amplified and led directly to a wave analyzer (model 302 A, Hewlett-Packard). The phones (PDR 600, Permoflux) could reproduce frequencies of up to 50 khz with minimal harmonic distortion.

The present method may be more accurate and reproducible than existing procedures used on the awake, intact monkey (*1, 2, 4*). However, at the higher frequencies there is probably some error in measurement caused by standing waves in the probe tube and in the ear canal. We feel that the most serious problem in studies of auditory thresholds are related to the presentation and measurement of stimulation by high frequency tones.

The subjects, three young male *Macaca irus* (M-2, -3, and -6) and one adult male *Macaca nemestrina* (M-5) were kept in restraining chairs (*3*) for the duration of the experiment. Experimental sessions were conducted in a double-walled, sound-proofed room (Industrial Acoustics); the programming and recording equipment were located outside the room. During a session the subjects were further restrained to prevent head movement so that head phones could be fitted over the openings of the ear canals and kept in place for the duration of the session.

The monkeys were conditioned to press a telegraph key (A) for food reinforcement (190 mg whole diet, banana-flavored pellets, Ciba) in the presence of a pure tone (1 khz at about 100 db re 0.0002 dynes/cm^2) binaurally presented. After conditioning, the tone was turned off, and reinforcement was withheld when the animal responded by pressing key A. A second key (B) was then added. Pressing key B turned on the tone for 3 seconds during which time a response on key A was reinforced with food. The tone was scheduled aperiodically in such a way that only occasional responses on key B produced it. The average interval between presentations of the tone was about 15 seconds. Pressing key B during the tone had no effect; pressing key A in the absence of the tone resulted in a 3 second time-out from the experiment. The time-out was used as a mild form of punishment (*5*). During the time-out the animal was in effect disconnected from the experiment, and the programming equipment stopped.

After the animals had been trained, their thresholds were estimated by decreasing the intensity of the tone until a response on key A failed to occur.

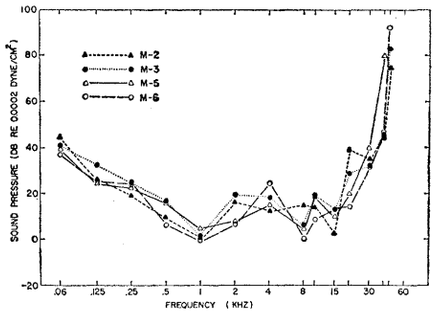

Fig. 1. Auditory threshold functions for the four monkeys from this experiment.

Five intensities above and below the estimated threshold were selected. These intensities, at intervals of 10 db, were presented to the animal in a mixed order; each intensity was presented ten times for a total of 50 trials (one animal was given 20 trials at each intensity). The absolute threshold was calculated on the basis of the number of times the monkey pressed key A in response to each intensity. The frequency with which key A was pressed was a function of the intensity of the stimulus, and the threshold was defined as that intensity which produced a response on key A 50 percent of the time that it was presented.

Thresholds were calculated in this manner at 13 frequencies ranging from 60 to 45,000 hz. Subjects were tested at 2 different frequencies each day. Each subject was tested until, for two successive sessions, the thresholds were not more than 5 db apart at any frequency.

The results of the test are shown, for each individual monkey, in Fig. 1. Each point on the curve represents the average threshold at each frequency in the final two sessions in which it was given. Our data show that the monkey's hearing is most sensitive to a frequency of 1 khz. For the most part, our subjects were only slightly less sensitive to 8 and 15 khz. There is a definite decrease in sensitivity of all subjects to frequencies of 2 and 4 khz; this finding has been reported previously (*1, 2*).

In general, the sensitivity of our monkeys (see Fig. 1) to the frequencies between 60 hz and 30 khz closely resemble thresholds obtained at these frequencies by previous investigators. The differences that do exist are not great and may be due to the differences in training procedures, but they are more likely a result of the closed system (earphones) used in this experiment for presentation and measurement of sound.

One monkey, M-5 (*M. nemestrina*), showed a sharp decrease (40 db) in sensitivity to frequencies between 30 and 40 khz. We were unable to evoke a key A response from this animal at 45 khz at a sound pressure level (SPL) of almost 100 db. The other subjects (*M. irus*) showed an equally sharp decrease in sensitivity to frequencies between 40 and 45 khz. No key A response could be evoked from these animals at 50 khz at about 95 db SPL. Because our sample was small and because the *M. nemestrina* was the oldest animal in our study, species comparisons are hardly meaningful. It is clear, however, that the macaque can hear frequencies ranging at least one octave above those heard by man.

