A NEW SARCOPHAGID PARASITE OF GRASSHOPPERS

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INTRODUCTION

On a bright, sunny afternoon early in September, 1908, near Wellington, Kans., the writer noted hundreds of grasshoppers (Melanoplus differentialis Thos. and M. bivittatus Say) upon tall weeds which grew in abundance along the sides of the road. They were continually flying in front of him, when suddenly his attention was attracted to flies which were striking the grasshoppers, causing the latter to drop to the ground as if shot. Several of the fallen grasshoppers were examined, but no eggs could be found on them, and no attempt was made at that time to rear possible parasites.

On July 31, 1912, the writer caught an individual of Melanoplus differentialis as it was being struck by flies, both flies and grasshopper being captured, but, as before, a close examination of the grasshopper indicated that no eggs had been deposited upon it.

The flies, which at first were thought by the writer to be tachinids, were preserved, and the grasshopper, together with four others that had been struck by flies, was caged in an effort to rear the parasites. The grasshoppers died on August 4 and 6. Full-grown maggots issued from these dead grasshoppers on August 10, pupated from August 12 to 14, and adults, identical with those collected on July 31, issued on August 26. These flies were determined by Mr. W. R. Walton, of the Bureau of Entomology, as belonging to several species, one of which has since been determined as undescribed by Dr. J. M. Aldrich. (See description on p. 443-444 as Sarcophaga kellyi.) These rearings seemed to furnish ample proof that the species under observation were parasitic, and the writer supposed that in striking the grasshoppers the flies were ovipositing.

The peculiar, quite shrill tone produced by the flying sarcophagids is very characteristic, and being so much louder than that of other flies, it greatly facilitates observations.

FIELD STUDIES OF SARCOPHAGIDS

On September 17, 1912, a number of grasshoppers, which had been struck by the fly described herein as Sarcophaga kellyi Aldrich, were caught and examined closely, but again no eggs could be found on them. A grasshopper upon which no eggs were to be found was then caught and released in the vicinity of five of these flies, all of which were sitting on a block of wood. As soon as the grasshopper was released, the flies darted after and struck it, causing it at once to drop to the ground. It was caught again for examination, but, as before, no eggs could be found upon it. This experiment was repeated several times, always with the same negative results. After this continued fruitless searching for eggs, a number of

1 Description of new species by Dr. J. M. Aldrich, Entomological Assistant, Cereal and Forage Insect Investigations, Bureau of Entomology
the grasshoppers were collected for the purposes of rearing and dissection. Dissection revealed several small maggots in the viscera of the thorax and abdomen and tiny maggots under the scutellum of the metathorax. Flies were then captured and preserved for reference.

On September 19 further investigations of the supposed oviposition of this sarcophagid were undertaken in a different manner. A female fly was caught, and upon dissection the uterus was found to be full of tiny larvae, indicating that the flies were viviparous. A search was then made on the bodies of grasshoppers for the tiny maggots, and they were readily found on the metathorax, just beneath the scutellum. More critical examinations and observations showed that tiny larvae were placed by the fly on the underside of the unfolded posterior wings of the flying grasshopper, the striking of the wing by the fly probably causing the sudden dropping of the victim.

A large grasshopper (Schistocerca americana Drury) was captured, and when it attempted to fly, while being held by its hind legs, it was at once struck on the underside of the unfolded wing by several sarcophagids. By repeating this experiment in inducing it to attempt flight, the writer was thus afforded opportunity to observe more carefully the larviposition habit of the fly. Several individuals of Melanoplus atamus Riley and M. femur-rubrum DeGeer were also collected and the undersides of their wings examined to determine whether this habit of placing the maggots on the underside was usual. On no less than 32 specimens the maggots were found on the underside of the unfolded wing, with a few also placed promiscuously on the abdominal segments. An examination of 75 individuals of M. bivittatus gave similar results.

An examination of the folded wing of a grasshopper which had been struck by a fly and suddenly dropped to the ground disclosed the tiny maggots crawling toward the base of the wing, using the sides of the fold for a trough in which to travel. Thus they reach the base of the wing and the metathorax, where the body is quite soft and moist, and enter the body of their victim to feed upon the internal vital organs. They grow rapidly, maturing in from 10 to 30 days. Not all of the maggots, however, are placed on the wing; some are deposited on segments of the abdomen, and these enter through the segmental divisions. After becoming full grown, the larvae crawl from the body of the grasshopper and enter the soil to a depth of from 2 to 6 inches, pupate, and later emerge as adult flies.

