band, evident for a short distance anterior of subapical band; sutural line produced a little on each side of submedian band; lateral line present between loop and sub-

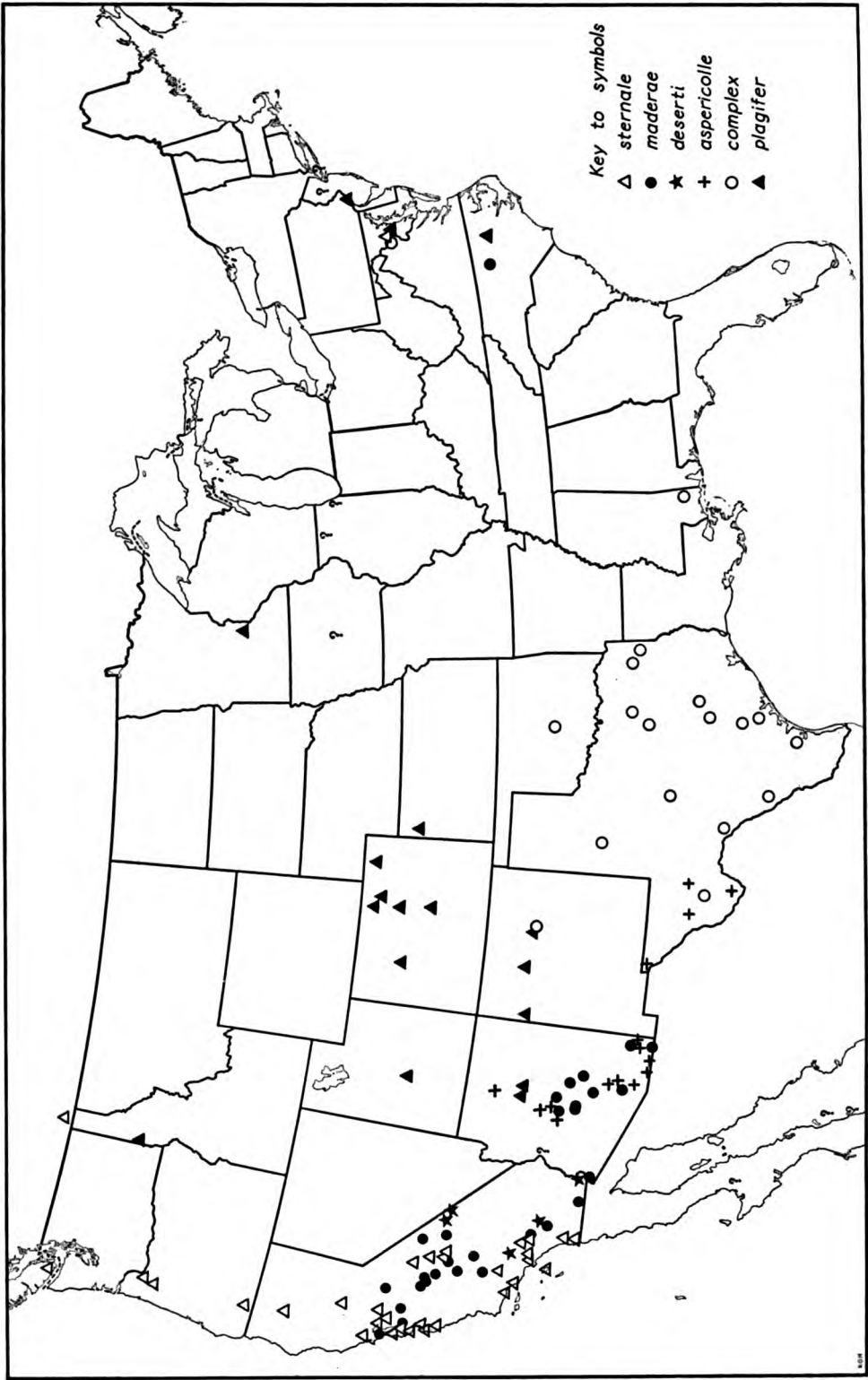


Fig. 7. Nearctic distribution of the subspecies of *Trogoderma sternale*.

median band; marginal line present but evanescent except at apical margin where it is plainly distinct; loop completely formed; submedian band entire; subapical band entire and quite pronounced.

Holotype male, allotype female (both in collection of California Academy of Sciences), and seven paratypes: Madera, Madera County, California, November 17, 1945 (E. G. Linsley); three paratypes: 10 miles east of Madera, Madera County, California, February 15, 1944 (E. G. Linsley); twelve paratypes, same data, June 12, 1945. Paratypes deposited in collections of author, California Academy of Sciences, California Insect Survey, and U.S. National Museum.

The type series of this form is rather uniform in its pattern of elytral maculation. Series from other localities to the north show occasional specimens with patterns of maculation tending toward *sternale sternale*. Specimens taken farther south in the San Joaquin Valley and in southern Arizona also show a tendency to vary toward other geographic forms. However, the form found in the type locality is predominate in all the San Joaquin Valley of central California and in the lower elevations of central and southern Arizona. Undoubtedly this or a closely allied form is to be found in Nevada and perhaps Utah, but collections from these states are rare.

Larvae of this subspecies have been found in the nests of the cliff swallow, *Petrochelidon albifrons*, in the nest of a barn owl, and in the nest of an English sparrow. Throughout its entire range it is commonly found in the nests of *Sceliphron* wasps. E. G. Linsley has collected it in California from the nests of black widow spiders.

***Trogoderma sternale deserti* new subspecies**

Adult.—Admedian line evident but not pronounced between loop and submedian band, somewhat evident posteriorly of subapical band; lateral and marginal lines not evident; loop broken, but median basal quadrant and posterior lateral quadrant evident along with humeral extension; submedian band interrupted; subapical band interrupted. Punctations of pronotum tending to be crateriform.

Holotype male (in collection of California Academy of Sciences): Palm Springs, California, April (A. Fenyes); allotype female (in collection of California Academy of Sciences): Palm Springs, California, May 19, 1917 (E. P. Van Duzee). Paratypes as follows: two specimens, Palm Springs, California, May 20, 1905 (A. Fenyes); one specimen, Piñon Flat, San Jacinto Mountains, California, April 20, 1940 (W. F. Barr); one specimen, Potholes, Imperial County, California, May 13, 1923 (E. P. Van Duzee); one specimen, Mojave Desert north of Palm-dale, California, June 21, 1931 (F. E. Lutz); two specimens, Death Valley, California, April, 1891 (A. Koebele); two specimens, Furnace Creek, Death Valley, California, April 6, 1936 (H. Hultgren); one specimen, Yuma, Arizona, May 22, 1904 (A. Fenyes). Paratypes deposited in U.S. National Museum, California Academy of Sciences, American Museum of Natural History, and the University of Idaho collections.

In addition to the material regarded as typical a specimen has been taken in Los Angeles County, California, intermediate between this subspecies and *sternale maderae*. A specimen from Mojave, California, questionably belongs here. Specimens from Wickenburg and Bill Williams Fork, Arizona, seem intermediate between this form and *sternale aspericolle*. This subspecies occurs in the hottest deserts of southeastern California, extending perhaps into western Arizona. It might be said that the decision to give these forms subspecific status was based on the study of pinned material. It is barely possible that the reduced pattern

evident in the specimens is a result of a dry environment and insufficient food supply. Living specimens from these areas have not been available for rearing under other conditions.

Trogoderma sternale aspericolle Casey, new status

Trogoderma aspericollis Casey, 1900, Jour. N.Y. Ent. Soc., 8:154; Dalla Torre, 1911, Junk Col. Cat., 33:67.

Adult.—Admedian line narrow and rather short between loop and submedian band, not apparent between submedian and subapical bands; lateral line and marginal line usually not evident; loop completely formed or broken; submedian band frequently interrupted, widely removed from subapical band; subapical band more or less transverse. Punctuation of pronotum usually rather crateriform.

Type locality.—Arizona. Type specimen in the collection of the U.S. National Museum.

This form seems to be confined largely to the mountains of the southwestern United States, particularly along the Mexican border. Possibly this form finds a much fuller expression in the Mexican fauna, which, however, is poorly collected. Specimens from the Davis Mountains in Texas are almost identical in elytral pattern, but are uniformly darker, being almost entirely black. Several specimens found in collections labeled "Tucson" and "Phoenix" appear to belong to this subspecies, but rather extensive collecting in natural habitats in the deserts of southern Arizona has turned up nothing but specimens of *sternale maderae*. Probably such specimens were taken in the near-by mountains.

From *sternale sternale* this geographic form is distinguished by the relatively shorter and less pronounced admedian line behind the loop, and by the relatively greater separation between the submedian and subapical bands. From *sternale maderae*, with which it is most closely associated geographically, it is separated by its lack of lateral and marginal lines and by the lack of any lines connecting the submedian and subapical bands. It can be separated from *sternale deserti*, which it most closely resembles, by the relatively wider space between the submedian and subapical bands.

Trogoderma sternale complex Casey, new status

Trogoderma complex Casey, 1900, Jour. N.Y. Ent. Soc., 8:153; Dalla Torre, 1911, Junk Col. Cat., 33:70.

Trogoderma virginicum Casey, 1900, Jour. N.Y. Ent. Soc., 8:154 (new synonymy).

Trogoderma oblongulum Casey, 1900, Jour. N.Y. Ent. Soc., 8:154; Dalla Torre, 1911, Junk Col. Cat., 33:69 (new synonymy).

Adult.—Admedian line partly bisecting loop or not, rather pronounced but short between loop and submedian band; lateral line evident between loop and submedian band, occasionally between submedian and subapical bands; loop ordinarily complete; submedian band entire, closely approaching loop; subapical band entire, transverse, pronounced, less distantly separated from submedian band than in preceding subspecies; marginal line sometimes evident laterally, strongly pronounced in apical region.

Type locality.—Texas. Type specimen in collection of U.S. National Museum.

