Fifth Report of the Laguna Marine Laboratory

and Contributions from the Zoological Laboratory of Pomona College

FIFTH REPORT OF THE LAGUNA MARINE LABORATORY AND CONTRIBUTIONS FROM THE ZOOLOGICAL LABORATORY OF POMONA COLLEGE

Published by Pomona College
December, 1917

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The Central Nervous System of Serpent Stars

WILLIAM A. HILTON

Several summers ago the activities of small serpent stars attracted my attention. The young of *Ophioderma panamensis* Lutken, possibly mingled with the minute young of *Ophionereis annulata* Le Conte were found in great numbers at Laguna Beach. These little creatures seemed fully as active as the adults. As compared to mature forms they were often very minute, the diameter of the discs being one-tenth or one-twentieth that of the adults.

As compared with the starfish the adult nervous system is, of course, more highly organized although as well known it follows the same general plan of arrangement. In the adult form studied, *Ophioderma,* the larger more superficial or epineural nerve bands were best marked and were chiefly studied. The hyponeural nerves were not prominent or well separated from the epineural. The large pedal ganglia are well marked and of the same general structure as the radial parts of the epineural strands, but the cells seemed a little larger and the fibers not quite so marked in the same preparation.

In some quite small serpent stars where the radial and circumoral systems were compared although the structure was the same in general, the more central part of the nervous system was much larger. In a specimen with a disc one milimeter in diameter the radial was about half the diameter of the circumoral. This would indicate more of a centralization than in the starfish.

A section across the radial nerve shows the nerve cells similar to those in starfish, located in the outer zone, two or three cells deep. The wider fiber area is quite homogeneous in some preparations but in others there were here found large numbers of cell processes similar to those of starfish. Certain rather fortunate slides showed these processes with great clearness. The best results of this sort were obtained from specimens fixed in Flemming's fluid, the calcium salts of the skeleton were afterward removed by means of acid alcohol, sections were cut in paraffine. Some sections were stained with iron hematoxylin, but some were mounted unstained and occasionally a very fine Golgi-like impregnation of certain cells with their branches was evident. From such preparations it was learned that the cell processes were about one to a cell and that this often branched at half its length or a little more, although it was difficult to make this out because of frequent crossing of the fibers. Most cells seemed to be uni- or bi-polar, but some had other branches running back among the cells of the celular area. In some places the long fibers from the cells were very wavy and they often ran slantingly, crossing many cell processes, some may have been larger than others, although it was impossible to be sure of their comparative size because of differences in position and staining. In small specimens smaller fibers or fibrils were evident and very numerous. In this, as compared with the starfish studied, there was more the indication of fibrillae, but no marked development of these. On the whole, the central nervous system seems more like the complex systems of other forms than does starfish.

The nerve cells are well marked, sometimes with nucleoli and with much chromatin but not usually with the characteristic arrangement of chromatin material. In some cases a small amount of material in the cytoplasm gave the appearance of tigroid substance. As in starfish, fibers from cells usually appeared as single fibrils especially in the adult. In many places the fibers or fibrils seemed to start rather abruptly from the outer zone of cytoplasm of its cell. In a few cases two fibers seemed to start from the same place in a cell, but this of course may have been where one of the fibers in crossing was cut off, or possibly fibers entering and leaving the same cell. The details of fibers and cells were taken from Flemming's fluid preparations either stained or unstained.

The segmental arrangement of ganglia in the arms is one of the well known features which forms such a striking resemblance to the ganglionic cords of many segmented animals. In some of the smaller specimens the condition of the gangila is especially well marked, towards the ends the nerve strand becomes quite reduced. In longitudinal sections of the arms of serpent stars the thicker cell area is, of course, that of the superficial radial nerve while the cells of the closely applied deeper or hyponeural nerves seem like the less numerous dorsal nerve cells of the ventral ganglia of arthropods and annelids. It is understood by some that the epineural nerves are sensory in function, the hyponeural motor, if this be so then the statements in a number of places in literature that the ventral cells of certain arthropods are sensory and the dorsal cells are motor in function seems not without interest.

Upon comparing the size of the ganglia of small serpent stars with those of adults, it was found that the nervous system is in proportion, much better developed in the small specimens. All the larger figures shown were drawn to the same scale, yet the figures of the adult were from a specimen with a disc fifteen times that of the small specimens. The radial nerve of the small specimen shown in cross section is through its narrowest part. In a small specimen of 1 mm. disc diameter the radial nerve was one-third of the diameter of the arm. In an adult but small specimen the arm was 3.5 mm. in diameter while the nerve strand was only .04 to .01 mm. in diameter. The nerve cells were slightly more numerous in cell areas in the small specimens than in the large.