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Spermatophore Web Formation in a Pseudoscorpion

Abstract. *The male pseudoscorpion* Serianus *sp. n. deposits spermatophores without mating, but only when females are present. It marks a path to the spermatophore with silken threads produced in an endodermal gland, which is homologous to the rectal pocket in males and females of other species and in the female of the same species.*

Pseudoscorpions transfer sperm in one of two ways. The more advanced families, Chernetidae and Cheliferidae, have a pairing behavior in which they perform mating dances (*1, 2*). The Chthoniidae, Neobisiidae, and Cheiridiidae do not mate. Even when females are not present the males of these fami-

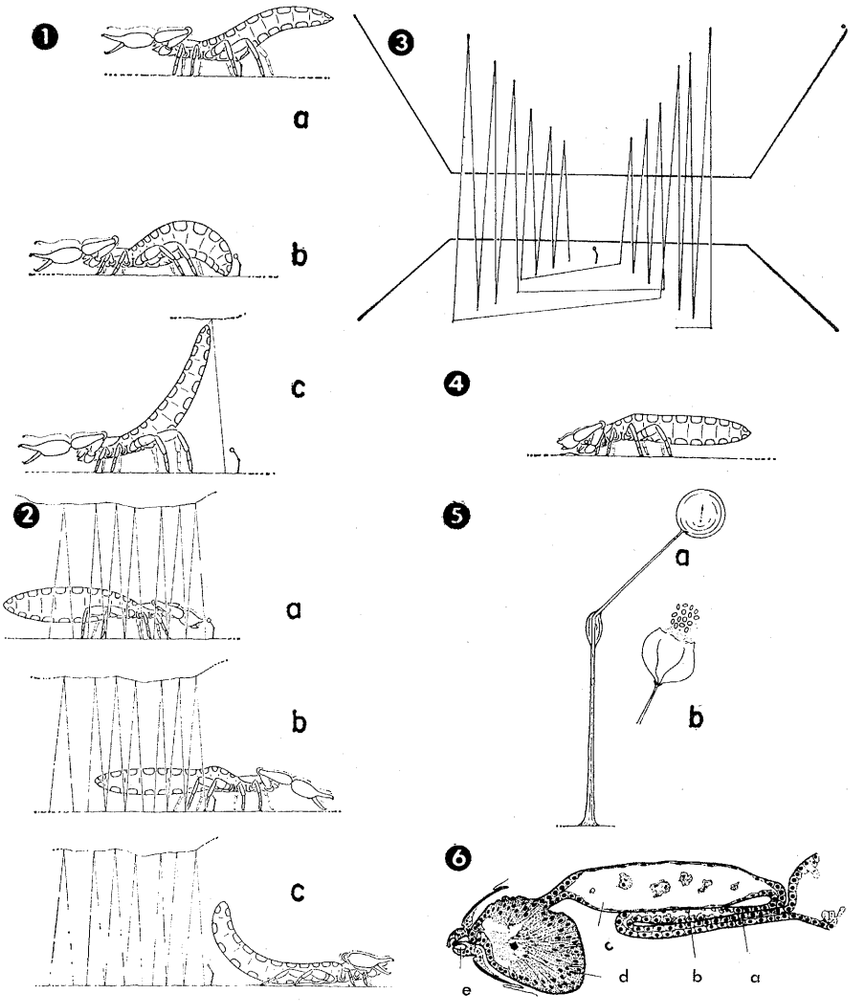

Fig. 1. A male *Serianus* deposits a spermatophore (a) and begins to spin the threads (b, c,). Fig. 2. The female *Serianus* taking up sperm from the spermatophore. Fig. 3. Reconstruction of the thread-marked path of *Serianus*, which leads to the spermatophore. Depending on the surroundings, it nearly never looks as regular as in this figure. Fig. 4. A *Serianus* destroying a spermatophore. Fig. 5. The spermatophore of *Serianus* (a) and the upper part after contact with water (b). Fig. 6. The posterior part of the alimentary canal of a male *Serianus: a, b,* and *c,* the three parts of the posterior midgut; *d,* silk gland; and *e,* anal segment.