The description above is that of the form most commonly found in the eastern part of Texas. Actually the line of demarcation between this and *sternale maderae* has been arbitrarily drawn in the map showing the distribution of these sub-

species (fig. 8). All specimens from the San Joaquin Valley, California, and all specimens from eastern Texas can be easily identified as belonging to one particular subspecies. However, specimens from intermediate localities, such as the deserts of Arizona, may be intermediate or may vary all the way between either

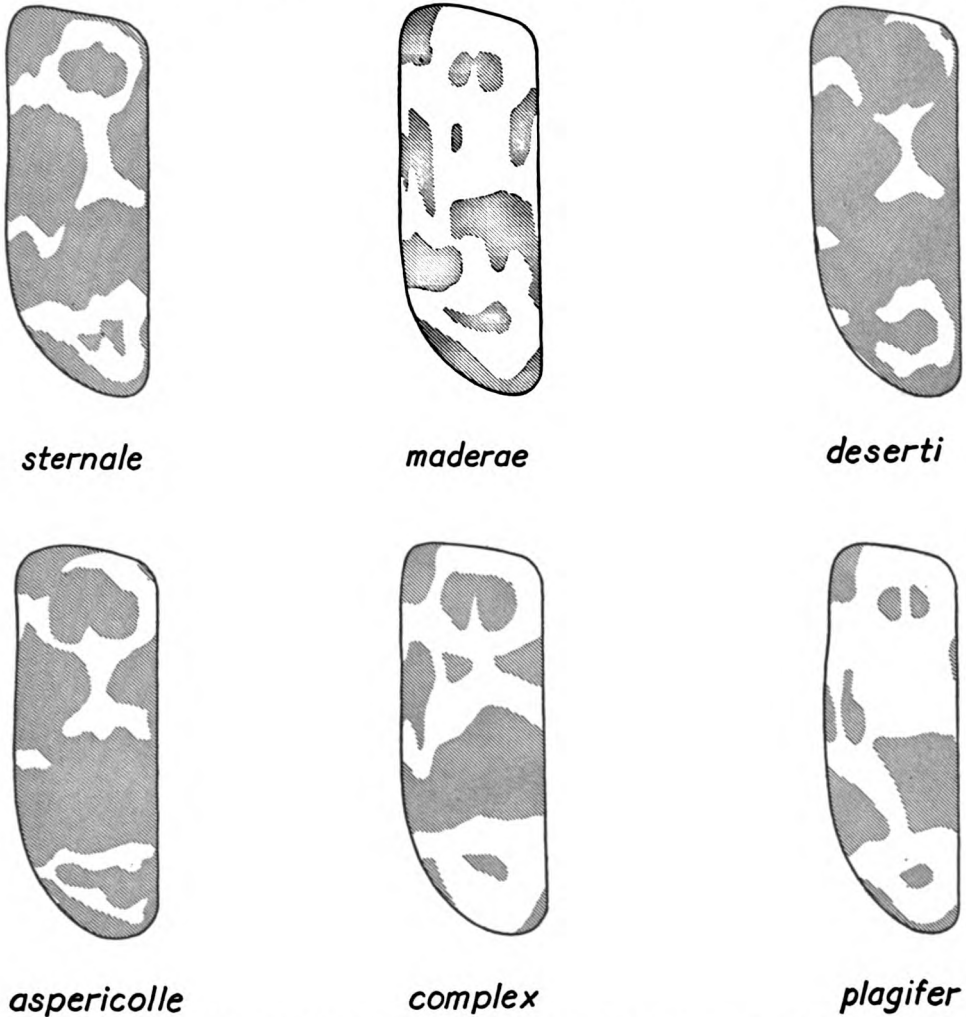


Fig. 8. Typical elytral patterns of subspecies of *Trogoderma sternale*.

extreme. Specimens from Lubbock and from Brewster County, Texas, tend toward *sternale maderae*. Two specimens, one from Dimmitt County and one from El Paso, Texas, tend very markedly toward *sternale aspericolle*. Specimens from Kingsville, Texas, seem to be intermediate between *complex*, *maderae*, and *plagifer* subspecies. Two specimens from Cleveland County, Oklahoma, are somewhat intermediate between the Texas and Colorado (*plagifer*) forms.

T. sternale complex differs from *sternale aspericolle* in its more pronounced light maculation, which usually includes a lateral line between the loop and sub-

median band and a completely formed loop. From *sternale maderae* it may be separated by the much larger dark space between the submedian and subapical bands. In *maderae* this dark space is reduced by the irregular shape of the subapical band, by a spur of the admedian line anterior of the subapical band, and by a prolongation of the sutural line posterior of the submedian band.

Trogoderma sternale plagifer Casey, new status

Trogoderma plagifera Casey, 1916, Mem. Col., 7:187.

Trogoderma cylindrella Casey, 1916, Mem. Col., 7:187 (new synonymy).

Adult.—Admedian line, apical half of loop, and submedian band more or less coalesced so that anterior half of elytron appears almost entirely light colored with the exception of a basal dark spot; admedian line bisecting loop; lateral line often coalesced with admedian line, quite variable, but usually distinct to apex, pronounced in apical region; subapical band more or less transverse. Basal half of elytra usually quite densely covered with light-colored pubescence.

Type locality.—Boulder County, Colorado. Type specimen in the collection of the U.S. National Museum.

Long series consisting entirely of typical forms of this subspecies have been collected at a number of different localities in northeastern Colorado. Beyond this area the geographic extension of this subspecies is a matter of question. Of four specimens collected in or near Las Vegas, New Mexico, two seem to belong to this form, whereas two are quite like *sternale maderae*. A series of seventeen specimens collected in a granary at Salina, Utah, has individuals resembling both *maderae* and *plagifer* forms, but seems to tend a little more toward the latter. It is questionable whether a single specimen from Douglas County, Kansas, represents an introduction or an extension of the eastern range of the species.

Trogoderma sternale plagifer is quite easily recognized by the dense, basal patch of light-colored pubescence, and by the small, subquadrate, dark area just behind the middle of the elytra. The light pubescence, actually, is limited more or less to the areas of light maculation, but in this form the large, light-maculate area on the basal half makes the light pubescence rather striking. In other subspecies the dark area behind the submedian band appears as a complete dark band across the elytra, or is more V-shaped than subquadrate.

Various forms of *sternale* have been collected in a number of other localities than those discussed above. Some of these represent the natural range of the species; some are unquestionably introductions by commerce. Specimens have been collected in a few localities on the peninsula of Lower California, but not in sufficient numbers to define the different subspecies which they evidently represent. A specimen in the California Academy of Sciences from Cuernavaca, Mexico, seems unquestionably to represent another subspecies of *sternale*. Four specimens from Moscow and one from Troy, Idaho, are within the natural range of the species, but are of uncertain status. The question marks on the map (fig. 7) represent similar localities from which specimens of *sternale* of uncertain subspecific status have been collected.

Commercial introductions of the various forms of the species seem most likely to be represented by collections from the following localities. A single specimen from Ames, Iowa, may be an introduction of *sternale maderae*. One specimen from Chicago and one from Algonquin, Illinois, seem to lie between the Texas

and Colorado subspecies. A specimen from an unidentified locality in Missouri seems unlike any of the forms described here. Fifteen specimens of *sternale plagifer* were found infesting a storage of popcorn in Minneapolis, Minnesota. One specimen from New York City and one specimen from an unnamed locality in New Jersey seem to be of an undescribed form, but may be hybrids of two of the subspecies described above. A large series representing five different collections in Philadelphia, Pennsylvania, seems to be quite typical of *sternale plagifer* and suggests that this subspecies is well established in that city. Forty-eight specimens collected in Washington, D.C., can be segregated to *sternale sternale*, *sternale maderae*, and *sternale plagifer*, as well as an undescribed (possibly Mexican) form. These doubtlessly represent at least four separate introductions of the species. Since most of them were taken at the U.S. National Museum, it is probable that they were introduced with dried insect or dried animal specimens.

***Trogoderma grassmani* new species^{*}**

(Figs. 12, 14, 15, 16)

Adult male.—Color of dorsal and ventral surfaces black with elytral maculae reddish; antennae with segments one to five brown, apical segments piceous black; femora black with extremities of legs becoming piceous. Pubescence of dorsal surfaces coarse, suberect, consisting of blackish, light golden-brown, and white hairs; pubescence of undersurfaces moderately coarse, recumbent, more or less light piceous. Head with punctures of front shallow, somewhat umbilicate, two to three times as large as facets of eye, separated by one-fourth to one-half diameter on disc, contiguous at sides; punctures on vertex simple, about equal in size to facets of eye, separated by as much as three diameters; surface between punctures smooth and shining; pubescence of light golden-brown hairs with a few blackish hairs on vertex. Antenna 11-segmented, extending in repose beyond base of prothorax about half length of eleventh segment, moderately densely set with very fine, short, erect hairs; segment three minute, half as wide as segments two or four; segments four to nine strongly eccentric; segment ten subeccentric; segment eleven one-sixth longer than segments nine and ten combined (configuration quite similar to that of *T. sternale*, fig. 13). Eyes with medial margins straight. Pronotum with punctures of disc simple, one to one and a half times as coarse as facets of eye, separated by one to three diameters, becoming coarser and denser toward sides; surface between smooth and shining; hairs of pronotum predominately black on disc and basal margin, light golden brown on sides and anterior margin. Elytra with punctures of disc very slightly coarser than on pronotum, about as sparse and with margins somewhat raised; surface between more or less smooth and shining; maculation as illustrated in figure 12 ("typical pattern"); light pubescence limited to areas of light maculation and consisting mostly of white hairs with a few scattered light golden-brown hairs. Epipleura ending about opposite hind margin of metasternal epimera, more or less flattened transversely for entire length. Hind wings with pigmented proximal spur on stigma; first anal vein short, less than half as long as second anal vein. Prosternum deeply and confluent punctate on disc, confusedly punctate at sides; process moderately long with sides subparallel to apex; median carina present, a little wider than lateral carinae. Antennal fossa extending almost to base of pronotum, about one-third as wide as long, moderately deeply excavated; anterolateral wall concave; posterior diagonal margin raised and knifelike, extending to lateral apex of fossa; floor of fossa minutely rugose and shining on median half, finely punctate-rugose on lateral half. Mesosternal disc with raised part on either side of sulcus subtrapezoidal, slightly longer than wide. Metasternum without oblique discal striae; median anterior projection broad, subtruncate, widely and strongly margined at sides. Ratio of width between procoxae and mesocoxae 1:2.2. Abdomen without oblique striae on first sternite. Tergite of first periphallie segment rounding, set with several series of

^{*} Named for the late P. C. Grassman of Phoenix, Arizona, a collector of the species.

setae along apical margin; lateral lobes of phallobase relatively narrow; bridge narrow, slightly arcuate at middle. Length (of pronotum and elytra): 2.1 mm. Width (across humeri): 1.2 mm.

Adult female.—Punctuation of head relatively much finer, punctures large and umbilicate only at extreme sides and on clypeus. Antenna light brown with all segments symmetrical; segments three to six subequal, half as wide as segment two; segment seven somewhat wider; segments eight to eleven much wider, half again as wide as second segment and forming 4-segmented club. Maculation of elytra more pronounced; submedian band continuous from sutural to lateral margins. Length (of pronotum and elytra): 2.9 mm. Width (across humeri): 1.7 mm.

Range of observed variations.—Color of dorsal surfaces varying from black to piceous; light pubescence of dorsum varying from nearly all white to half white and half light brown, evenly intermingled; punctuation of head coarse, shallow, and umbilicate to fine, sparse, and simple; punctuation of elytra varying between simple with integument smooth to strongly crateriform with surface between strongly rugose. Maculation of elytra varying from reduced form described for male above to pronounced form of figure 12, however, never with basal half of loop evident. Ratio of width (across humeri) to length (pronotum and elytra) varying from 1:1.6 to 1:2.0.

Pupa.—Gin-traps absent; no sclerotization apparent on abdominal tergites; no tubercles present on integument.

Mature larva.—Acrotergites of thorax and abdomen strongly sclerotized; fine spicisetae of acrotergites long, on abdominal segments one to four at least half as long as sclerotized part of tergite, all extending across antecostal suture; disc of each abdominal tergite with few to many small slender spicisetae in addition to submedian row of large spicisetae, most small spicisetae being antieriad of large submedian spicisetae; posterior margin of each abdominal tergite with numerous spicisetae appreciably more slender and (in fully developed instars) shorter than submedian spicisetae. Antenna with nudisetae only; setae of basal segment at least as long as length of second segment; no setae present on second segment; accessory papilla ovate, extending well over base of terminal segment; basal sensory pores of terminal segment about on basal fourth; configuration of antenna as illustrated. Outer setal series of labro-epipharyngeal margin 7 to 8. Proximal series of epipharyngeal sensory papillae 12 to 13.