While they are most frequently found beneath the host, the larvae do not always enter the soil immediately beneath the dead grasshopper, but have sometimes been observed to crawl a distance of 40 inches before descending into the ground.

The sarcophagid larvae removed from the uterus of the female, as well as those deposited on the grasshoppers, are quite small, tapering from the thoracic segments almost to a point at the posterior extremity. The segments are bordered by a heavy fringe of short, dark bristles or hairs that give the larvae a banded appearance. The head tapers slightly and is fitted with a pair of toothed hooks that project laterally. The hooks and bristles are used by the maggot in clinging to and working its way into the body of the host. The maggots, soon after entering the host, lose the dark-colored bristles, becoming of a creamy white color and retaining this color until their emergence from the grasshoppers to enter the soil.
A peculiarity of the sarcophagid flies is that they are often unable to distinguish grasshoppers from other insects; they were observed to strike moths and butterflies, actually depositing larvae upon them. However, attempts to rear the flies from moths and butterflies so attacked were unsuccessful.

While in the midst of these observations a cicada (Cicada tibicen L.) flew up, and no less than a dozen flies flew after it. Owing to the exceedingly strong flight of the cicada it could not be captured. The species attacking the cicada could not be determined, but apparently it was Sarcophaga kellyi, as this species was the only one collected in the field at that time. The following note by Mr. Theodore Pergande, now in the files of the Bureau of Entomology, indicates, without proving it, that sarcophagids can develop in C. tibicen.

On August 22, 1894, Mr. Thomas J. Brady, of Colonial Beach, Va., sent one dead specimen of Cicada tibicen to Washington; from it emerged a number of dipterous larvae, the adults of which have been determined by Dr. Aldrich as Sarcophaga helicis.

As further illustrating the indiscriminate deposition by the flies, the writer crumpled a piece of tissue paper and threw it into the wind among them, when no less than half a dozen flies struck it. When the paper was examined, two tiny maggots were found clinging to it.

In July, 1913, nymphs of Melanoplus differentialis and M. bivittatus became quite plentiful, affording ample material for study. Adults of Sarcophaga kellyi were very common, depositing on nymphs of grasshoppers in the second, third, and fourth instars as they hopped about, but in no instance could a fly be observed depositing on those not in motion.

Mr. H. E. Smith, of the Bureau of Entomology, repeatedly observed flies depositing on nymphs of Dissosteira longipennis Thos., on June 16, 1913, during a severe outbreak of this species at Elida, N. Mex. His observations are as follows:

Immediately and for some time after molting, the grasshopper is very soft and by no means active, but crawls upon some vegetation in order to dry. The female sarcophagid flies in amongst weeds, etc., where the grasshoppers are drying themselves, crawls upon them, and though the grasshoppers kick, but not vigorously, sticks living maggots beneath the posterior end of the thoracic sculpture.

Mr. Smith succeeded in collecting enough of the depositing flies to substantiate his observations on the methods of larviposition; and, besides, a large number of Sarcophaga kellyi were reared at the Wellington, Kans., laboratory from material collected by him at Elida. Possibly this species in common with others utilizes more than one method of larviposition, thus responding to a variety of stimuli in depositing their young.

Quite a serious outbreak of grasshoppers occurred in the vicinity of Wellston, Okla., early in June, 1913, the prevalent species being Melanoplus differentialis, M. bivittatus, and M. atlantis, with a few scattering individuals of other species, both imagoes and nymphs doing much damage to corn and alfalfa and literally swarming in grasslands. The ground was strewn with dead nymphs and adults of the three species mentioned which had died from parasitism by sarcophagids, their bodies being alive with maggots, while the fields were also literally swarming with these flies engaged in striking adults and nymphs of each instar, except the first, but deposition took place only while grasshoppers were flying, or, in the case of the nymphs, hopping. The winged grasshoppers
appeared to know that the parasites were after them, as when they took wing they made many twists and turns in attempting to get away from the flies. Several adults of *Sarcophaga kellyi* were reared from this Wellston material, while later investigations indicated that the grasshoppers had been materially reduced and practically controlled, so that in late September few eggs were to be found.