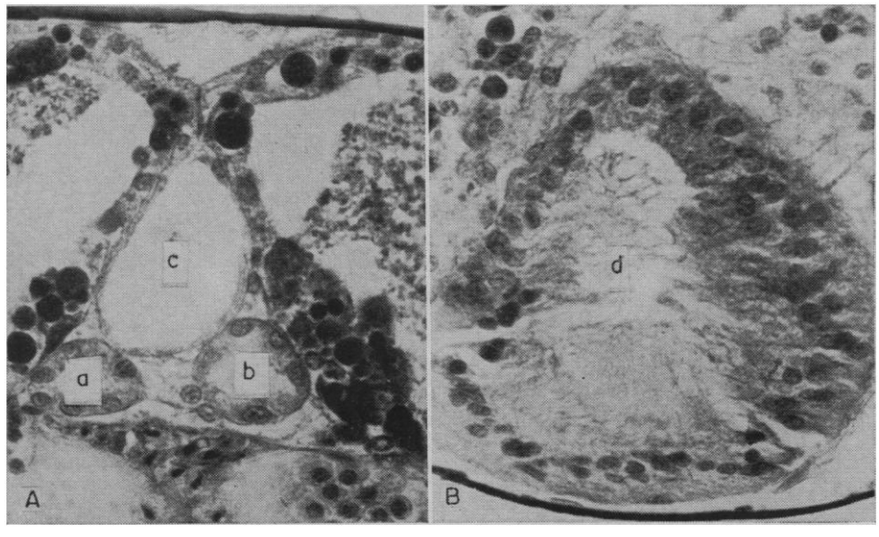

Fig. 7. A, Cross section through the three parts of the posterior midgut of a male *Serianus* (see Fig. 6). B, Cross-section through the silk gland, *d.*

lies deposit spermatophores (see *2, 3*), which the females find chemotactically.

The male olpiid *Serianus* sp. n., one of the forms that do not mate, deposits spermatophores only when a female is present. This species lives near the sea in dry sand dunes around Beaufort, North Carolina. When a male encounters a female it only exhibits the normal behavior shown by both sexes when encountering another member of their species. He may shake his pedipalps by moving both hands simultaneously, grasp one or both palpal hands of the partner for a short time, or show a "threatening gesture" by quickly moving the whole body forward and backward several times when one of them approaches the other too closely. Sometimes two animals may stay near each other for up to 15 minutes before they part, either performing these gestures or, without moving, stretching their pedipalps toward each other.

The male deposits spermatophores only after such an encounter with a female, whether she was receptive or not. He first, without paying further attention to the female, searches for a suitable place, preferably on the under side of a piece of wood, explores the place carefully in all directions, and finally deposits the spermatophore (Fig. 1a). The spermatophore consists of a stalk about 0.22 mm high, the upper part of which is inclined, and a sperm package (Fig. 5a) containing encysted spermatozoa and a substance which, on making contact with water, swells and forces the sperm out (Fig. 5b).

Then he attaches silken threads to the ground and to something above him (for example, a piece of wood or a cover glass) using an opisthosomal silk gland, which opens through the anus, rather than using the spinnerets on his chelicerae. He produces two rows of threads which originate beside the spermatophore and diverge at their ends. A path leading to the spermatophore is thus marked with threads on both sides. This path is wide at its beginning and narrow at the end where the spermatophore stands (Figs. 1b, 1c, and 3). Since the upper part of the spermatophore stalk is inclined, the spermatophore probably cannot be accepted from all sides by the female. The main function of the path marked with threads may thus be to lead the female to the spermatophore from the correct side. The exact place of the

spermatophore within the path is then located chemotactically.

When a receptive female (a young one or one that has recently bred) finds such a path she searches for the spermatophore by moving her palpal hands in front of her and finally, on extended legs, steps over the spermatophore (Fig. 2, a and b). The fluid inside her genital opening, on contact with the spermatophore, initiates the swelling mechanism, which forces the sperm out of the sperm package and into the receptaculum seminis. The female then rubs her ventral side against the ground and walks away, leaving the spermatophore with the emptied sperm package on the ground (Fig. 2c).

When a male finds a spermatophore, he destroys it by pushing it down with his chelicerae (Fig. 4), and he carefully tears down most of the threads. This behavior is independent of the age of the spermatophore; he destroys even those that have been deposited a minute before. When a female is present he then deposits a new spermatophore in the same place and marks a new path. Nonreceptive females either do not pay attention to the spermatophores, pass them and try not to touch them, or destroy them in the same way as the male does.