Holotype male and allotype female (both deposited in collection of the U.S. National Museum): Tucson, Arizona, December 28, 1950 (R. S. Beal). Spermotypes: numerous specimens of all stages reared from January, 1951, through January, 1953. Paratypes.—ARIZONA: one male, Tucson, December 28, 1950 (R. S. Beal); one female, same locality, December 27, 1950 (R. S. Beal); numerous specimens, all stages, reared between January and August, 1951, from preceding male and female; one male, Phoenix, March 8, 1942 (P. C. Grassman); one male, same locality (Charles Palm); one female, Catalina Springs, May 7 (Hubbard and Schwarz); one male, same data, April 30; two males labeled simply "Arizona"; one male, Williams, July 18 (Barber and Schwarz); CALIFORNIA: Imperial County: one female, Yuma, April 22, 1904 (A. Fenyés); Riverside County: one male and one female, Palms to Pines Highway, 3,000 feet elevation, May 24, 1940; one female, Indio, January 4, 1951 (R. S. Beal); Inyo County: two males, three females, Independence, June 6, 1905 (A. Fenyés); one female, Lone Pine, May 21, 1937 (E. C. Van Dyke); Kern County: one male, Mojave, June 1, 1905 (A. Fenyés); УТАН: 16 females, 7 males, Salina, July 2, 1943 (C. J. Sorenson); MEXICO: Lerdo, April (A. Fenyés). Spermotypes and paratypes deposited in the following collections: U.S. National Museum; California Academy of Sciences; California Insect Survey; University of Idaho; University of Arizona; Cornell University; American Museum of National History; Ohio State University; University of Kansas; Carnegie Museum; private collections of F. H. Parker and the author.

On the basis of all significant larval and adult characters, this species must be grouped with *sternale* and *ornatum*. The pupa differs from all known *Trogoderma* in the absence of gin-traps on the abdominal tergites, but this is probably to be regarded as a secondary loss rather than as a primitive condition. Adults of *grassmani* are most easily separated from *sternale* and *ornatum* by the character

of the elytral maculation. In *grassmani* the basal half of the loop is always absent, although the humeral extension and posterior half are quite pronounced. The absence of diagonal striae on the first abdominal sternite serves as well to distinguish this species from *sternale*, which has well-marked, though short striae. The larvae are separated from those of *ornatum* and *sternale* with difficulty, the distinguishing characters being principally those found in the antennae.

Conceivably more than one subspecies will eventually be found to be represented in the material described here as paratype. Three specimens examined from Independence, California, lack a pigmented proximal spur on the stigma of the hind wing. The specimen from Lerdo, Mexico, has a much more pronounced pattern of light maculation on the elytra than any of those from the type locality. The Utah specimens have the submedian band proportionately much more reduced than it is in the series from the type locality.

Specimens from Tucson, Arizona, were taken by the author in old nests of *Sceliphron caementarium* (Drury). In the laboratory the species can be successfully reared on a diet of pollen through several generations. Possibly there is a preference for dried insect food. Females placed in a dish with a large quantity of pollen and a few dried insects were observed to lay better than 90 per cent of their eggs on the dried insects. At room temperatures specimens mature after ten to fifteen larval instars. Specimens kept in a temperature cabinet at 31° C and fed on pollen pupated after six to eight larval instars and required about eight and a half weeks to become adults. One specimen in a dish exposed to an electric light was observed to pupate after only four larval instars.

***Trogoderma paralia* new species**

Adult male.—Color of dorsal and ventral surfaces black; antennae piceous with segments two to five brown; legs black, becoming piceous toward extremities. Pubescence of dorsal surfaces moderately coarse, subrecumbent, consisting of black, golden-brown, and white hairs; pubescence of undersurfaces somewhat finer, recumbent, golden brown in color. Head with punctures on front shallow, umbilicate, one and one-half to two and a half times as coarse as facets of eye, contiguous to separated by one-fourth diameter, becoming confluent between antennae and on clypeus and smaller and more remote on disc of vertex; surface between smooth and shining except on sides of vertex, where minutely wrinkled; pubescence mostly of black hairs with few scattered golden-brown hairs. Antenna 11-segmented, extending in repose not quite to base of prothorax, moderately densely set with very fine, short, erect, dark hairs; segment three about half as wide as segment two; segment four a fourth wider and half again as long as segment three; segments four to ten eccentrically placed on pedicels, pedicels being just visible between segments; club 5-segmented, segment nine widest; segment eleven about one-sixth longer than segments nine and ten combined. Eyes with medial margins very slightly curved medially, not at all emarginate. Pronotum with punctures of disc simple, one to one and a half times as coarse as facets of eye, separated by one to two diameters, becoming coarser and denser toward sides; surface between smooth and shining; pubescence black with narrow, lateral, transverse, antemedian band and wide, lateral, transverse, basal band of light, mostly white hairs. Elytra with punctures somewhat larger and denser than those of pronotum; margins of punctures raised; surface between lightly wrinkled; light maculation wholly absent; pattern of loop, submedian band, subapical band, and apical spot indicated by areas of light, mostly white pubescence. Epipleura ending about opposite hind margin of metasternal epimera, slightly concave transversely for entire length. Hind wings with pigmented proximal spur on stigma; first anal vein missing. Prosternum moderately deeply punctate with margins of punctures raised and confluent;

posterior process moderately long and narrow with middle of process forming a low, broad, punctate carina. Antennal fossa extending to base of pronotum, about a third as wide as long, deeply excavated; anteromedian wall concave; posterior diagonal wall raised as knife-like carina extending full length of fossa and laterally just a little lower than anterolateral wall; floor of fossa very minutely granulate. Mesosternal disc with raised part on either side of sulcus roughly quadrate, a little longer than wide. Metasternum without oblique discal striae; median anterior projection broadly rounded, short, strongly margined at sides and middle. Ratio of width between procoxae to width between mesocoxae 1:2.0. Abdomen without oblique striae on disc of first sternite. Length (of pronotum and elytra): 2.9 mm. Width (across humeri): 1.6 mm.

Adult female.—Antenna extending in repose to about middle of lateral length of pronotum; segments symmetrically arranged on pedicels; club 4-segmented with segment seven a little enlarged, segments somewhat loosely joined. Antennal fossa somewhat more shallow than in male; posterior diagonal wall with carina extending length of fossa, but much lower than anterolateral wall and scarcely knifelike on lateral half; floor of fossa finely granulate on median half, rugose-punctate on lateral half. Length (of pronotum and elytra): 3.4 mm. Width (across humeri): 1.7 mm.

Range of observed variations.—Color black to dark piceous. Ratio of width to length ranging from 1:1.81 to 1:1.98.

Holotype male (in collection of California Academy of Sciences): Mill Valley, Marin County, California, June 8, 1950 (H. B. Leech); allotype female (in collection of U.S. National Museum): Fieldbrook, Humboldt County, California, May 29, 1903 (H. S. Barber); one damaged male paratype, same data; four female paratypes, same locality, May 28, 1903 (H. S. Barber). Paratypes in collections of U.S. National Museum and of author.

In many characteristics this species is quite close to *boron*, but differs significantly in the structure of the male antenna, which is more like that of *sternale*. Tentatively it has been placed in a phylogenetic group with *boron* and *versicolor*. Whether this should be its final assignment is a question that will have to wait until specimens are available for a study of the male genitalia and of the larval characters. Females of this species can be separated from *boron* by the absence of striae on the first abdominal sternite, which are present in *boron*, and as well by the proportionate width to length of each. The species is not likely to be confused with any other known Nearctic species because of its black color and complete lack of elytral maculation.

Details of the biology and life history of this species are unknown.

Trogoderma boron new species

(Fig. 17)

Trogoderma nigrescans, Hicks, 1953, Jour. Kans. Ent. Soc., 26:13, 14.

Adult male.—Color of dorsal and ventral surfaces black except for vague piceous markings on humeri and on apical margins of elytra; color of legs and antennae piceous to brown. Pubescence of dorsal surfaces moderately coarse, suberect, consisting of black, golden-brown, and white hairs; pubescence of ventral surfaces moderately fine, recumbent, golden brown. Head with punctures one and a half times as coarse as facets of eye, separated on front by one-half to one and a half diameters, a little sparser on vertex; surface between smooth and shining; pubescence golden yellow with a few intermingled black hairs. Antenna 11-segmented, extending in repose to basal half of prothorax; surface clothed with very fine, subrecumbent puberulence; segments all compact, symmetrical; segment three minute, half as wide as segment two; club appearing 6-segmented, widest at segment ten. Eyes with medial margins somewhat sinuate but not emarginate. Pronotum with punctures of disc about as coarse as facets of eye, separated by two to four diameters, becoming coarser and denser at sides; surface between smooth and shining; pubescence of black hairs on

disc with large patches of golden-brown and white hairs on lateral margins and extending across disc as two, narrow, interrupted, transverse bands and with patch of white hairs on basal lobe. Elytra with punctures of disc about twice as coarse as those of pronotum; surface between shining and feebly wrinkled; light-colored pubescence forming a loop, submedian band, and subapical band, no longitudinal lines being apparent. Epipleura extending to about hind margin of metepimera, slightly transversely concave, at least on anterior half. Hind wings with proximal pigmented spur on stigma; first anal vein extending nearly to margin of wing, unbranched. Prosternum moderately, confluent punctate, granulate on sides; posterior process moderately broad, tapering gradually to apex; median carina obsolete except at apex. Antennal fossa about half as wide as long, three-fourths as long as lateral length of prothorax, moderately deeply excavated; anterolateral wall somewhat concave; posterior oblique margin raised, extending length of fossa as knifelike carina; floor of fossa glabrous and shining, obscurely marked with oblique striae. Mesosternal disc with elevated part on either side of sulcus subquadrate to rhomboidal and a little wider than long. Metasternum with very short stria extending obliquely from mesocoxal cavity on either side; median anterior projection moderately broadly rounded, moderately margined on sides. Ratio of width between procoxae to width between mesocoxae 1:2.7. Abdomen with oblique striae on first sternite extending outward from inner margins of metacoxal cavities. Tergite of first periphallid segment with large, unsclerotized apical area; apical fringe of setae interrupted at middle (similar to *versicolor*). Lateral lobes of phallobase broad and strongly incurved at apex; bridge narrow, transverse. Length (of pronotum and elytra): 2.3 mm. Ratio of width (across humeri) to length: 1:1.53.

Adult female.—Antenna extending in repose to about apical third of lateral margin of prothorax, clothed with very fine, short, dense, subrecumbent puberulence and a few short, fine setae; third segment about half as wide as second; segments five to eight increasing gradually in width; segments eight to ten subequal in width making club appear 4-segmented. Antennal fossa moderately excavated; posterior lateral angle not precisely defined but fossa about two and a half times as long as wide; posterior diagonal margin raised and carinate but carina becoming evanescent laterally; floor of fossa shining and finely striate medially becoming subpunctate laterally. Length (of elytra and pronotum): 3.7 mm. Ratio of width (across humeri) to length: 1:1.66.

Range of observed variations.—Head with punctures as fine as facets of eye to one and a half times as coarse; surface between smooth or very finely, indistinctly granulate. Antenna extending in repose to basal half or basal third of prothorax. Pubescence of pronotum varying from almost all black hairs with only a few golden-brown hairs on lateral margins to black on disc with large lateral patches of golden-brown and white hairs extending across disc as two, narrow, transverse bands, and with large patch of white hairs on basal lobe. Elytra with light-colored pubescence variable in color and in dense or sparse patches. Ratio of width between procoxae to width between mesocoxae varying from 1:2.2 to 1:3.0. Length (of pronotum and elytra) varying from 2.0 mm. to 2.8 mm. in male, and 2.3 mm. to 4.4 mm. in female. Ratio of width (across humeri) to length varying from 1:1.50 to 1:1.60 in male, and 1:1.60 to 1:1.75 in female.