**REARING EXPERIMENTS WITH SARCOPHAGIDS**

In order to get ample material for study and identification of the species involved, a lot of parasitized grasshoppers were collected and placed in rearing cages. Seventy-two grasshoppers containing a number of these sarcophagid larvae were collected at the edge of a wheat field on October 21, 1912, and were put in a closed receptacle containing soil; on November 6 following, 97 sarcophagid larvae were removed from the soil. On December 3, 24 of these pupated and were removed to a receptacle especially designed for rearing Diptera. The remaining 73 larvae were allowed to continue for hibernation in the soil, which was placed in flowerpots in the laboratory, where they began to pupate on February 3, 1913, adults issuing from the former lot of 24 by the middle of February and from the latter 73 in early March.

On November 8, 1912, 118 living grasshoppers were collected in the same wheat field from which the 72 dead individuals previously mentioned were obtained. Owing to the lateness of the season, these grasshoppers were quite sluggish, but dissection of some of them revealed nearly grown *Sarcophaga* maggots, as many as 5 to 9 larvae being removed from some of the grasshoppers. The remaining living grasshoppers were placed in a Riley rearing cage outdoors near the laboratory, but all of them were dead by November 28. The soil of this cage was examined on December 5, and 137 sarcophagid larvae were removed from it, 75 of these being placed in a large flowerpot and removed to the laboratory, while the remainder were placed in a similar flowerpot which was buried in the soil in the field. These two cages were covered with wire screens. From the indoor cage adults began to issue on February 24, 1913, and continued to issue until May 3. From the flowerpot placed in the field adults began to issue on March 8, continuing to issue until May 5, when the soil was examined and the puparia were all found to be empty.

From the bodies of some 800 dead grasshoppers collected during the fall of 1912 nearly 1,200 *Sarcophaga* of several species issued. About 800 of these were kept inside in flowerpots and other rearing receptacles, from which adults began to issue about the middle of February, continuing to issue until early May. About 400 of this lot of larvae were placed in large flowerpots, securely covered, and buried in the soil in the field. An examination of one of these flowerpots in mid-December while the ground was thoroughly frozen indicated that the *Sarcophaga* were hibernating as larvae. These larvae were at once returned to the soil, but unfortunately they were killed by the transfer. Another of these outdoor flowerpots was examined in February. It being then clear that the larvae had not yet pupated, continued examination until March 8 was made necessary in order that the date of pupation under natural conditions might be learned.

Adults from the flowerpots in the field began to issue in late March and continued emerging until May 28. Comparison of the adults reared
from the Sarcophaga larvae that issued from grasshoppers collected after death with the adults of Sarcophaga issuing from the living grasshoppers which died in confinement revealed the fact that they were the same species. The indoor and outdoor rearings were indicative of their natural hibernating habits, and subsequent rearings from larvae from the fields in the spring gave proof of the habit.

SEASONAL HISTORY AND NUMBER OF GENERATIONS

Observations on the habits of species of Sarcophaga in their relation to grasshoppers were continued in 1913 in the vicinity of Wellington, Kans., beginning with the issuance of the first adults in late April and early May, which was simultaneous with the entering of the second and third instars by the earliest hatched Melanoplus differentialis and M. bivittatus. At the same time Chortophaga viridifasciata DeGeer, a species of grasshopper that hibernates in the nymphal stages, was becoming plentiful in both the adult and nearly grown nymphal forms. The four species, Sarcophaga kelleyi, S. cimbicis Towns., S. hunteri Hough, and S. sarraceniae Riley, were observed depositing on adults and nymphs of the last species and on the larger nymphs of the other two species, which, however, were not very common. Adults of these four species, which constituted a distinct second generation, began issuing sparingly from these grasshoppers by the first week of June and did not become very much in evidence until about the first week of July, and from this time until November no distinction could be made between generations on account of overlapping. However, judging from the rapidity of their development, there were probably three or four additional generations, making about five or six for the season.

EFFECT OF POISON ON SARCOPHAGID MAGGOTS

About 200 living grasshoppers that had eaten poisoned bran were collected on October 3, 1913, and by the 17th all had died. Of these grasshoppers 117 contained dead Sarcophaga larvae and no live ones, as many as 9 larvae being found in 1 individual. These maggots, with the exception of one which was nearly full grown, were rather small. The use of the poisoned bran in this instance was very effective, for in addition to clearing the field of the grasshoppers it killed the parasites. Poisoned bran was also very effective in the vicinity of Kinsley, Kans.