SOME POINTS SUGGESTED BY THESE OBSERVATIONS

1. The synapse in this form and probably other echinoderms seems to be by simple contact, possibly at the sides as well as at the terminals of nerve cells.
2. If fibrils are found within nerve cells they are represented by very few, possibly only one to a fiber in many cases.
3. Some slight indications of tigroid substance were found.
4. With the growth of the nervous system the nerve cells become less abundant at any one place while the relative size of the nerves becomes much less in the adult.
5. The nervous system of the serpent stars looks much more like the nervous structures of more complex forms than does that of the starfish.
6. A striking general resemblance of the nervous system to the segmental arrangement of the ganglia of arthropods and annelids is shown in the arms of serpent stars.

7. The close application of the deep strands to the superficial gives the appearance of dorsal and ventral cells in the ganglia of segmented animals. The suggestion of a dorsal sensory part and a ventral motor has interest if not importance in this connection.

8. A simple condition of relationship of nerve cells to each other seems evident in the radial and circumoral strands of this form as well as in starfish and these conditions may have an important bearing in understanding the more complex relationships of other species. If the conditions here simply shown are not exactly reproduced in vertebrates or arthropods, they may give some indication of the way in which the more complex have come about.

9. If the more superficial parts of the radial and oral system are sensory and the smaller dorsal parts motor, then it seems that the larger ventral strand must be a little more than sensory, as has been shown by numerous experiments, because of its size and because of its inter-relationships. In other words we have here the origin of a central nervous system or associating part from a sensory portion. This may be an important suggestion in connection with the origin of the central nervous system in other forms.

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(Contribution from the Zoological Laboratory of Pomona College)

EXPLANATION OF FIGURES

Figures 1-3. Cross sections through the superficial radial nerve of an adult serpent star. X350.

Figures 2 and 3 do not show the whole breadth, and Fig. 2 shows a little of the deeper more dorsal nerve area.

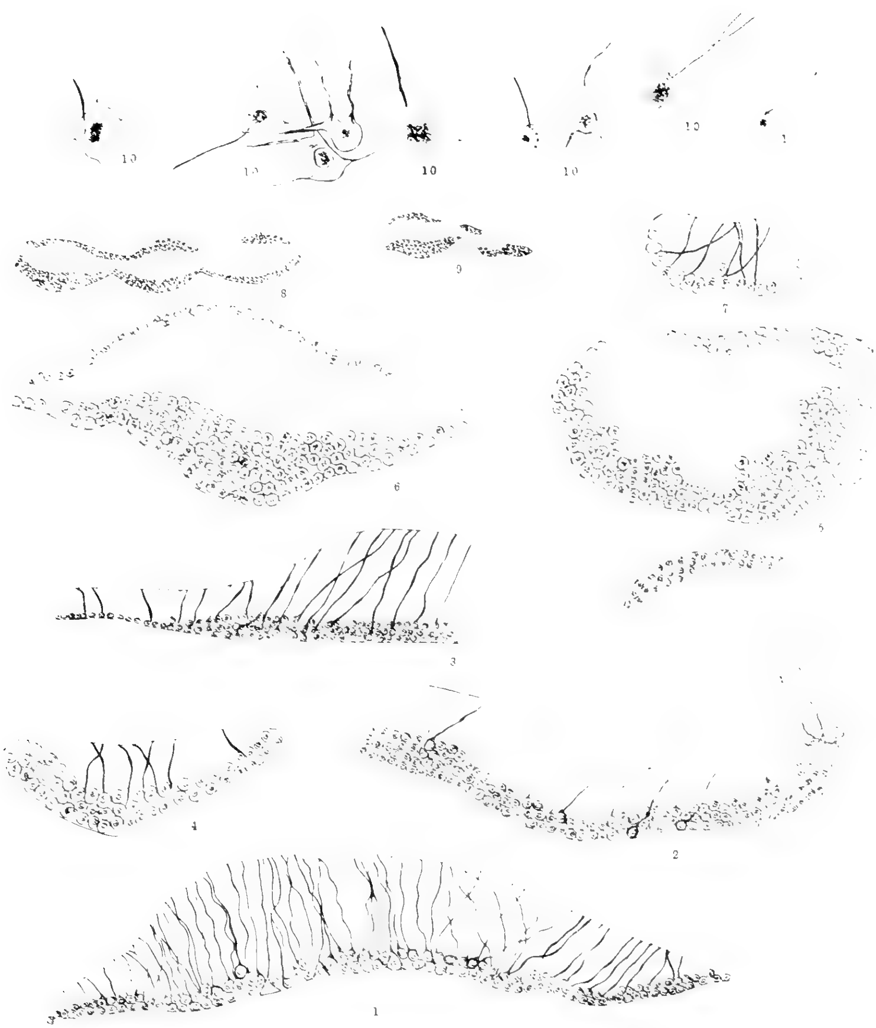
Figure 4. Section through the pedal ganglion of an adult. X350.