Pupa.—Gin-traps present; posterior margin of fourth abdominal tergite weakly if at all sclerotized; anterior jaws of gin-traps moderately and somewhat irregularly serrate with teeth roughly equal in length to distances between apices; posterior jaws of gin-traps shallowly concave, margin with row of tubercles in about three series; inferior and median series of tubercles subequal, superior series smaller; tubercles not extended across integument laterad of sclerotized area of jaw; setae in posterior depression of gin-trap 34 to 40.

Mature larva.—Acrotergites of thorax and abdomen strongly sclerotized; fine spicisetae of acrotergites short with anteriormost not extending across antecostal suture; disc of each thoracic and abdominal tergite with numerous fine spicisetae in addition to large spicisetae; posterior margin of thoracic tergites bearing row of large spicisetae which approximate in size large spicisetae of disc; posterior margin of abdominal tergites with one or two or with no large spicisetae approximating size of large submedian spicisetae. Antenna with nudisetae only; setae of basal segment nine to eleven, each at least as long as length of second segment, inserted

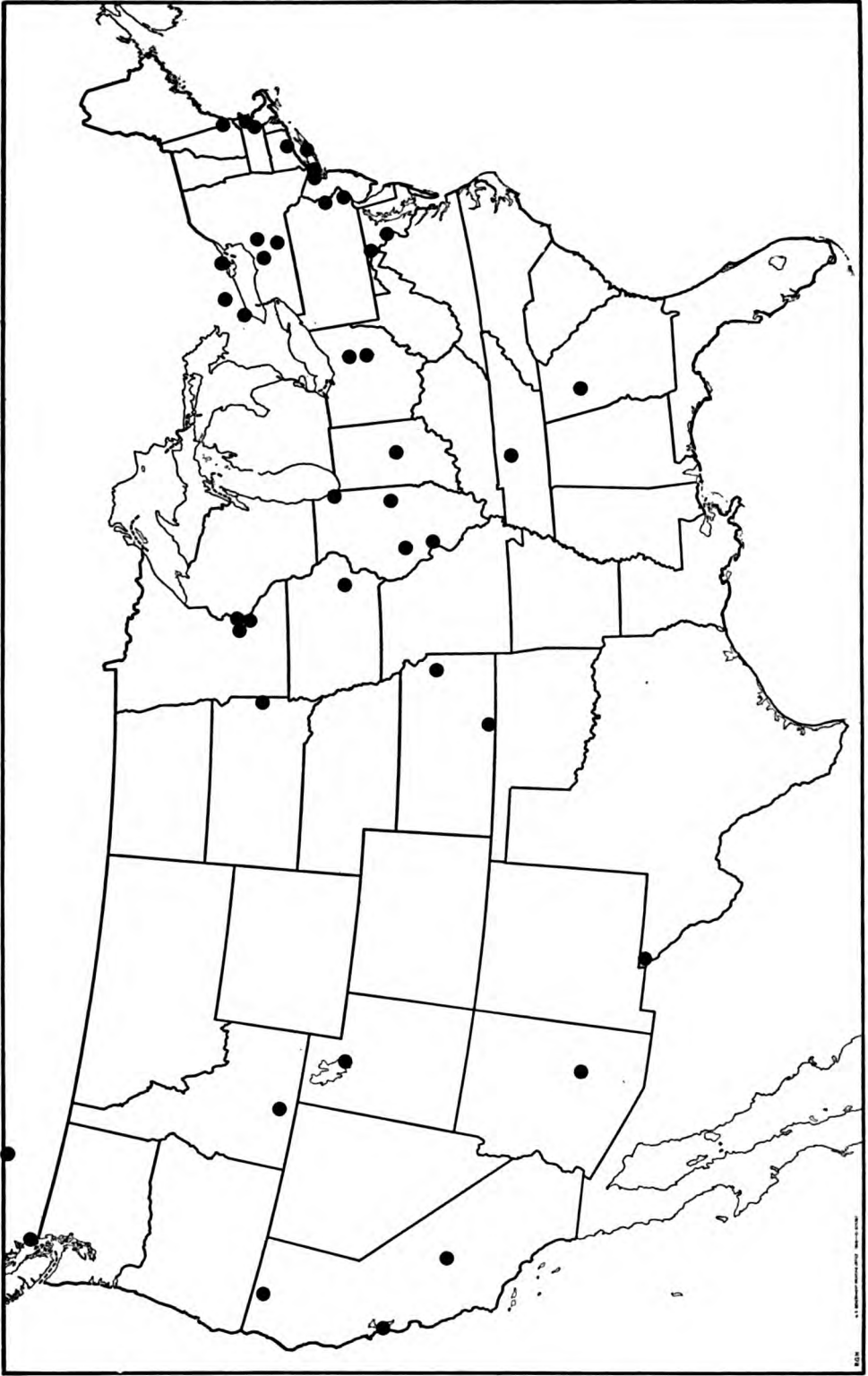


Fig. 9. Nearctic distribution of *Trogoderma versicolor* (Creutzer).

more or less evenly around entire circumference of segment; no setae present on second segment; accessory papilla short, projecting but little if any over base of terminal segment; most proximal sensory pore of terminal segment located on basal fifth of segment, somewhat removed from other proximal sensory pore; configuration of antenna as illustrated. Outer setal series of labro-epipharyngeal margin plus or minus 17.

Holotype male and allotype female (both deposited in collection of the U.S. National Museum): Nez Perce County, Spalding, Idaho (reared by author from old hackberry leaf galls September 29, 1952). Spermotopes: Numerous specimens in all stages reared since October, 1953. Paratypes from the following localities: COLORADO: Greeley, March 16, 1952 (taken in larval stage; R. S. Beal); Weld County, Galeton, June 27, 1952 (taken in larval stage; R. S. Beal); IDAHO: Nez Perce County, Spalding, reared various dates since June, 1951 (R. S. Beal); hackberry leaf galls from which specimens reared collected by W. F. Barr; Parma, January 10, 1951 (A. J. Walz); ILLINOIS: Chicago, July 19, 1938 (W. E. McCauley); East St. Louis, October 25, 1940 (A. W. MacDonald); Findley, October 8, 1940 (Farrar and Winburn); Lexington, June 26, 1941 (M. D. Farrar); Oregon, December 29, 1941; Shawneetown, June 27, 1936 (DeLong and Mohr); Wood River, August 17, 1942 (W. R. Research Laboratory); IOWA: Ames, May 28 through August 19, 1949; April 9, 1951 (W. S. Craig); KANSAS: Maize, May 31, 1938; MINNESOTA: St. Paul, June 9, 1947 (H. E. Milliron); June 18, 1934 (C. H. Hoffman); MISSOURI: St. Louis, July 16, 1937; Rogersville, June 7, 1938; Bounds, June 8, 1938; OREGON: Mission, May 15, 1947 (Morrison and Crumb); Fulton, May 14, 1947 (Morrison and Crumb); WASHINGTON: Yakima, July 8, 1950 (E. J. Newcomer); Albion (Y. C. Chao). Spermotopes or paratypes deposited in most of the institutions listed under "Acknowledgments."

Because of its black color this species bears a superficial resemblance to *paralia*, from which, however, it is easily distinguished by the characters given in the key. It is much more difficult, actually, to separate from darker specimens of *glabrum*. The separation rests on the lack of any trace of loop, submedian band, or subapical band in the maculation and in the consistently deeper antennal fossae in *boron*.

This species is most likely indigenous to the northwestern United States. In Idaho it has been found living on insect remains in psyllid-formed hackberry leaf galls in an area where, according to a personal communication from W. F. Barr, it seemed unlikely that it could have been introduced by commerce. In Colorado the writer has found it in mud-dauber wasp nests, but close to a populated area from which it might have been introduced. Its present widespread distribution may well be accounted for by its ability to grow on stored grain. It has been found in stored wheat, shelled corn, and nuts. It was found as a pest of dried insect specimens at the University of Minnesota. The specimens from Ames, Iowa, were all taken from English sparrow nests and reared in fishmeal.

Trogoderma versicolor (Creutzer)

(Figs. 9, 12, 13, 14, 17)

Anthrenus versicolor Creutzer, 1799, Ent. Vers., 117, pl. 2, fig. 21.

Trogoderma versicolor, Berthold in Latreille, 1827, Nat. Fam. Thierr., 352; Latreille in Cuvier, 1829, Règne Animal, 4:511; Dalla Torre, 1911, Junk Col. Cat., 33:70; Mutchler and Weiss, 1927, N.J. Dept. Agr. Cir., 108:23; Uyttenboogaart, 1938, Ent. Berichte., 10:41; Hinton, 1945, Monog. beetles assoc. with stored prod., 1:377; Howe, 1952, Ent. Monthly Mag., 88:182.

Trogoderma inclusum LeConte, 1854, Proc. Acad. Nat. Sci., Phila., 7:110; Jayne, 1882, Proc. Amer. Philos. Soc., 20:363; Casey, 1900, Jour. N.Y. Ent. Soc., 8:154; Dalla Torre, 1911, Junk Col. Cat., 33:68; Casey, 1916, Mem. Col., 7:186.

Trogoderma tarsale (non Melzheimer 1846), Riley, 1894, Ins. Life, 6:215; Wodsedalek, 1913, Jour. Anim. Behav., 3:61; Wodsedalek, 1917, Science, 46:366.

Trogoderma advena Casey, 1900, Jour. N.Y. Ent. Soc., 8:154; Dalla Torre, 1911, Junk Col. Cat., 33:67 (new synonymy).

Trogoderma obsolescens Casey, 1900, Jour. N.Y. Ent. Soc., 8:154; Dalla Torre, 1911, Junk Col. Cat., 33:69; Casey, 1916, Mem. Col., 7:185 (new synonymy).

Trogoderma nigrescans Casey, 1916, Mem. Col., 7:188 (new synonymy).

Trogoderma brunnescens Casey, 1916, Mem. Col., 7:189 (new synonymy).

Trogoderma frosti Casey, 1916, Mem. Col., 7:188 (new synonymy).