OUTBREAKS OF GRASSHOPPERS REDUCED OR CONTROLLED BY SARCOPHAGIDS

The outbreak of Dissosteira longipennis in eastern New Mexico, previously mentioned, was considerably reduced by the attack of Sarcophaga larvae, according to notes made by Mr. H. E. Smith on June 24, 1913, in which he says:

Found thousands of grasshoppers that had been killed by Sarcophaga larvae lying dead on the prairie. In some places as many as 15 per square foot were found in this condition.

While in the majority of cases the maggots were still feeding within the bodies of their victims, many full-grown maggots had issued and could be found buried ½ to 2 inches below the surface of the soil.

The investigations by Mr. Smith ended about the 1st of July, and no data as to the results of this parasitism were collected later. Mr. F. R.
Meadows, of American Falls, Idaho, reported on July 22, 1910, that a fly had destroyed the grasshoppers which had been so destructive in that locality during the three preceding years. Unfortunately, specimens of the flies submitted with the letter can not now be located.

Mr. C. B. Neihart, Coulee, Wash., in a letter to Mr. George I. Reeves, of the Bureau of Entomology, dated October 9, 1907, makes the following statement:

Crops badly injured by grasshoppers; latter now dying by millions. Inclosed specimens collected, some separately, others in bodies of grasshoppers out of which they came after hoppers were put in alcohol. Farmers say that 10 days ago they had no hope of getting crops, but now prospect is good.

Mr. Reeves observed many specimens of Melanoplus biliturus Walk. and especially of sarcophagid flies in the fields in a draw at Wilson Creek, Wash., on June 22, 1908. He collected 10 flies, 8 of them having been determined by Dr. Aldrich as Sarcophaga kellyi and the other 2 as S. hunteri. Mr. Reeves stated that he casually observed one female ovipositing on a Melanoplus, but he unfortunately did not describe the method of the oviposition.

Mr. C. N. Ainslie observed grasshoppers swarming in alfalfa fields in the vicinity of Payson, Utah, in July, 1911. The following note was made by him at that time and is given in full because the flies that he observed have been identified by Dr. Aldrich as Sarcophaga kellyi and partially confirm the writer's observations:

July 16, 1911. While in the vicinity of Payson, 65 miles south of Salt Lake, grasshoppers, mostly immature, were observed swarming in most of the alfalfa fields of that vicinity. Several species appeared to be represented.

In connection with this grasshopper infestation, swarms of flies, large fellows with tessellated abdomens, were everywhere in evidence, being particularly numerous in the vacant spaces in the field that had previously been devastated by the ant, Pogonomyrmex. The numbers of these flies were so great that the hum of their flight was almost equal to that from a swarm of bees. Ten days later in the same locality the grasshoppers were found to be still extremely numerous, both in the stubble and in the alfalfa fields. Swarms of the same species of flies were also observed as on a previous visit. Most of the dead grasshoppers were found to be beneath the alfalfa stems, their bodies being now mere shells, dry and brittle, crushing with the least touch. On digging in the earth beneath some of these dead bodies a number of dipterous puparia were found at depths varying from ½ to 2 inches. The dipterous larva, before transforming, seemed to seek damp ground, and in some cases did not descend vertically from the host. In one case a fresh puparium was taken directly from the body of the host, but that was apparently not a common thing.

In one case four large dipterous larvae were removed from the body of a single grasshopper, two being present in several cases. One crippled grasshopper that could still jump feebly was examined and a small larva was found in its abdomen.

The flies were present in enormous numbers, and as one walked through the alfalfa they would rise in flight, seeming to have unbounded curiosity, and at different times while I was lying on the ground taking notes in the field they would alight on me in large numbers. In several instances as many as from 40 to 50 were counted on my arms and shoulders, resting in the sun. On the wing they are as quick as a flash, as was shown by the manner in which they pursued the winged grasshoppers.

In a stubble field adjoining the alfalfa in which I was making my observations were quite a number of the large-winged grasshoppers (Hippiscus ?) that would take wing as I neared them. In almost every case when one would rise to fly it was pursued by a small swarm of flies, in some cases by as many as a dozen, although the flight was so rapid that nothing more than a guess was possible as to the number of the pursuing flies. The chase was not a mere chance flight, for the flies would mass about the flying grasshopper just as angry bees will gather about one's head in case of pursuit. Dragonflies (Odonata) were not molested in this way, and there seemed to be something in the flight of the grasshoppers that invited pursuit.