Figure 5. Section through the circum oral strand of a serpent star of 1mm. disc diameter. X350.

Figure 7. Cross section through the narrowest part of the radial nerve strand of a 1 mm. serpent star.

Figures 8-9. Longitudinal section through the nervous system of the arm of a 1 mm. serpent star. X75.

Figure 10. Nerve cells from the nerve strands of adult serpent star fixed in Flemming's fluid. X700.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1917 Pomona College Journal of Entomology and Zoology, Vol. IX, No. 4, December

Some Remarks on the Nervous Systems of Two Sea-Urchins

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The largest and smallest species of sea-urchins occurring at Laguna Beach are the materials for this study. *Lytechinus anamesus* H. L. C., a centimeter or less in diameter, were sectioned while the radial nerves from *Strongylocentrotus franciscanus* A. Ag., of fifteen times this diameter were studied.

In sections of the smaller species it was possible to trace the chief branches of the nervous system. The long radial nerves, with their side branches to the tube feet and the branches to the large spines, with the ganglion-like rings about the bases of the spines, were easily found, also the branches from the circumoral nerve ring to the intestines in the region of Aristotle's lantern. Here stands fused with epithelial cells of the intestine. The general parts of the nervous system, such as described and figured by Delage and Heroward, '03, were found. The radial and circumoral bands of nervous tissue as is well known, resemble those of the superficial radial and circumoral strand of starfish very closely, but the deep system is poorly represented. The superficial plexus was clearly seen as a whole, only parts were made out such as ganglion-like rings at the bases of the larger spines, a section of one of which is shown in Fig. 4. From the radial nerves lateral branches were easily followed to the tube feet. Fig. 2 is a cross-section of a radial nerve, in which a branch on the right is shown just as it enters a tube foot. The radial nerves are thickest in the more central portions, thinner at the oral and especially at the aboral end. A longitudinal section of one of the radial nerves of the smaller sea-urchin is shown in Fig. 1. The oral end is below and at the left, the aboral above at the right. Fig. 2 is a cross-section of two-thirds of one of the radial nerves near its central portion, and Fig. 3 is a cross-section of a portion of a radial nerve near one end. These figures are from the smaller sea-urchin, but enlarged more than Fig. 1.

The structure of the nerve bands seems a little more complex than those of starfish, in that the nerve cells are more modified and the fibers and fibrils more intimately related in all parts of the thickness of the nerve strands. In cross section the fibers and fibrils may be followed straight in more easily than in longitudinal sections, where there is evident a decided longitudinal disposition of the fibers and fibrils. Cells, especially in the smaller sea-urchin, are *very* numerous and the fibers or fibrils very small.

In the larger species the radial nerve is broad, but the cell area is narrow, with only several layers of cells. Fig. 5 is a section of one of the nerve strands from the smaller species. Fig. 6 is from the larger species. Both figures are drawn to the same scale and enlarged more than the other drawings. As the cells are larger in the larger species the fibers seem to show better. There are many fine fibrils and possibly in some cases fibers made up of fibrils. Many cells in the larger species seem more complex than bi-polar forms and some true nerve cells have migrated to the area of fibers and fibrils. Some of these show fibrillae joining the cytoplasm. Some of the cells in the fibrous area especially seem to be neuroglia cells, or at least are not nerve cells. Some multi-polar cells are shown in the figure, probably many others are multi-polar in the general cell area. There are many cross lines of fibers and fibrils in the whole thickness, but the massing of fine strands is more intricate than in starfish.

As to the general character of the nervous systems of these two species of sea-urchins is compared with starfish, they differ as much from each other in general appearance of the sections as they differ from starfish.

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(Contribution from the Zoological Laboratory of Pomona College)

EXPLANATION OF FIGURES

Figure 1. Longitudinal section through a radial nerve of *Lytechinus anamesus* H. L. C. The aboral end is toward the top of the page. ×75.