Adult male.—Color of head dark brown to black; pronotum black to reddish brown, with or without vague pale lateral maculae; elytra black to reddish brown with lighter, usually reddish-brown maculae; undersurfaces black to brown; antennae very dark to pale brown; legs dark to pale brown with tarsi usually quite pale, but rarely dark. Pubescence of dorsal surfaces moderately coarse, suberect, consisting of black or dark piceous, golden-brown, and white hairs; pubescence of ventral surfaces moderately fine, recumbent, golden brown or light yellowish. Head with punctures about twice as coarse as facets of eye, shallow, separated by one-fourth to one-half diameter on front, becoming contiguous or confluent on sides and clypeus, becoming sparser on vertex; surface between smooth and shining; pubescence of mixed dark and golden-brown hairs, rarely with scattered whitish hairs. Antenna 11-segmented, extending in repose to basal third or fourth of prothorax; surface clothed with short, dense, suberect puberulence; configuration as illustrated; segment three minute; segments three to eight gradually increasing in width; segments nine to eleven slightly, progressively narrower; segments four to six a little eccentric; segment eleven about one-sixth longer than segments nine and ten combined. Eyes with medial margins shallowly to rather deeply, arcuately emarginate at about middle. Pronotum with punctures as fine or finer than facets of eye, separated on disc by three to five diameters, somewhat closer at sides; surface between smooth and shining; maculation, when present, of more or less transverse, confluent, light areas near anterior and posterior lateral margins and on basal lobe; pubescence of dark, golden-brown, and white hairs in varying proportions with lighter hairs generally disposed on same areas which tend to become light maculate. Elytra with punctures slightly but distinctly coarser than those of pronotal disc, separated by one to two diameters; surface between smooth to feebly rugose, usually minutely wrinkled; maculation strongly pronounced, or obsolescent with pattern as illustrated, or with wide variations but always exhibiting following characteristics: admedian line never continued between submedian band and subapical band, never completely bisecting loop, in strongly maculate specimens continued prominently posteriad of subapical band, in specimens with reduced maculation not extended into loop but always present between loop and submedian band; in all specimens lateral line nearly always present as short spur posteriad of loop. Light pubescence disposed on lines of light maculation and consisting mostly of white hairs. Epipleuron extending just beyond hind margin of metepimeron, transversely flattened for entire length or very slightly concave on posterior half. Hind wings with proximal pigmented spur on stigma; first anal vein extending nearly to margin of wing, unbranched. Prosternum moderately granulate-punctate medially, finer and confusedly granulate laterally; posterior process moderately broad to quite broad, with sides subparallel or tapering gradually to apex; median carina broad and raised, or posterior process nearly flat with carina evident only at apex. Antennal fossa two-fifths to two-sevenths as wide as long, extending nearly to base of prothorax, deeply excavated; anterolateral wall deeply concave, very finely pubescent; posterior oblique margin raised, extending as knifelike carina full length of fossa; floor of cavity glabrous and shining, transversely strigose on posterior half. Mesosternal disc with elevated part on either side of sulcus usually roughly rhomboidal, as wide as or wider than long. Metasternum marked with long or short striae extending obliquely from medoposterior margins of metacoxal cavities; median anterior projection moderately to strongly margined, narrowly to broadly rounded, or truncate or rarely slightly emarginate for reception of prosternum. Ratio of width between procoxae to width between mesocoxae varying from 1:2.2 to 1:2.8. Abdomen with striae present on first sternite, extending obliquely outward from inner margins of metacoxal cavities, but often extremely short and fine, so scarcely noticeable. Tergite of first periphallie segment with a large, unsclerotized, apical area; apical fringe of setae interrupted at middle. Lateral lobes of phallobase broad and strongly incurved at apex; bridge narrow, transverse. Length

(of pronotum and elytra): 1.8 mm. to 3.1 mm. Ratio of width (across humeri) to length varying from 1:1.62 to 1:1.85.

Adult female.—Antenna extending in repose to apical third or fourth of lateral margin of prothorax, clothed with very fine, short, dense, subrecumbent puberulence and a few, short, fine setae; third segment about half as wide as second; segments five to eight increasing gradually in width; segments eight to ten subequal in width making club appear 4-segmented. Antennal fossa moderately excavated; posterior lateral angle not precisely defined, but fossa roughly three to five times as long as wide; posterior diagonal margin raised and carinate; carina low but extending most of length of fossa; floor of fossa shining and finely striate medially, becoming striate-punctate laterally. Length (of pronotum and elytra): 1.9 mm. to 4.2 mm.

Pupa.—Gin-traps present; posterior margin of fourth abdominal tergite weakly if at all sclerotized; anterior jaws of gin-traps moderately and somewhat irregularly serrate with teeth roughly equal in length to distances between apices; posterior jaws of gin-traps subtransverse or very shallowly concave with margin bearing row of tubercles in about four series; inferior tubercles large; superior tubercles gradually decreasing in size; tubercles not extended across integument laterad of sclerotized area of jaw; setae in posterior depression of gin-trap 48 to 64.

Mature larva.—Acrotergites of thorax and abdomen strongly sclerotized; fine spicisetae of acrotergites short with anteriormost not extending across antecostal suture; disc of each thoracic and abdominal tergite with numerous fine spicisetae in addition to large spicisetae; posterior margin of thoracic and abdominal tergites bearing row of large spicisetae which approximate in size large spicisetae of disc (number variable: from two to eight or more).⁹ Antenna with nudisetae only or with a few spicisetae; setae of basal segment nine to eleven, each at least as long as length of second segment and inserted more or less around circumference of segment; no setae present on second segment; accessory papilla short, projecting but little if any over base of terminal segment; most proximal sensory pore of terminal segment located on basal margin of segment and somewhat removed from other proximal sensory pore; configuration of antenna as figured or with segments somewhat longer in relation to length of setae. Outer setal series of labro-epipharyngeal margin 15 to 21. Proximal series of epipharyngeal sensory papillae 16 to 22.

Type locality.—Europe.

Distribution.—Nearly cosmopolitan. The Nearctic distribution is indicated in figure 9. It is well established and perhaps indigenous to the eastern half of the continent with occasional scattered introductions in the West. Apparently it has not become well established in the West—at least it does not seem to be found anywhere in nature in the Pacific coast states. In all probability many of the published records of *versicolor* along the Pacific coast are misidentifications of *parabile*.

The emarginate eyes of this species will serve to separate it from most other *Trogoderma*, except *glabrum*, which has occasionally somewhat shallowly emarginate eyes. However, this latter species never has well-marked longitudinal lines in the elytral pattern, and this immediately distinguishes it from *versicolor*, in which the admedian line at least is clearly present between the loop and submedian band.

Trogoderma advena Casey has been placed in the synonymical bibliography above with a little hesitancy. The unique male in the Casey collection has no discernible elytral pattern, but is probably nothing more than a teneral form of *versicolor*. *Obsolescens* is evidently a form of *versicolor* with an extremely reduced pattern. *Nigrescans*, *frosti*, and *brunnescens* are simply specimens of *versicolor* of different sizes.

The biology of this species has been well summarized by Hinton (1945) and need not be repeated here.

⁹ This seems to be an unusually wide range of variation and suggests the possibility that specimens of a close, unidentified species may have been included in the material examined by the writer.

Trogoderma parabile new species

(Figs. 10, 11, 13, 14, 15, 17, 18)

Trogoderma versicolor, Linsley and Michelbacher, 1943, Jour. Econ. Ent., 36(6):830; Linsley, 1946, Pests and their control, July.

Adult male.—Color of dorsal surfaces black with reddish-brown maculae on elytra; under-surfaces black; femora dark brown; tibiae and tarsi light brown; antennae light brown. Pubescence of dorsal surfaces of medium coarseness, subrecumbent, consisting of black and golden-brown hairs with a very few cinereous hairs; pubescence of ventral surfaces of medium coarseness, recumbent, light golden brown. Head with punctures on anterior part of front and clypeus shallow, twice as coarse as facets of eye, separated by one-fourth diameter or contiguous, on posterior half of front and on vertex becoming as fine as facets of eye, separated by one to two diameters. Pubescence of nearly all black hairs. Antenna 11-segmented, extending in repose to basal fifth of prothorax; surface entirely clothed with moderately short, dense, suberect puberulence except for segments one and two, which bear moderately long, fine setae; configuration as illustrated; segment three minute; segment four two-thirds again as wide as segment three; club appearing 8-segmented; segment eleven only a trifle shorter than segments eight, nine, and ten combined; apex of segment eleven more or less obtuse. Eyes with broad, very shallow sinuation slightly anterior of middle. Pronotum with punctures on disc simple, about as coarse as facets of eyes, separated by two to four diameters, becoming somewhat coarser and closer on sides; surface between smooth and shining; light pubescence consisting almost entirely of golden-brown hairs in large patch on each lateral declivous area, in patch on basal lobe, and in narrow, interrupted anterior and posterior transverse bands on disc; disc otherwise covered with dark hairs. Elytra with punctures slightly but distinctly coarser than those of pronotal disc, separated by one to two diameters; surface between minutely wrinkled; base and sides feebly rugose; maculation similar to that of "reduced" form of figure 11; light pubescence limited mostly to areas of light maculation, consisting largely of golden-brown hairs with only a few scattered cinereous hairs; epipleura extending just beyond hind margin of metepimera, transversely flattened for most of length. Hind wing with pigmented proximal spur on stigma; first anal vein extending nearly to margin, unbranched. Prosternum moderately coarsely punctate, confluent punctate on disc, becoming granulate-punctate on sides; posterior process moderately narrow with sides subparallel; median carina evident only at apex of process. Antennal fossa a trifle less than half as wide as long, extending nearly to base of prothorax, deeply excavated; anterolateral wall moderately concave, finely pubescent; posterior oblique margin raised, extending as knifelike carina full length of fossa; floor of cavity glabrous, microscopically punctate on median third (along prosternal suture) and more or less longitudinally strigate on lateral and posterior areas. Mesosternal disc with raised part on either side of sulcus roughly rhomboidal, about as wide as long. Metasternum not marked with discal striae; median anterior projection moderately broad, semicircularly rounded, feebly margined. Ratio of width between procoxae to width between mesocoxae 1:2.3. Abdomen without distinct discal striae on first sternite. Genital segments as illustrated; first periphallitic tergite entirely sclerotized except for minute apical area with setae extending across entire apical margin; lateral lobes of phallobase wide; bridge rather wide and strongly arcuate but with median part transverse. Length (of pronotum and elytra): 2.7 mm. Ratio of width (across humeri) to length 1:1.82.

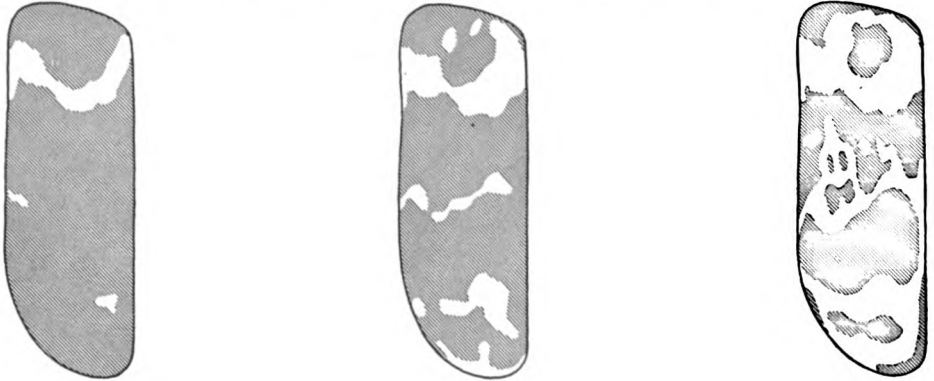
Adult female.—Antenna extending in repose no farther than middle of lateral length of pronotum; surface clothed with short pilosity and longer fine setae; terminal club consisting of four compactly and symmetrically joined segments. Antennal fossa two and a half times as long as wide; floor irregularly strigate on median third, longitudinally strigate distally. Length: 3.5 mm.

Range of observed variations.—Color of elytra piceous to black; color of maculae reddish brown to yellowish red; color of legs and antennae light brown to piceous. Pubescence of head varying from nearly all golden-brown to nearly all black hairs; pubescence of pronotum with proportion of light and dark hairs varying, but pattern of light pubescence generally similar, and light pubescence always predominantly of golden-brown hairs. Ratio of width between

procoxae to width between mesocoxae 1:2.3 to 1:2.7. Length of male (pronotum and elytra) ranging from 2.4 mm. to 3.3 mm. Ratio of width (across humeri) to length varying from 1:1.78 to 1:1.88. Length of female (pronotum and elytra) ranging from 2.9 mm. to 4.4 mm. Ratio of width (across humeri) to length of females varying from 1:1.84 to 1:1.95.