The formation of threads in connection with sperm transfer is quite unusual in pseudoscorpions and is better known in several centipedes, one millipede, and some primitive insects which also construct spermatophore webs or paths leading to the spermatophore (*4*). The possession of an opisthosomal silk gland is even more unusual in pseudoscorpions. Histological sections show that the silk material is produced in part of the intestine. The last part of the midgut in pseudoscorpions, generally, and in the female of *Serianus* is differentiated into a rectal pocket, a large sac that serves as a storage space for excretory material [in pseudoscorpions the gut is the most important excretory organ (*5*)] which, from time to time, is emptied in defecation. This sac is surrounded by flattened epithelial cells. This part of the alimentary canal has quite a different histology in the male *Serianus*; its epithelium consists of tall, very closely packed cells, the tips of which extend far into the lumen of the pocket (Figs. 6*b* and 7B) and produces a secretion, which is stored in the lumen. This large silk gland, like the rectal pocket of other species, opens through the anus. In the small anal segment a little spinneret is developed with which the silk secretion can be attached to the substratum.

Excretory material is stored more anteriorly in the midgut of the male *Serianus*. A part of the midgut, which in other species and in the female *Serianus* is a narrow tube surrounded by cuboidal cells, is widened in the male *Serianus*, and its epithelial cells are flattened (Figs. 6*c* and 7*c*). In histological sections this segment appears to contain excretory material. It is not known, however, how the animal controls defecation and prevents the accumulation of excretory material in the silk gland.

The rectal pocket is derived from the endoderm (*6*), and the silk gland must, therefore, also be derived from the endoderm. Silk glands are common in arachnids and may occur in the prosoma (for example, pseudoscorpions and some mites) or in the opisthosoma (spiders). However, no arachnid has been reported to have a silk gland derived from the endoderm. In most other cases the silk glands are not connected to the alimentary canal, except in some mites (*7*) in which silk glands open into the stomodaeum, but these are considered to be homologous to salivary glands and not derived from the endoderm. That part of the midgut of the male *Serianus* is differentiated into a gland for silk production seems, therefore, to be quite unique. This silk is used only in connection with sperm transfer. The male *Serianus* also has the usual silk glands in the prosoma, which open through the chelicerae, but they are less well-developed than those in the female. The silk produced by this gland is probably used for the formation of winter nests.

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Addition Radicals Formed by Hydroxyl Radical Bombardment of Uracil

Abstract. *Direct addition of O—H radicals at room temperature to the carbon No. 5 of the uracil ring has been proved by measurement of the proton hyperfine structure in the electron spin resonance of the resulting uracil + O—H radicals. Upon addition of the OH, the H originally bound to carbon No. 5 shifts to No. 6, thus forming a methylene group at carbon No. 6, with the two protons having equivalent coupling of 28 gauss. The spin density on carbon No. 5 is 0.64. The radicals were produced when powdered samples of uracil were subjected to a low-velocity beam of O—H radicals coming from either hydrogen peroxide or water vapor under reduced pressure and subjected to an electric discharge.*

As judged by electron-spin resonance (ESR) patterns of resulting free radicals, hydrogen atoms from an atomic spray add directly at room temperature to carbon atoms of the ringed groups of uracil, thymine, adenine, and guanine in the solid state (*1*). We have now performed similar experiments that show that hydroxyl radicals likewise add directly at room temperature to the uracil ring. So far, we have been unable to

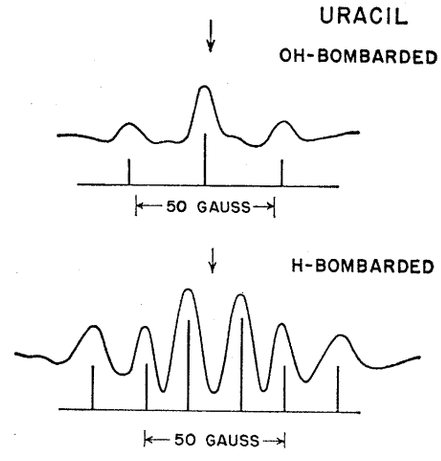

Fig. 1. Observed ESR patterns (second derivative curves) for uracil bombarded with O—H radicals (upper curve) and with H-atoms (lower curve). The bars under the upper curve represent the theoretical pattern expected for OH-addition radical (I) described in the text; those under the lower curve, for the H-addition radical (II). The observations were made at room temperature and at a frequency of 9000 Mc/sec. The lower curve is repeated from (*1*).