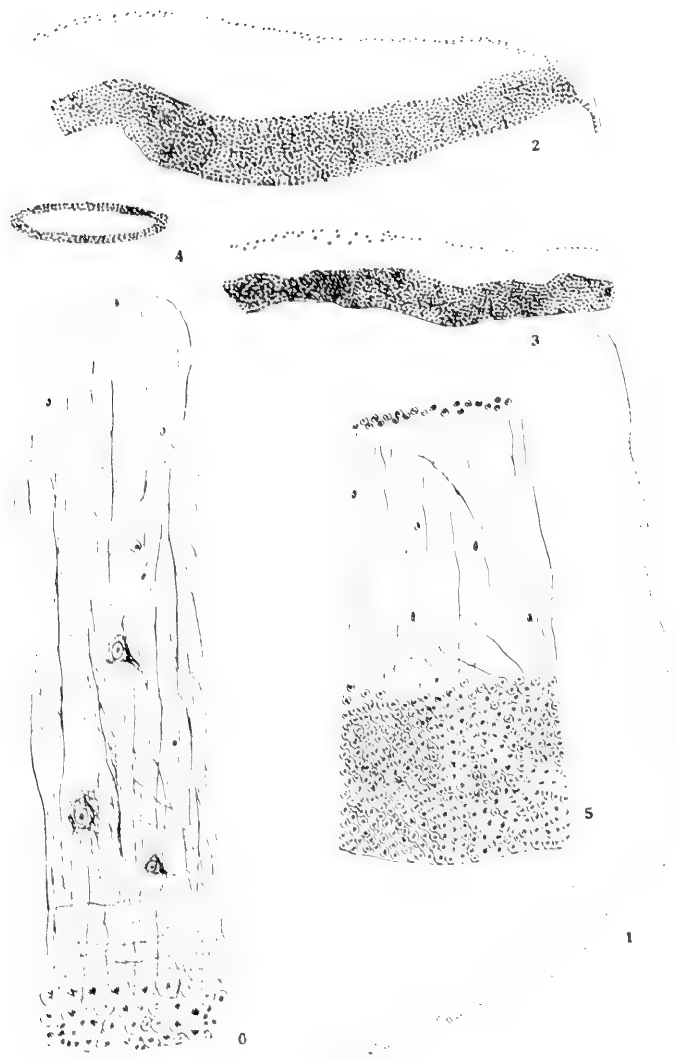
Figure 2. Cross section through a large part of a radial nerve of *Lytechinus*. A branch to a tube foot is shown at the right. ×160.

Figure 3. Cross section of a radial nerve of *Lytechinus* nearer one end than Fig. 2. ×160.

Figure 4. Cross section through the band of nervous tissue found at the base of one of the larger spines of *Lytechinus*. ×160.

Figure 5. Section through a radial nerve of *Lytechinus*, drawn with best oil objective obtainable. ×750.

Figure 6. Section through a radial nerve of *Strongylocentrotus franciscanus* A. Ag. Drawn the same as Figure 5. ×750.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The Nervous System of Aracoda Semimaculata and the Description of a Method of Stereographic Reconstruction

WILLIAM F. HAMILTON

Aracoda semimaculata, of the family Lumbriconereidæ (polychætous annelids) is found in great abundance in the mussel beds near Laguna Marine Laboratory. In length the worm may be from five to fifty cm. and in diameter, from two to six mm. In general appearance these worms resemble the earth worm, being without palpi, or tentacles and usually of a reddish brown color. Pigmentation, however, varies from a deep reddish brown to a pale yellow. The cuticle is a tough chitinous membrane clear yellow in cross section, but due to the fact that it is laid on in exceedingly thin laminæ it presents a beautifully iridescent surface.

The prostomium (Fig. 1), is a blunt, ovoid and slightly depressed organ which is practically made up of nervous and sensory tissue, constructed and inter-related in a very complex manner. The peristomium is about as long as the prostomium and twice as long as the body segments (Fig. 3). The body segments are unianulate and very distinct. The parapodia (Fig. 3; a), are biramous, the neuropodium, typically—in the middle segments of the worm—being distinctly longer than the notopodium and bent up finger-like at the tip. The notopodium appears as a broadly rounded discontinuation of the upper half of the body of the parapodium. It is equipped with a varying number of winged pointed setæ and blunt uncinate setæ. The front and hind parapodia become less and less typical as the ends of the worm are approached.

METHODS

Fixation. A large number of the worms, fixed in acetic sublimate and in hot mercuric chlorid were prepared during the summer at the Laguna Marine Laboratory, transferred to 80 per cent alcohol and saved for study the following winter in Claremont. Those fixed in the acetic mixture could easly be sectioned whole in paraffin of a melting point of 60-62 degrees, but it was necessary to peel off the cuticle and withdraw the setæ of those fixed in hot mercuric chlorid. The internal connective tissues, however, were better preserved in this fluid. There seemed to be no marked difference in fixation of the other tissues.

Staining. The most effective stain for tracing out gross anatomy and nerve distribution proved to be a faintly acidified borax carmine used after a fixation of hot mercuric chlorid. The muscular and epithelial tissues were stained a uniform light pink, the nervous tissues a darker pink and the connective tissues, especially the perineurium a bright red. Villain's copper hematoxylin, iron hematoxylin, and double stains of these and methylin blue with eosin, "licht grün" and neutral red were of value for cellular detail.