Pupa.—Gin-traps present; posterior margin of fourth abdominal tergite weakly if at all sclerotized; anterior jaws of gin-traps moderately serrate; serrations somewhat irregular with teeth roughly equal in length to distances between apices; posterior jaws of gin-traps shallowly concave with margin bearing row of subequal tubercles in two series; tubercles extended across integument laterad of sclerotized area less than one-third distance of width of jaw; setae in posterior depression of each gin-trap 20 to 34.

Mature larvae.—Acrotergites of thorax and abdomen strongly sclerotized; fine spicisetae of acrotergites short with anteriormost not extending across antecostal suture; disc of each



a. reduced

b. typical

c. expanded

Fig. 11. Variations in elytral pattern of *Trogoderma parabile* Beal.

thoracic and abdominal tergite with numerous, fine spicisetae in addition to large spicisetae; posterior margin of thoracic and abdominal tergites bearing row of large spicisetae which approximate in size large spicisetae of disc (four to eight marginal large spicisetae on at least first three abdominal tergites). Antenna with nudisetae only; setae of basal segment six to eight, at least as long as length of second segment and inserted largely on medial side of segment; no setae present on second segment; accessory papilla short, extending somewhat over base of terminal segment; most proximal sensory pore of terminal segment located at about basal fourth or fifth; configuration of antenna as illustrated. Outer setal series of labro-epipharyngeal margin 17 to 25. Proximal series of epipharyngeal sensory papillae 20 to 30.

Holotype male and allotype female (both deposited in collection of the U.S. National Museum): Fresno, California (reared by author from specimens originally taken in Fresno infesting store of dried horsebeans). Spermotypes: numerous specimens in all stages reared since 1953. Paratypes from the following localities: ARIZONA: Phoenix, March 28, 1932 (A. H. Caldwell, Jr.); Tucson, August 13, 1952 (W. J. Beal); CALIFORNIA: Bakersfield, March 6, 1945 (E. G. Linsley); Berkeley, January 20, 1947 (D. J. Raski); Fresno, numerous specimens from dried prunes reared since October, 1950 (R. S. Beal); numerous specimens from stored dried horsebeans reared since March, 1951 (R. S. Beal); Visalia, May 4, 1950 (Don Little); April, 1950 (P. Simmons); COLORADO: Denver, June 9, 1952 (R. S. Beal); OREGON: Adams, Umatilla County, June 15, 1947 (Morrison and Crumb); June 28, 1948 (H. E. Morrison); Mission, June 15, 1947 (Morrison and Crumb); June 27, 1948 (H. E. Morrison); Sparks, Umatilla County, June 29, 1948 (H. E. Morrison); DISTRICT OF COLUMBIA: Washington, March 20, 1945 (W. B. Woods); IDAHO: Boise, April 10, 1935 (W. E. Shull); Moscow Mountain, 3,000 feet elevation, October 26, 1940 (J. Klahr); Parma, January 10, 1951 (A. J. Walz); MINNESOTA:

St. Paul, November, 1939 (H. H. Shepard); NEW JERSEY: New Brunswick, May 14, 1941 (R. E. Neal); ONTARIO: Windsor, July 22, 1940 (W. R. Code); PENNSYLVANIA: Pittsburg, August 10, 1949; UTAH: Ogden, August 8, 1940 (Miss A. R. Holly); Logan Canyon, August 31, 1945 (G. F. Knowlton). Spermotypes or paratypes deposited in most of the institutions listed under "Acknowledgments."

This species is easily distinguished from *glabrum* by the light-colored hairs of the pronotum, which in *parabile* are almost entirely golden brown, but which in *glabrum* are at least half whitish. It is more difficult to distinguish from *versicolor*. However, in *parabile* the eyes are never distinctly emarginate, and in the maculation the admedian line is never distinctly evident between the loop and the submedian band. The larvae are quite similar to those of *versicolor* and *boron*, and are separated from them with difficulty, primarily by the characters used in the key. An additional character separating *versicolor* and *parabile* is found in the scalelike structure of the large spicisetæ of the abdominal and thoracic tergites; in *versicolor* the scales are ill-defined and barely raised at their apices, whereas in *parabile* the scales are well marked, sublunate, with their apices visibly deflected.

Most of the known details of the biology of *parabile* have already been discussed in the sections on geographic distribution, life histories, and economic importance. Foods upon which it has been found to feed include the following: dried horsebeans, "grain," oatmeal, brewers' yeast, and pollen. In Idaho it was found as a pest in an insect collection.

Trogoderma glabrum (Herbst)

(Figs. 12, 13)

Anthrenus glaber Herbst, 1783, in Füessly, Arch. Ins., 4:26.

Anthrenus glabrer Herbst, 1797, in Jablonsky, Nat. Ins. (Käfer), 7:331, pl. 115, fig. 5.

Anthrenus niger Herbst, 1797, in Jablonsky, Nat. Ins. (Käfer), 7:338, pl. 115, fig. 2.

Anthrenus elongatulus Fabricius, 1801, Syst. El., 1:106.

Anthrenus ruficorne Latreille, 1802, Gen. Crust. Ins., 2:39.

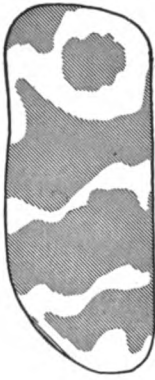
Trogoderma nigrum, Mulsant and Rey, 1867 (1868), Ann. Soc. Linn. Lyon (n.s.), 15:122;

Ganglbauer, 1904, Käf. Mitteleur., 4(1):35; Dalla Torre, 1911, Junk Col. Cat., 33:68.

*Trogoderma glabrum*¹⁰, Reitter, 1880 (1881), Ver. zool.-bot. Ges. Wien, 30:85; Hinton, 1945, Monog. beetles assoc. with stored prod., 1:397.

Adult male.—Color of head and pronotum black to piceous black; elytra black to brown with maculae brown to light brown; undersurfaces black to piceous black; antennae piceous; legs piceous to brown. Pubescence of dorsal surfaces coarse, subrecumbent, consisting of piceous-black, light golden-brown, and white hairs; pubescence of ventral surfaces somewhat finer, recumbent, consisting of light golden-brown and cinereous hairs. Head with punctures about as coarse as facets of eye, separated on front and clypeus by one-fourth to one-half diameter, becoming sparser and separated by as much as two diameters on vertex; surface between smooth and shining; pubescence entirely light golden brown. Antenna 11-segmented, extending in repose to basal two-fifths of lateral margin of prothorax; surface clothed with very short, dense, subrecumbent puberulence; configuration as illustrated; third segment less

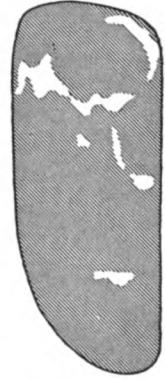
¹⁰ Following Ganglbauer, Dalla Torre and others have understood *Anthrenus glaber* Herbst, 1783, to refer to a species other than this on the basis of the original description, which states, "Fast die Form und Grösse des *Dermestes pellio*, Kopf und Brustschild schwarz und glatt, die Deckschilde dunkelbraun, glatt, glänzend, ohne Zeichnung." However, there is nothing in the description which could not refer to a large, teneral form of *glabrum*, or, for that matter, to any one of several *Trogoderma*. Hence the pictures in Herbst, 1797, must be regarded as decisive in settling the identity of *glabrum*. From these, *nigrum* and *glabrum* appear to be synonyms.



glabrum



versicolor
typical pattern



versicolor
reduced pattern



ornatum



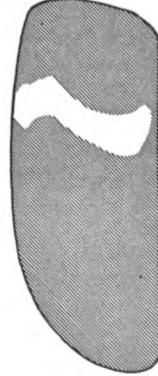
grassmani
typical pattern



grassmani
expanded pattern



fasciferum



primum



angustum

Fig. 12. Elytral patterns in species of *Trogoderma*.

than half as wide as second segment; segments three to ten gradually increasing in width; segment eleven narrower than ten, a little longer than segments nine and ten combined. Eye with broad, shallow, arcuate emargination in front of middle. Pronotum with punctures about as fine as facets of eye, separated on disc by two to four diameters, somewhat coarser and denser toward sides; surface between smooth and shining; light pubescence disposed along lateral declivities of pronotum only, or extending across pronotum in two transverse bands, white hairs predominating, especially along lateral posterior angles and on basal lobe. Elytra with punctures about twice as coarse as those of pronotum, separated by one to two diameters; surface between shining or very feebly wrinkled; maculation usually weakly indicated, but pattern strongly indicated by disposition of light pubescence; pattern always lacking longitudinal lines except for occasional weak or evanescent continuation of admedian line posterior of subapical band; submedian band usually continued entirely across each elytron as distinct, uninterrupted line, abruptly expanded at suture or bent abruptly posteriorly; light-colored pubescence consisting mostly of white hairs. Epipleura ending indefinitely a little posterior of hind margins of metepimera. Hind wings with proximal pigmented spur on stigma; first anal vein extending nearly to margin of wing, unbranched. Prosternum moderately coarsely punctate; punctures contiguous and somewhat confluent; posterior process moderately broad, tapering gradually to apex; median carina obsolete or rarely as long as posterior process. Antennal fossa half as wide as long, extending nearly to base of prothorax, shallowly excavated; anterolateral wall very little concave; posterior oblique margin raised, extending full length of fossa as knifelike carina; floor of fossa glabrous and shining, marked with a few, fine, longitudinal striae. Mesosternal disc with elevated part on either side of sulcus roughly rhomboidal, a little longer than broad. Metasternum marked on each side with stria extending obliquely outward from medoposterior margin of metacoxal cavity; median anterior projection moderately narrowly rounded, thinly margined at sides. Ratio of width between procoxae to width between mesocoxae plus or minus 1:2.4. Abdomen with striae present on first sternite, extending obliquely outward from inner margins of metacoxal cavities. Tergite of first periphallie segment with large, unsclerotized, apical area and with apical fringe of setae interrupted at middle (similar to *versicolor*); lateral lobes of phallobase broad and incurved at apex; bridge narrow, slightly arcuate. Length (of pronotum and elytra): 2.0 mm. to 2.9 mm. Ratio of width (across humeri) to length varying from 1:1.60 to 1:1.72.

Adult female.—Antennae extending in repose to about apical third of lateral margin of prothorax, clothed with very short, dense, subrecumbent puberulence and with a few, short, fine setae; third segment about half as wide as second; segments five to seven increasing gradually in width; segment eight more abruptly so, making antennal club appear 4-segmented; club widest at segment ten. Antennal fossa shallowly excavated with posterior lateral angle not precisely defined; posterior diagonal margin raised and carinate but carina becoming evanescent laterally; floor with fine confluent punctures and fine pubescence on posterior half, and on anterior half glabrous and minutely strigate. Length (of pronotum and elytra): 2.5 mm. to 3.9 mm. Ratio of width (across humeri) to length varying from 1:1.68 to 1:1.82.

Recorded distribution.—Europe, U.S.S.R.

New records.—Iowa: Sioux City (C. N. Ainslie); MINNESOTA: Grey Cloud Island, October 1 and 2, 1939 (Philip Marvin); Ramsey County, June 19, 1936 (H. H. Shepard); University Farm, November 30, 1938 (H. E. Milliron); St. Paul, November, 1939 (H. H. Shepard); December 1, 1938 (Miss Phelps); June 12, 1939 (J. Reinhardt); May 13, 1942 (M. Rockstein).