August 25, 1911. Studied to-day the grasshopper situation in the same neighborhood as before. Less grasshoppers were present than on July 26. The leafless stems
in the particular field studied had been cut and a new growth had come up that showed little damage. Plenty of dead grasshoppers still lay on the ground beneath the alfalfa, but I could find none that appeared to have recently died. The swarms of flies present in July had diminished somewhat, but many were still on hand. Counted 18 on one arm and shoulder during a brief halt in the field to-day, and noticed repeatedly the same instantaneous dash of these flies for the flying grasshoppers that had been observed before.

It would seem that these parasitic flies have reduced very materially the number of the grasshoppers in this region, but further observation is needed to confirm this—another year.

SPECIES OF SARCOPHAGA KNOWN TO PARASITIZE GRASSHOPPERS

Several other less abundant species of Sarcophaga were observed in the act of larvipositing on grasshoppers and were subsequently reared from them during these investigations—notably, *Sarcophaga cimbicus*, *S. sarraceniae*, and *S. hunteri*, and in addition to these *S. helicis* Towns. was reared from the dead grasshoppers.

While there are on record many observations strongly indicating that several species of Sarcophaga may be parasitic upon grasshoppers, unfortunately absolute proof as to whether they actually are parasitic upon living grasshoppers or are scavengers feeding upon the dead bodies of grasshoppers has heretofore been wanting. Some of these records are incomplete, through no fault of the observer. As an illustration, Dr. Aldrich stated to the author that he had reared a great number of sarcophagids from grasshoppers at Market Lake, Idaho, during an outbreak in 1898, but unfortunately this material was destroyed by a fire in the University of Idaho, so that no determinations of the material could be made.

Dr. Aldrich has, however, very kindly examined material reared from grasshoppers at Wellington, Kans., and other places, with the result that the following species may now be considered parasitic, having been reared from grasshoppers: *Sarcophaga hunteri* from Payson, Utah, Wilson Creek, Wash., Hamburg, N. Y., and Wellington, Kans.; *S. sarraceniae* from Wellington, Kans., and Washington, D. C.; *S. sinuata* Meig., one specimen from Columbia Cross Roads, Pa.; *S. helicis* from Wellington, Kans.; *S. cimbicus* from Wellington, Kans.; and *S. kelleyi* from Wellington, Kans., Washington, D. C., and points in New Mexico, Arizona, and Utah. It appears from the rearings that *S. kelleyi* predominates, *S. sarraceniae* being second in abundance according to the material reared from grasshoppers at Wellington, Kans., and the other species occurring rarely.

REFERENCES IN LITERATURE TO THE HABITS OF SARCOPHAGIDS

Frank Calvert (1882)\(^1\) has reported *Sarcophaga lineata* Fall. as being destructive to locusts in the Dardanelles.

C. V. Riley (1875) has recorded *Sarcophaga carnaria* L. as having been reared from *Melanoplus spretus* Uhl. Dr. Aldrich has shown that this species of Sarcophaga does not occur in North America and that references to it in literature must be referred to another species, or most probably to several native species.

Riley also records rearing sarcophagids from the body of a mantid (Riley, 1875), several species of grasshoppers, and the cotton worm *Alabama (Aletia) argillacea* Hübn. (Riley, 1885), but was of the opinion that these flies were scavengers.

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\(^1\) Bibliographic citations in parentheses refer to "Literature cited," p. 445.
Comstock (1879) reports having reared *Sarcophaga sarraceniae* from *Alabama (Aletia) argillacea*, and gives some interesting data regarding the biology of the Sarcophagidae.

Coquillett (1892) observed sarcophagids attacking locusts in California during the summer of 1891, and, although he did not succeed in rearing the adult flies, his observations as to the method of attack agree quite closely with those of the writer.

Lugger (1896) observed a species of Sarcophaga, erroneously determined as *S. carnaria*, striking grasshoppers, but erred in stating that it deposited an elongated white egg upon the body of the locust.

S. J. Hunter (1899) has expressed the opinion that species of Sarcophaga which he observed deposited their eggs upon the soft body of the locust immediately after molting had occurred.

H. A. Morgan (1901) has published a list of Sarcophagidae reared from grasshoppers in 1900.

Lahille (1907) states that he has reared a lot of sarcophagids from grasshoppers and thus has recognized them to be parasitic. He did not, however, make any observation on the method of larviposition of the sarcophagids.