Reconstruction Method. A wax and blotting paper model of the brain (Fig. 2), was made in the usual way. To supplement this two stereographic reconstructions (Figs. 1, 4) were made which were of advantage over the wax model in the following ways. They are easier to make, eliminating the steps that involve cutting out, impregnating and reassembling the parts of the wax reconstruction. It is possible as was done in Fig. 1 to make a "sciagraphic reconstruction" that will show the internal parts in their normal relation to the other organs. If necessary, colors could be used to make the morphological differentiation clearer. When the reconstruction is finished it is the reproduction at a certain magnification of any desired aspect of the object and is equal in all important respects and superior in many respects to a photograph or drawing of a wax reconstruction. What little distortion there is may be calculated as a function of the displacement angle and easily taken into account.

The method pursued may be described as follows: The object should be embedded with a piece of liver or similar tissue having a smooth and quite rectangular face parallel to the axis of the specimen. The pieces may be arranged on a watch crystal after infiltration and the embedding paraffin poured on hot enough not to form a crystallization capsule around them. This gives an orientation guide whose projection is represented in b (Fig. 14). Fig. 14 is a diagramatic illustration of the reconstruction of one cylinder inside another by means of this method.

The sections are cut at right angles to the orientation plane and hence transversely to the axis of the object. The knife must be sharp and care must be taken in the mounting to prevent any warping or wrinkling of the sections. An outline of the first section is drawn by means of a projection lantern—represented by the shaded circles (Fig. 14; a)—and a line drawn on the projection of the edge of the section of the liver-piece, represented by the first cross line on b (Fig. 14). From the ends of this cross line are drawn lines in that direction from the cross line that is related to the cross line in the same way as the side of the drawing, which is a projection of part of the aspect to be reconstructed, is related to the center of the drawing. These two lines (the long parallel lines, Fig. 14; b), determine the projection of the orientation plane, and on them are measured off segments about equal to half of the product of the thickness of the sections times the magnification in diameters. The projection of the second section of the series is so placed that the projection of the edge of the liver section coincides with a line drawn between the dots marking off the first segment on the lines determining the orientation plane. The section itself is outlined in the same way except that those parts of the second outline which are "covered up" or are within the area bounded by the first outline are left blank, since they represent the parts of the surface which are hidden from view by the outcurving nearer surfaces. The process is repeated progressively along the segments of the displacement lines with all of the rest of the sections. Those lines which form the edges of the completed figure are re-enforced and then transferred to a separate sheet of paper. This bare outline is shaded to fill out the contour of which the lines on the other sheet are a topographic diagram as shown (Fig. 14c).

It is obvious that the cylinder is somewhat distorted since the face of the figure seen from this point of view should be an ellipse The distortion is known as a sheering distortion, but as it is constant and does not appreciably alter the relations of the parts the distorted reconstruction is quite as useful as the normal one.

The distortion may be eliminated in either of two ways. The first and best is to set the orientation guide at an agle of about 45 degrees from the axis of the object and cut the sections at right angles to the orientation guide and hence obliquely to the specimen. The reconstruction lines are drawn in the same way except that the projection of the orientation line is allowed to fall in the same place each time, thus eliminating the displacement and consequent distortion. It is hard, however, to get a clear idea of the relations of parts from oblique sections. The reconstruction does not show any more than one that follows the first method, and each series is good for reconstructing only one aspect.

The other way of getting rid of the distortion is to insert at the place of proper magnification in the cone of light rays from the projector a lense of sufficient curvature to refract the rays into a parallel bundle. By tilting the drawing board at a proper angle to this bundle the field will be caused to fall in such an ellipse as to eliminate any distortion. This angle is one whose tangent equals the displacement divided by the product of the thickness of the section times the magnification in diameters.

Occasionally wrinkling of the section in cutting or in mounting occurs and renders it necessary to disregard the orientation guide. It is easy, however to put the section in approximately its right place and to check it up by the next section. In reconstructing symmetrical specimens where there is a clearly marked axial line it is often possible to dispense with the orientation guide and to place the successive sections from landmarks which they themselves bear.

ANATOMY

The brain (Fig. 1, 2, 4) is a very complex structure. Topographically it is divided into two parts, the dorsal and ventral by the central mass of muscle and blood vessels (Figs. 5, 6, 7; q), which tissue, going forward from between the central part of the brain and the visceral ganglion, pinches out into a muscular sheet at either side and separates the six dorsal lobes from the eight to ten ventral lobes or branches of the fore part of the brain. The brain is symmetrical and is divided into lateral halves by a septum which continues as a canal through the main brain (Fig. 6; w).

Along slightly different lines the brain may be divided into sensory, cross-connective visceral and nuchal parts.