This species is unquestionably close to *versicolor* and *parabile*, but is distinguished from them by consistent elytral characters as well as by differences in the male antennae. The elytra lack any suggestion of admedian or lateral lines, thus separating it from *versicolor*. The light-colored pubescence on the pronotum and elytra, consisting mostly of whitish rather than golden-brown hairs, serves to separate it from *parabile*. From the latter it can also be distinguished by the proportional differences between the lengths and widths of the respective sexes.

Kalandadze (1930) records this species as a pest of stored food products in

Georgia (U.S.S.R). H. E. Milliron found it infesting a display of silk at the Minnesota University Farm. In France it has been found out of doors under bark, feeding on the cast skins of caterpillars (Mulsant and Rey, 1868) and in nests of *Osmia* and *Odynerus* (Marchal, 1932).

Trogoderma sinistrum Fall

(Figs. 13, 14)

Trogoderma sinistra Fall, 1926, Pan. Pac. Ent., 2:193.

Adult male.—Color of head and pronotum black; elytra uniformly dark brown; undersurfaces dark brown; antennae brown; legs brown with extremities sometimes yellowish brown. Pubes-

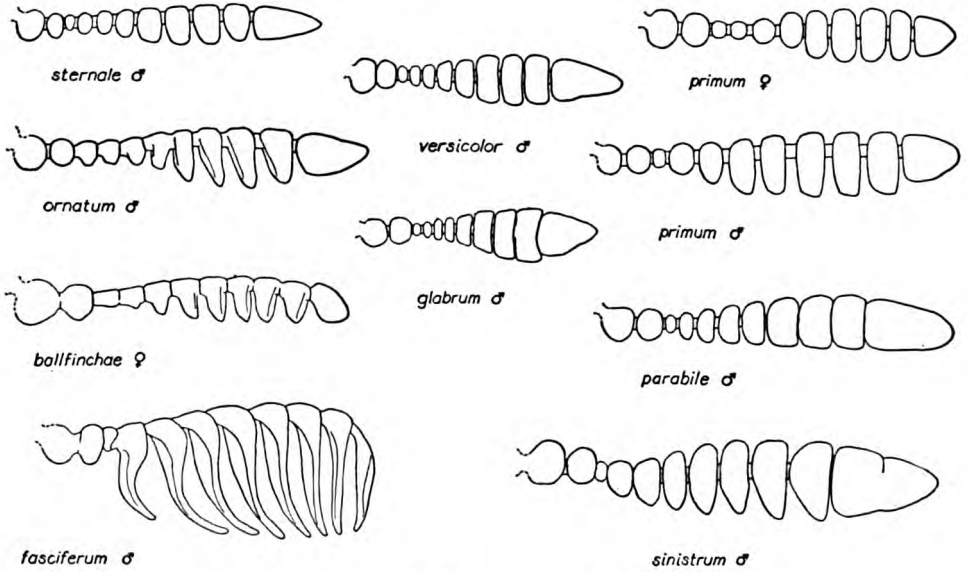


Fig. 13. Antennae of adults of species of *Trogoderma*.

cence of dorsal and ventral surfaces recumbent, fine, uniformly light brown. Head with punctures about three times as coarse as facets of eye, contiguous or separated by about half a diameter on front, becoming sparser on clypeal area and on vertex. Antenna 11-segmented, extending in repose to basal angle of pronotum, or beyond by as much as half length of eleventh segment; configuration as illustrated; surface clothed with very short, dense, sub-recumbent puberulence; segments four to eleven eccentrically placed on pedicels; segment three slightly eccentric or not. Eye with medial margin slightly rounded or straight, not at all emarginate. Pronotum with surface shining and finely wrinkled; punctures on disc about twice as coarse as facets of eye, separated by one to two diameters, becoming slightly coarser on lateral margins. Elytra with punctures of disc about twice as coarse as facets of eye, separated on disc by about two diameters, each puncture with anterior margin very slightly raised above surrounding area; surface between smooth and shining on disc, becoming finely wrinkled toward sides. Epipleura extending just beyond posterior margins of metepimera, transversely flattened on anterior third, gradually becoming shallowly concave behind. Hind wings with proximal, pigmented spur on stigma; first anal vein long, extending nearly to margin of wing, unbranched. Prosternum coarsely granulate; posterior process broad, each side tapering concavely to apex; median carina of process low, broad, and indefinite or absent. Antennal fossa one-half as wide as long, deeply excavated; anterolateral wall very slightly concave, minutely pubescent; surface (bottom) glabrous, extremely minutely and closely granulose; posterior diagonal margin

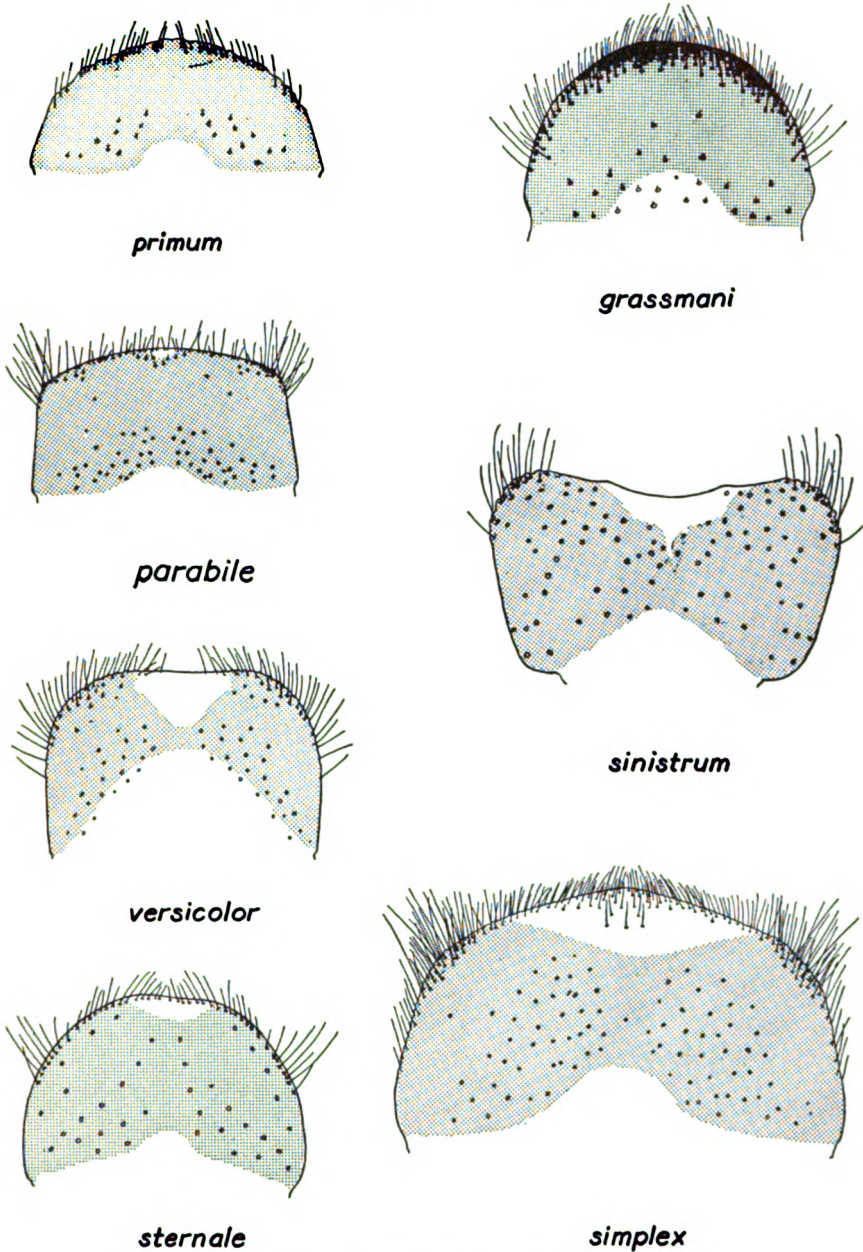
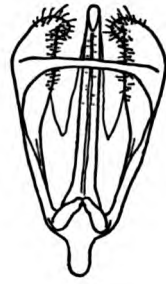
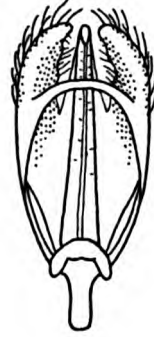
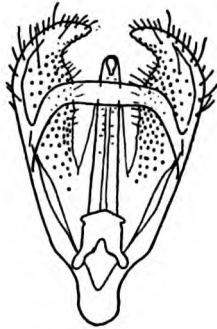
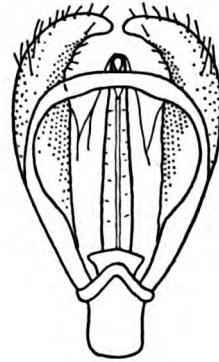


Fig. 14. First periphallie tergites of males of *Trogoderma*.

low, extending as knifelike carina full length of fossa. Mesosternal disc with elevated part on either side of sulcus roughly rhomboidal in shape. Metasternum not marked with oblique discal striae; median anterior projection strongly margined or not at all, moderately narrow to broad. Ratio of width between procoxae to mesocoxae varying from 1:1.8 to 1:2.6. Abdomen without oblique striae on first sternite. Genital segments with first periphallie segment as illustrated; phallus with lateral lobes broad, abruptly inflexed at apex, and with bridge relatively

*grassmani**primum**sternale**ornatum**parabile**simplex*Fig. 15. Phalli of males of *Trogoderma* (ventral aspect).

narrow, subtransverse. Length (of pronotum and elytra): 2.6 mm. to 3.3 mm. Ratio of width (across humeri) to length varying from 1:1.73 to 1:1.92.

Adult female.—Antennae extending in repose to about middle of lateral length of pronotum; surface clothed with short pilosity and longer fine setae; segments three to seven gradually

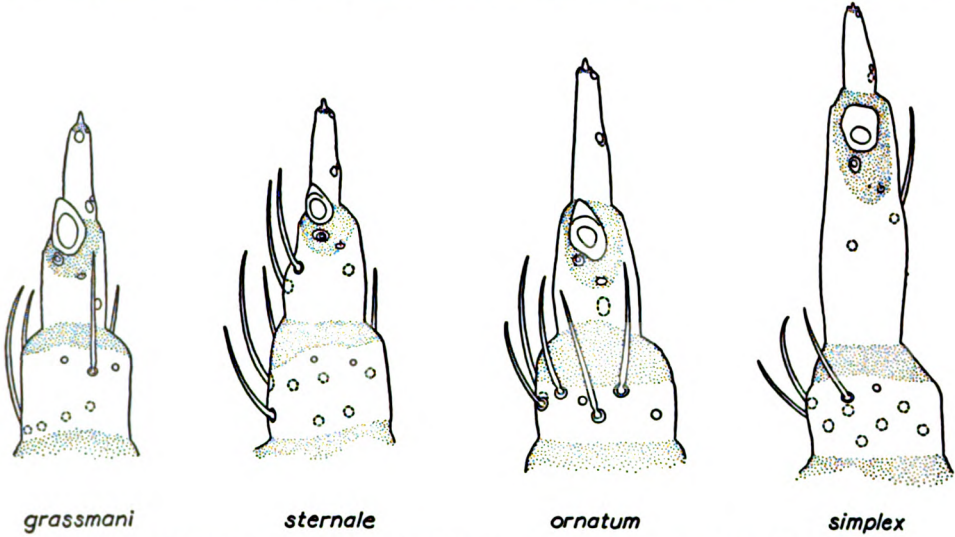


Fig. 16. Antennae of mature larvae of species of *Trogoderma*, I.