Künckel d'Herculais (1893–1905) has described the method of larviposition of *Sarcophaga clathrata* Meigen. His observations were as follows:

We saw swarms of flies on the ground, flying in the neighborhood of the grasshoppers. We were surprised to see them introducing a tiny larva into the abdominal segments of the grasshoppers (*Stauronotus maroccantis*), but observing patiently and scrupulously they finished the attempt before we were able to seize them. (Translation.)

D'Herculais reared large numbers of *Sarcophaga clathrata* from dead grasshoppers collected in Algiers, and stated that the parasites materially reduced the numbers of the grasshoppers.

It appears from the statements made by the observers quoted herein that sarcophagids have really been known to be parasitic on grasshoppers for a number of years, and yet each of the observers, with the exception of D'Herculais and Lahille, seemed to doubt this fact, on account of the supposedly well-known carrion-feeding habits of the genus. However, the observations by Lugger, Coquillett, and C. N. Ainslie substantiate those of the writer as to the parasitic habit, and if the flies observed by Lugger and Coquillett had been collected they would very likely have proved to be *Sarcophaga kellyi*, since this species predominates in the rearings of Ainslie and the writer.

It is hoped that the facts stated herein will place these species on their correct footing as parasites and will eliminate all doubt as to their habits.

PARASITES OF THE SARCOPHAGIDS

From the puparia of Sarcophaga were reared *Perilampus hyalinus* Say, only one specimen issuing from each puparium. This species, however, has been fully discussed by H. S. Smith (1912).

*Chalcis coloradensis* Cress. was also reared from a number of the puparia of *Sarcophaga kellyi*, only one adult issuing from each puparium. A few specimens of this species have been collected in eastern Colorado, and on July 27, 1900, Mr. George W. Martin, of Sterling, Colo., sent a number of grasshoppers to Washington which were heavily infested with sarcophagid larvae. On August 10 adults of *Sarcophaga sarraceniae* issued, and on August 14 two secondary parasites (*Chalcis coloradensis*) issued from puparia of the Sarcophaga.
Several individuals of *Aphaereta* sp. were reared from a few puparia of *Sarcophaga kellyi* at Wellington, Kans., as many as 8 to 12 issuing from each puparium, and several *Eupteromalis* sp. were reared from puparia, the larvae of which were collected at Dodge City, Kans., in April, 1913. About 10 to 12 adults issued on June 3 from each puparium, and every effort was made to rear them on parasitized grasshoppers, but with negative results.

The *Perilampus, Chalcis,* and *Aphaereta* issued during the late winter and early spring of 1913 from puparia in the laboratory under laboratory conditions, and no life-history work could be done on them. Continued observations on grasshoppers during the season of 1913, with special effort toward working out the method and time of oviposition and habits of these hyperparasites, were disappointing; and even a lot of sweepings of crops and weeds where grasshoppers and sarcophagids were very numerous did not reward the writer with a single specimen.

To what extent the parasites of the sarcophagids affect the efficiency of the latter could not be estimated, but it is to be hoped that they never become more than museum rarities.

**DESCRIPTION OF SARCOPHAGA KELLYI**

By J. M. Aldrich

*Sarcophaga kellyi*, n. sp. (PL XL, fig. 1).

**MALE.**—Front at narrowest about one-fifth as wide as the head (PL XL, fig. 2)—average of 10 measured with micrometer and compound microscope is 0.216 mm., the extremes being 0.195 and 0.241 mm.—brownish at vertex, becoming silvery with a slight yellow cast below, the same color extending down the orbit to the lower corner of the eye; frontal stripe dark brown, as wide as one orbit on the upper part; a single pair of vertical bristles (the normal inner pair) inserted somewhat behind the vertex proper (PL XL, fig. 3); ocellar bristles normal; frontals ordinary, the upper pair stout and recurved, the lowermost pair inserted toward the eye margin; side of face about half as wide as the median depression, with a few fine hairs in a row next the eye below; antennae black, third joint about twice the second, reaching two-thirds of the way to the oral margin; arista plumose for more than half its length; vibrissae slightly above the oral margin, the ridges above them with only a few hairs close down; beard whitish; palpi black; proboscis smallish, retracted.