Sensory System. The prostomial system of sense organs in this form is one of the most complex and highly specialized among annelids. Just forward of the central cross-connective part (Fig. 6) the brain divides into two lateral halves, which extend down and connect with the two front branches of the visceral ganglion. These halves (Fig. 7), give off two rounded lateral sensory lobes (Figs. 1, 4, 6; b) and then divide into quadrants, the larger of which compose the lower pair. Each of these lower quadrants subdivides into four and sometimes five lobes (Figs. 1, 4, 5; c). The inner three are long and slender, while the outer one, which shows a tendency in large specimens to subdivide at the tip is much shorter and broader. The dorsal pair of quadrants each divide into three distinctly longer and more slender lobes, giving in all from fourteen to sixteen lobes. The lobes are each composed of a cellular and a fibrilar tract. The fiber bundle is on the inside and runs directly back to the main brain, while the cellular area is on the surface side of each lobe and is directly connected with the subcuticular sense organs. These cells (Fig. 12; u), underlie the whole of the prostomial cuticle and are connected with the brain by means of fibers which run into the brain in larger or smaller irregularly placed bundles or even as individual fibers, threaded between the epithelial cells of the subcuticular region. The whole of the prostomial nervous system, including the visceral ganglion and its branches give off sensory fibers in great abundance. In many cases the sense cells seem to send off sensory fibers direct to the cuticle.

In the front lobular region, besides the sense cells and the ordinary small nerve cells (Figs. 5, 6, 7, 10; d), there are a few large cells embedded in the brain (Figs. 5, 10; f). These have nucleoli and in some cases fibers can be traced from them. They are much smaller than the giant cells (Figs. 11, 8; g) in the ventral nerve cord, more irregular, the structure of the protoplasm is much finer and they are much harder to stain with ordinary stains. Hematoxylin leaves them clear unless a mordant is used. Methylen blue and the other common nuclear stains do not touch them. Villain's copper hematoxylin gives the best results, staining the protoplasm reddish purple and the nucleus blue-black. These cells are found only in the front part of the prostomium. Associated with these in location are a number of mucous cells which have invaded the brain and from their staining reactions seem to be functional (Figs. 5, 10; h).

Cross-connective part of the brain. The main part of the brain contains the fibrilar cross-connections for the whole brain. The brain cells are practically ail confined to the dorsal side. The eyes, four in number, are buried in this cell layer. The central pair is very small and vestigial, none of the lense structure remaining and but little of the pigment. The lateral pair is complete, with lense and cup-shaped pigment layer, but in all of the specimens I have sectioned the eye is inverted, with the pigment outside and the lense facing down toward the brain. As if to render this ocular paradox more striking the perfect eyes are deeply embedded in the head and the degenerate eyes are just under the cuticle. This is a rather interesting example of degeneration.

From the rear of the brain extend the circumœsophageal commissure and the nuchal ganglia. The former is biramous, dividing on each side into a dorsal and ventral branch. This is analagous to the phenomenon found in Nepthys where the ocular and surface-sensory parts of the brain are separate structures. (Quatrefages; 44.)

The nuchal ganglia (Figs. 13, 1, 4; i), are connected to the brain by means of two nerves .3 mm. apart, .03 mm. in diameter and 4 mm. long. These nerves come out from the "punkt-substanz" of the brain immediately below and behind the central pair of eyes, follow along the nuchal pits for some distance, when they join on the two nuchal ganglia on their lower front surface. The nuchal pits act as a pair of narrow-mouthed sacks opening, close together just under the lip of the peristomium, enlarging as they go in until they are large enough to contain in their thin chitino-membranous sack, each, a ganglion. The apparatus bears a rather vague resemblance to the otocyst found in Arenicola (Ehlers, '92), but inasmuch as there are no otolyths to be found and the only cavity to contain them is very small and pyramidal instead of round, the diagnosis is doubtful. The thing could hardly be functional, but is probably degenerate or else for some other purpose. The ganglia are connected by their perineurial sheaths in the mid line and the nuchal sacks, though they do not fuse are separated merely by a thin septum. They differ in this respect from *Lumbriconereis erecta* Moore where the ganglia are quite widely separate. Histologically the structure is much the same as the other ganglia of this form. The cells are a little larger than those of the brain and the reticulum is considerably more noticeable.

The subœsophageal ganglion (Fig. 1; j) is of the usual annelid form as is the nerve trunk (Figs. 8, 9). The segmental nerves are given off one pair to each segment from a long narrow pedicle (Fig. 3; k). They follow around the segment just outside the muscular coat. At the base of the foot there is a small ganglion giving off two branches, one to the foot, which branches twice and one passing beyond the foot to the dorsum where it branches extensively in both the epithelium and muscles.

Visceral System. The visceral nervous system (Fig. 4), consists of three visceral ganglia, and a complex system of nerves serving the various pharyngeal muscles. The system originates in a main visceral ganglion (Fig. 4; v). which is situated just below the brain and is equipped with four pairs of symmetrical branches. The front pair of nerve trunks are short and rather thick. They lead to the lateral halves of the brain and their fiber masses fuse with the "punkt-substanz" of this part of the brain. The side branches leave the visceral ganglion at about its central and widest part and lead to the base of the œsophageal connectives. Near where these nerves leave the visceral ganglion a pair of small nerves (Fig. 4; r) about .01 mm. in diameter branch off from the ventral side and extend caudad for a distance of about 2.5 mm. These nerves form an analogue of the complex labio-visceral nervous system found in Eunice. (Quatrefages; '44.) The two hind trunks branch out into the visceral nervous system proper, as diagrammed (Fig. 4). They go straight back, parallel, assuming a diameter of about .04 mm. About 1 mm. behind the visceral ganglion they branch into an outer (Fig. 4; m) and an inner pair (Fig. 4; u).