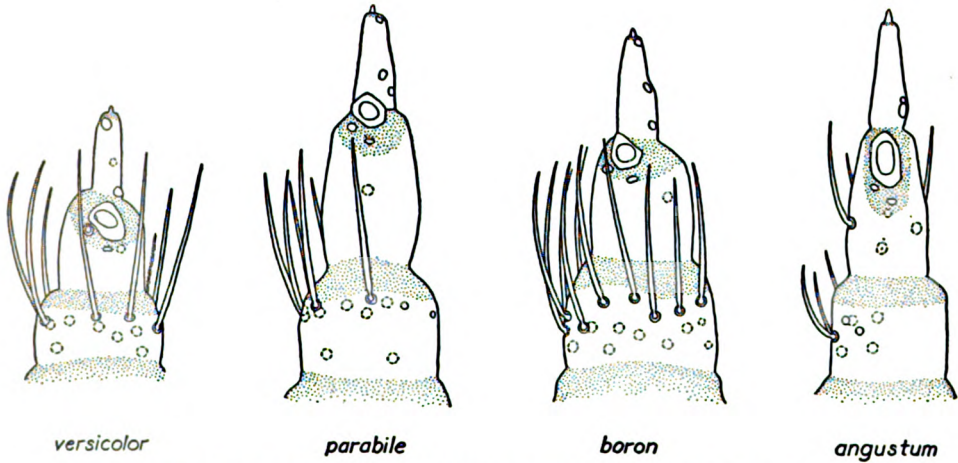
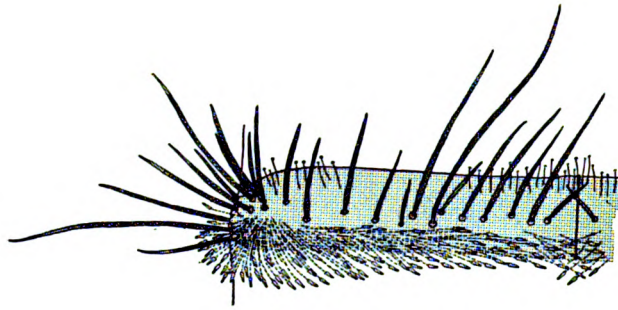


Fig. 17. Antennae of mature larvae of species of *Trogoderma*, II.

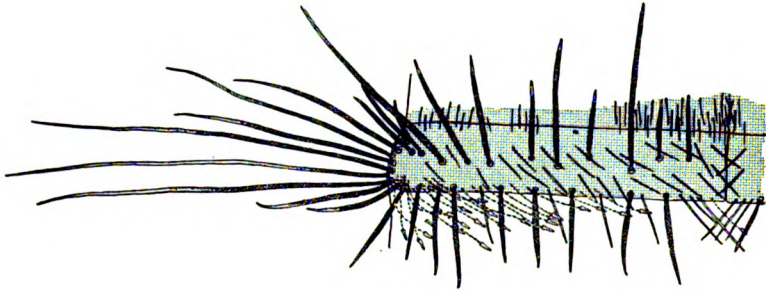
expanding; segment eight half again as wide as segment seven; segments eight to eleven forming compact terminal club; segments not at all eccentric or pectinate. Antennal fossa becoming shallow and coarsely granulate-punctate on lateral half. Length (of pronotum and elytra): 2.9 mm. to 3.7 mm.

Type locality.—Dawson, Yukon Territory. Type specimen in the Museum of Comparative Zoölogy, Cambridge, Massachusetts.

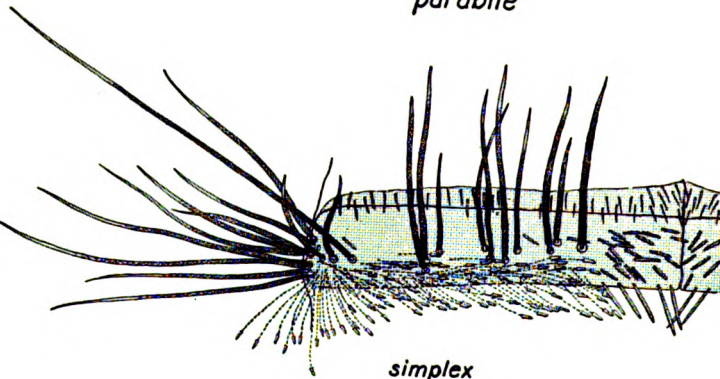
New records.—ALASKA (Schaeffer collection); ALBERTA: Banff, June 15, 1918 (E. C. Van Dyke); Edmonton, May 24, 1919 (F. S. Carr); BRITISH COLUMBIA: Salmon Arm, May 17, 1932 (Harrington); COLORADO: Platte Cañon, May 9, 1897 (H. Soltau); ILLINOIS: Algonquin, May



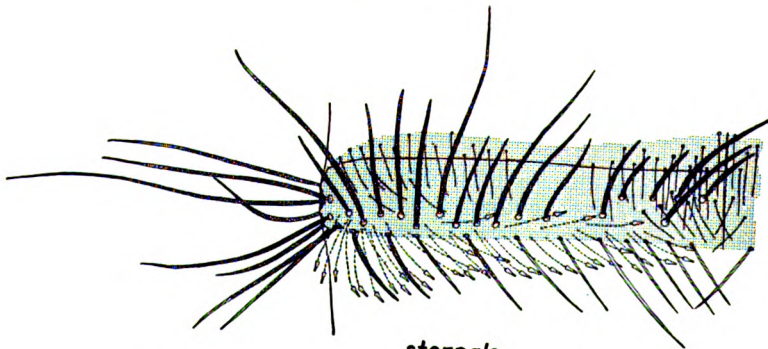
angustum



parabile



simplex



sternale

Fig. 18. First abdominal tergites of larvae of species of *Trogoderma*.

5 and 10, 1896; MINNESOTA: Olmstead County (C. N. Ainslie); ONTARIO: Blackburn, May 12, 1937 (W. J. Brown); QUEBEC: Cascapedia River, July 6, 1933 (C. C. Smith); UTAH: Alta; WYOMING: Jackson.

This distinctive species evidently belongs to a section of the genus separate from all other species of our fauna, its fine pubescence, immaculate elytra, and male antennal structure possibly relating it to a large group of Australian species. It is also remarkable among Nearctic *Trogoderma* for occupying the northernmost habitat of all the species, coming south as far as Colorado and Utah only along the Rocky Mountains. Stages other than the adult and details of its biology are unknown.

SPECIFIC NAMES OF UNCERTAIN STATUS APPLIED TO NEARCTIC TROGODERMA

Trogoderma brevis Casey, 1900, Jour. N.Y. Ent. Soc., 8:154; Dalla Torre, 1911, Junk Col. Cat., 33:67.

The unique male of this species in the Casey collection has emarginate eyes, and looks otherwise like *versicolor*, except that the elytral pattern seems more like that of *T. sternale maderae*. The type locality is San Francisco, California, which suggests the possibility of its being a form of *sternale*.

Trogoderma scabripennis Casey, 1916, Mem. Col., 7:189.

The single male type is puzzling. The elytral pattern, the form of the antennae, and the configuration of the antennal fossae are rather similar to that of *parabile*. However, the eyes are broadly emarginate, and the first abdominal sternite appears to have short, diagonal striae. This might be either an aberrant form of *parabile* or an introduced form unknown to me. Eleven other specimens identified by Casey as belonging to this species and deposited in the Casey collection unquestionably belong to *versicolor*. An examination of the hind wings and of the genitalia of this species and of that above would probably settle the nomenclatural problems involved.

SUMMARY

The present study on Nearctic species of *Trogoderma* is an effort to clarify the taxonomic difficulties existing in this group. Where possible, use has been made of the external characters of the larval and pupal stages as well as of the adults. The wing venation was studied and was found useful in elucidating certain group relationships. The male genitalia were also studied, and characters associated with them proved valuable in the clarification of both specific and group relationships.

In previous studies the elytral patterns of adults have received but scant attention. In this study a system is proposed for the identification of the species on the basis of these patterns. Identifications are made possible by a recognition of certain specific characters in the patterns of closely related species. These characters are in contrast to variations which are subspecific, discontinuous, or reflective of environmental changes. Ratios between the lengths and widths of various external parts of the adults are treated statistically. Certain propor-

tionate differences which have been relied on by previous authors for the separation of species, such as the ratio between the width of the head and the width of the pronotum, proved worthless. Other ratios, however, were found to be constant on a specific level, and are relied on to some extent as supporting characters in the differentiation of species. Finally, the evidence afforded by geographic distribution was found helpful, not only in separating closely related species, but in synonymizing forms previously regarded as distinct. It is believed that a fairly accurate picture can be drawn of the natural distribution of most of the species in spite of the spread by commerce of many of the forms.

As the result of these investigations, nineteen species and subspecies of *Trogoderma* are recognized in the Nearctic fauna. Of these, the following seven are described as new: *ballfinchae*, *boron*, *grassmani*, *parabile*, *paralia*, *sternale deserti*, and *sternale maderae*. Species already described and recognized in this paper as valid are the following: *angustum* (Solier), *fasciferum* Blatchley, *glabrum* (Herbst), *ornatum* (Say), *primum* (Jayne), *simplex* Jayne, *sinistrum* Fall, *sternale aspericolle* Casey, *sternale complex* Casey, *sternale plagifer* Casey, *sternale sternale* Jayne, and *versicolor* (Creutzer).

The species above were found to fall into six rather well-defined groups. In the past a few of these groups have been separated into other genera. Such a separation leaves the remaining groups in a polyphyletic genus. Until a revision can be made of the entire genus on a world-wide scale, it is best to treat these species as a single genus.

Where possible, the life histories of the species above have been compared with the life history of the well-known Khapra beetle, *Trogoderma granarium*. In general the life histories are quite similar. However, with each species investigated there are sufficient differences to indicate genetic changes in the physiology. These differences confirm the taxonomic treatment outlined above. In each of the species the life history may be remarkably altered in its duration by variations in temperature, food, and probably humidity as well. Under optimum conditions an individual may complete its life history in as few as twenty-eight days, undergoing only four or five larval instars. Under adverse conditions an individual may live as many as five years before maturing, passing through thirty or more larval instars.

All the species which have been studied in their natural habitats live as scavengers on food of high protein content. Some Nearctic species are capable of development on cereal food, but those investigated seem to feed in nature only on the bodies of dead insects, on pollen stored by bees, and the like. Some species are found in a variety of habitats, such as bird nests, under bark, in bee and wasp nests, and so on. Other species seem limited, perhaps by humidity requirements, to nests such as those made by *Anthophora* bees in clay banks. Two species, *T. sternale* and *T. ornatum*, are known occasionally to leave their roles as scavengers and to feed on living spider eggs.

Most of the Nearctic species are potential pests of stored foods, animal museum specimens, and other such materials. Four species in the past have been recorded as economic pests. In addition to these, the following five are found as pests of stored foods: *angustum* (Solier), *boron*, n. sp., *grassmani*, n. sp., *simplex* Jayne, and *parabile* n. sp.

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¹¹ In Russian.