Thorax (PL XL, fig. 1) rather narrow and long, cinereous, slightly ocherous, dorsum with 5 ill-defined subshining black stripes, of which the median one is continued narrowly on the scutellum, and the lateral are abbreviated at both ends; at the front margin another stripe, narrow but distinct, beginning on each side of the median one, but soon disappearing; four postsutural dorsocentrals, the first and second behind the suture smaller than the remaining two, and one or the other of them occasionally represented only by a large hair, but only in rare instances (in the related *Sarcophaga cimbicis* there are three postsutural dorsocentrals, but the anterior one is large and equally spaced with the others); a moderately large pair of prescutellars; acrostichals before the suture about two pairs, rather slender; scutellum with two large bristles on each side, a small apical cruciate pair (absent in two of about 200 specimens examined), and a slightly larger subdiskal pair; notopleurals four, alternating large and small; pleura concolorous with dorsum, three sternopleurals; calypters waxy white, the lower edge with silky whitish hairs; halteres brown.

Abdomen rather narrow, not much curved downward toward apex, yellowish cinereous pollinose, with 3 dorsal blackish ill-defined stripes, most distinct when viewed from behind; segments 1 to 3 with lateral macrochaete only; segment 4 with a circle of about 16; hypopygium (PL XL, fig. 4) moderately prominent, its first segment black in ground color, opaque, with yellowish cinereous pollen, on its apical margin with a row of about 8 very distinct bristles, the row slightly interrupted in the middle; second segment of hypopygium red, with irregular, scattered hairs.

Forceps at base slender, wide apart, yellow, changing to black at about one-fourth the length; at about the middle there is a sudden expansion on the lower inner side (morphologically the dorsomedian), ending in a somewhat recurved point; from this the member tapers very irregularly to the tip. In profile the forceps have an evident
Bend dorsal near base. There are numerous stubby, slightly recurved spines on the black part, as shown in Plate XL, figs. 4, 5, and 6. The basal hooklets of the penis are small, not shown in the illustrations; both are recurved at tip, black and approximately equal in length; the posterior has a long hair just before the point on the ventral side; the anterior is wider on the basal half and has a thumblike, sharp point projecting forward, separated from the apical point by a deep incision. The central part of the penis is black and highly chitinized dorsally, prolonged in a pair of slender, upcurved pieces which extend past the softer parts as shown in Plate XL, fig. 4; the ventral soft part consists of two deep irregular folds side by side, without distinct accessory structures or apical lobe.

Legs black; middle tibia on outer front side with two good-sized bristles near the middle; hind tibia on the inner median edge with a sparse row of 8 or 10 fine erect hairs about as long as the tibia is thick, but not villous in any sense, as in some species of Sarcophaga.

Wings hyaline, no infuscation on small cross vein; angle of fourth vein somewhat acute; third vein with a short row of about 7 hairs, first vein bare. Length, 9 to 10 mm.

**FEMALE.**—More grayish in general color than the male. Head (Pl. XL, fig. 7) wider than that of the male, the front at narrowest (the vertex) one-third as wide as entire head (average of 10 measured with micrometer is 0.339 mm., the extremes being 0.291 and 0.360 mm.); two stout pairs of vertical bristles; two strong orbitals; lower frontals inserted toward the eye margins as in male; palpi much stouter than in male, but ending in a point; scutellum without the small apical pair of bristles; abdomen oval, somewhat tessellated, the three stripes less distinct; fifth segment red, with a row of small bristles at apex from one-half to two-thirds as long as those of the fourth segment; no chitinous ovipositor showing in the many specimens examined. Length, 8.5 to 9.5 mm.


**MATERIAL EXAMINED.—**173 males, 238 females, Wellington, Kans. (Kelly); 62 males, 66 females, Elida, N. Mex. (H. E. Smith); 4 males, Gila River, Ariz. (R. N. Wilson, Webster No. 19555); 2 males, 7 females, Colorado (Hough Coll.); 1 male, 4 females, Wawawai, Wash., reared from grasshoppers in the fall of 1913 by M. A. Yothere, assistant entomologist of the Washington State Agricultural Experiment Station, emerged on September 2 and 13; 3 males, 4 females, Wilson Creek, Wash. (Reeves); 1 male, Payson, Utah, August 11, 1911, reared from grasshoppers (C. N. Ainslie); 1 male, 3 females (Riley's No. 733p); 1 male, 1 female, marked "From Caloptenus differentialis Bessey.—Sarcophaga carnaria, 174" (referred to in Riley's Seventh Missouri Report, p. 180; reared at Ames, Iowa); 10 males, 1 female (Riley's No. 315a); 2 males, Riley's No. 722p, the label on the pin of one specimen reading "From eggs of *S. pretus*, Sept. 10, '76," on the other, "Par. on fledged *S. pretus*, sent by Wm. Cutter, Junction City, Kans.—issued Oct. 15, '76"; 4 males, Dallas, Tex., labeled, "From *S. pretus*, May 17, 77, Boll"; 4 males, 1 female, Ave, Manitoba, reared from *Melanoplus atlantis* (N. Criddle), sent by J. D. Tothill.