The outer pair form the maxillary nervous system. They bend ventrad and branch in a very complex manner on either side of the denticular pouch, serving the complicated musculature of the four pairs of maxillæ.

The inner pair of visceral nerves form the superpharyngeal nervous system. Near where they branch off from the outer pair they partly anastomose, interchanging a few fibers, but with no attendant ganglionic structure. The anastomosis continues for a distance of .16 mm. and then the nerves separate, assuming a diameter of .02 mm. and run parallel about .2 mm. apart for a distance of 1.3 mm. As they do this they bend dorsally so that they are deeply embedded in the upper wall of the denticular pouch and are quite dorsad of the maxillary musculature. This brings them to where the intestine folds off from the dorsal side of the denticular pouch. The nerves bend still more dorsad and become embedded in the intestinal epithelium. Here they become enlarged by ganglion cells and separating (Fig. 4; p), go around the mouth of the intestine proper and come together in the ventral wall of this structure. Just before their second anastomosis they send off two branches into the lateral and dorsal walls of the intestine. These nerves and the one into which the main pair fuses extend back along the intestinal wall for a short distance.

An interesting observation was made on the muscle which acts on the mandibles. It is a long spindle-shaped muscle reaching from the back of the pharynx to the mandibles. These bifurcate black chitinous plates are in apposition to the slit (Fig. 4; 6), whose walls are armed with the maxillæ and form the denticular pouch. The mandibles are bound to the walls of this slit by small muscles used in prehension. Now the members of this group that has the denticular pouch do not completely evert their pharynx in the act of prehension. They merely, from what observations I have been able to make on the Eunicidæ and on this form, push out the mandibles and the forceps jaw of the maxillæ. There is no proboscoideal musculature, such as is found in Phyllodoce, Glycera and Nereis, which functions from the inside and by contracting, turns the proboscis inside out. To take the place of the muscles which evert the proboscis by contracting and pulling it out we have in this form a muscle which, acting on the mandible forces this and the forceps teeth of the maxillæ out and does so, paradoxical as it may seem by *expanding*. The fibers in this muscle, instead of running from the origin to the insertion of the muscle as a whole run dorsoventrally from wall to wall so that any stimulus acting on the nerve which supplies this muscle and causing the fibers to contract would cause the muscle to become rigid, of less diameter and of greater length. Since the origin of the muscle is in the back part of the pharnyx and since this organ is bound to the body wall by connective tissue and muscles, the "expansion" of the mandibular muscle must force the mandible forward and with it the forceps teeth of the maxillæ, which are closely bound to it. This action extrudes the teeth and a secondary reflex seems to be established that causes them to be snapped together forcibly soon after they are extruded. This reaction is carried on with such vigor that I have known eunicids to bite themselves into two or three pieces while dying in fixatives.

The advantage of this extrusion system over the more primitive proboscoideal eversion found in the forms without the denticular pouch can be seen in the quickness of the reaction, its superior vigor and the fact that the teeth are extruded first rather than as a final consequence of the comparatively slow eversion of a soft fleshy proboscis.

SUMMARY

1. The annelid, *Aracoda semimaculata,* is a highly specialized and evolved member of the lumbriconereidæ, inhabiting the mussel beds near Laguna.

2. Reconstructions were made stereographically as described in this paper.

3. The brain is very complex and highly specialized sensorially. It is divided into the sensory, connective, nuchal and visceral systems, is symmetrical and has a *central* tubal cavity running through the lower part of the main cross-connective portion of the brain, from front to back, parallel to a cavity which is partly filled with muscles and glands, and runs between the visceral ganglion and the main brain and forward between the dorsal and ventral lobes of the fore brain. This *central* cavity, taken together with the very complex and convoluted olifactory forebrain presents an appearance which seems quite similar to that described by Patten in *Limulus* and other invertebrates, but which can probably be best explained

as a mere functional adaptation rather than as a phenomenon of phylogenetic importance.

A. The sensory system is composed of the entire surface portion of the brain, i.e., those parts underlying the surface of the prostomium. The forepart of the brain is subdivided into fourteen to sixteen slender lobes of sensory cellular and inside fibrilar tracts. The sensory cellular tracts are not confined to the lobes in front, but extend all over the brain and give off fibers which connect with the subcuticular sense cells or go directly to the cuticle as sense fibers.