1 The notes, still preserved in the Bureau of Entomology, give the following data:

*Sarcophaga sarraea* Riley, bred from eggs of *S. pretus*. Brought by Prof. C. V. Riley from Kansas, Nov. 16, 75, 3 larvea in a tin box. One larvea put in box 9-72. Also from Manhattan, Kans., Box 9-5, Jan. 22, '77. Two of the flies issued. Spread and marked 733p. Jan. 26, '77. Two more issued. There are 8 chrysalis and one larva living yet. Flies spread and marked 733p.

2 The note on this number is as follows:

Dipsera parasite in *Caloptenus pretus*, May 4, 1880. Received to-day from D. D. Sanderson, Whitney F. O., Hill Co., Tex., a box containing parasitized locusts; most of the larvae had issued on the way and a few had transformed to puparia; the locusts are perfectly emptied of their contents so that nothing but the hard parts are left. The larvae are milk-yellow and when stretched to their fullest length measure nearly 54 mm; the surface is granulated and from each of these granules arises a very minute bristle of the color of the body; at the end on upper side of the abdomen is a deep cavity; at the outer edge, each side of the cavity, are 4 very short appendages, the upper pair longest and farthest apart and the lower pair shortest and nearest. At the end of the cavity is a pair of oval sinuators, each of which has 3 longitudinal narrow openings; the edge of the sinuators and of the openings is light brown; these sinuators are situated in the upper wall of the cavity; the main opening on under [side] is very small and situated between two tubercle-like projections; mandibles black; mounted on one larvea side 7443; 2 specimens are placed into box 4-1; remains of the larveas are placed into box 2.

3 The entry under 733p in the notes of the former Division of Entomology relates to anthomyiids reared from locust eggs, and could not apply to this second specimen, nor to the first except by misidentification.

4 Mr. Boll was an agent of the Government in entomological work at that time.

5 Since preparing this manuscript I have determined specimens of *Sarcophaga pantleri* reared by Prof. A. L. Quaintance from the codling moth, probably from larvae (Quaintance No. 6508). Heretofore it has been known exclusively as a grasshopper parasite. This is one of the species upon which Mr. Kelly made his observations, and in the light of Prof. Quaintance's record it is evident that these flies do not always deposit their larveas while on the wing. Therefore both Mr. Kelly's and Mr. Smith's observations (p. 457) were correct.—J. M. A.
The nearest relatives of *Sarcophaga kelleyi* are *S. cimbicis* and an undescribed species. *S. cimbicis* differs in having three postsutural dorsocentrals, as above mentioned, and also in having a smaller, wholly red hypopygium; the undescribed species differs in having the rows of frontal bristles not diverging toward the eyes at the lower end (subgenus Ravinia), no small pair of apical scutellar bristles in male, and in having the abdomen in the male strongly arched downward toward the tip.

**LITERATURE CITED**


1899. **Hunter, S. J.** Alfalfa, grasshoppers, bees: their relationship ... Univ. Kans., Lawrence, Contrib. Ent. Lab. 65, 152 p., 29 fig. Opinion that *Sarcophaga* sp. deposit eggs on soft body of locust immediately after molting, p. 34.


List of Sarcophagidae reared from grasshoppers, p. 24-26.


Fig. 1.—Sarcophaga kellyi: Adult male fly, dorsal view. Greatly enlarged.
Fig. 2.—Sarcophaga kellyi: Head of male, front view.
Fig. 3.—Sarcophaga kellyi: Head of male, lateral view.
Fig. 4.—Sarcophaga kellyi: Hypopygium of male, lateral view. Greatly enlarged.
Fig. 5.—Sarcophaga kellyi: Left half of main forceps of same, ventrolateral view.
Fig. 6.—Sarcophaga kellyi: Lateral view of same.
Fig. 7.—Sarcophaga kellyi: Head of female, front view. Original.
Sarcophagid Parasite of Grasshoppers

PLATE XL

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