B. The main or cross-connective part of the brain consists principally of "punkt-substanz" with dorsal sense cells.

C. Eyes are four in number, the central pair being degenerate close to the surface of the prostomium, and lacking in lense structure. The lateral pair are well-developed but buried deeply in the prostomium and so inverted that the lens is inside and the pigment outside. Neither pair of eyes can be regarded as functional in the adult.

D. The circum-œsophageal connectives branch on each side into a dorsal and ventral ramus. This is analagous to the phenomenon found in *Nepthys* where the ocular and the surface sensory parts of the brain are separate structures.

E. The nuchal ganglia, extending to the rear from the dorsal part of the main brain are connected with a more or less rudimentary organ which is doubtfully a functional otocyst.

F. The subœsophageal ganglion and nerve cord are of the usual annelid form.

G. There is one segmental nerve extending around the body to a small pedal ganglion, whence it branches into two nerves, a pedal and a dorsal. The former gives rise to a motor notopodial branch and a sensory neuropodal branch. The latter is both motor and sensory in its distribution.

H. The visceral system consists of a labial, maxillary and a superpharyngeal system.

(a) The labial system is degenerate from the much more complex system in *Eunice*, or even in the much more closely related *Lumbriconereis*. It consists of a pair of small short nerves running down the lateral and ventral walls of the œsophagus and originating in the lateral nerves of the visceral ganglion.

(b) The maxillary and superpharyngeal system originate in the main visceral ganglion which is situated just below the brain. The maxillary system branches repeatedly and serves the complex maxillary musculature. The superpharyngeal system goes straight back to where the intestine folds off. Here it developes a pair of slender ganglia which form a nearly complete circuminestinal ring and send off branches to the wall of the intestine.

4. The muscle which causes extrusion of the teeth is attached to the mandibular plates. It is a spindle-shaped muscle but acts by an increase of length instead of a contraction as is usual in muscles of this shape. This expansion is possible through the fact that the muscle fibers run across the muscle instead of from origin to insertion, and from the fact that the whole muscle is enclosed in a thick envelope of tough connective tissue, which holds the muscle rigid when a contraction of the fibers lessen the diameter and increase the length of the muscle. This adaptation seems to render prehension more efficient.

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(Contribution from the Zoological Laboratory of Pomona College)

EXPLANATION OF FIGURES

Figure 1. Stereographic reconstruction of the prostomium showing the position of the brain inside of it and the position of the fiber tract inside of the brain. The prostomium is shaded light, the brain darker and the fiber system darkest. The prostomial sensory branches are not shown. ×50.

Figure 2. Photograph of a wax reconstruction of the brain, showing the visceral and nuchal ganglia darkened. The two hundred odd prostomial sensory branches are shown in this reconstruction. ×40.

Figure 3. Diagram of the distribution of a segmental nerve.

Figure 4. Stereographic reconstruction of the ventral side of the brain and of the visceral nervous system. ×40.

Figure 5. Cross section through the front part of the prostomium cutting through the front lobes of the brain. ×50.

Figure 6. Cross section of the main cross-connective part of the brain showing the eye, the visceral ganglion and the canalicula that runs through this part of the brain. ×50.

Figure 7. Cross section of the brain in front of the main cross-connective part where it has divided into two lateral halves. ×50.

Figure 8. Cross section through the ventral nerve cord near where the segmental nerves come off showing giant cells. ×50.

Figure 9. Cross section of the above between the origins of these nerves. ×50.

Figure 10. Enlarged view of the connection of one of the lobes of the fore brain with the subcuticulum. ×250.

Figure 11. Giant cell and surrounding tissue. ×250.

Figure 12. Subcuticulum showing sense cells, mucous cells and regular subcuticular cells. ×500.

Figure 13. Cross section of nuchal ganglia. ×50.

Figure 14. Diagram of stereographic reconstruction, as described herein of two concentric cylinders; (a) is the first step, showing the cylinders with the topographical reconstruction lines; (b) is the orientation guide, and (c) is the shaded interpretation of (a).

MEANING OF THE LETTERS

(a) parapodia, (b) lateral brain lobes (c) frontal brain lobes, (d) brain cells, (e) fiber tracts, (f) large brain cells, (g) giant cells in ventral cord, (h) mucous gland cells, (i) nuchal ganglia, (j) subœsophageal ganglion, (k) pedicle of neurocord, (l) muscle tissue, (m) outer or maxillary nervous system, (n) inner or superpharyngeal nervous system, (o) maxillary slit opening into denticular pouch, (p) ganglia forming circumintestinal ring, (q) cavity which separates the dorsal from the ventral parts of the brain, (r) labial nerves, (s) subcuticular cell, (t) mucous gland cell, (u) sense cell, (v) visceral ganglion, (w) neural canal.

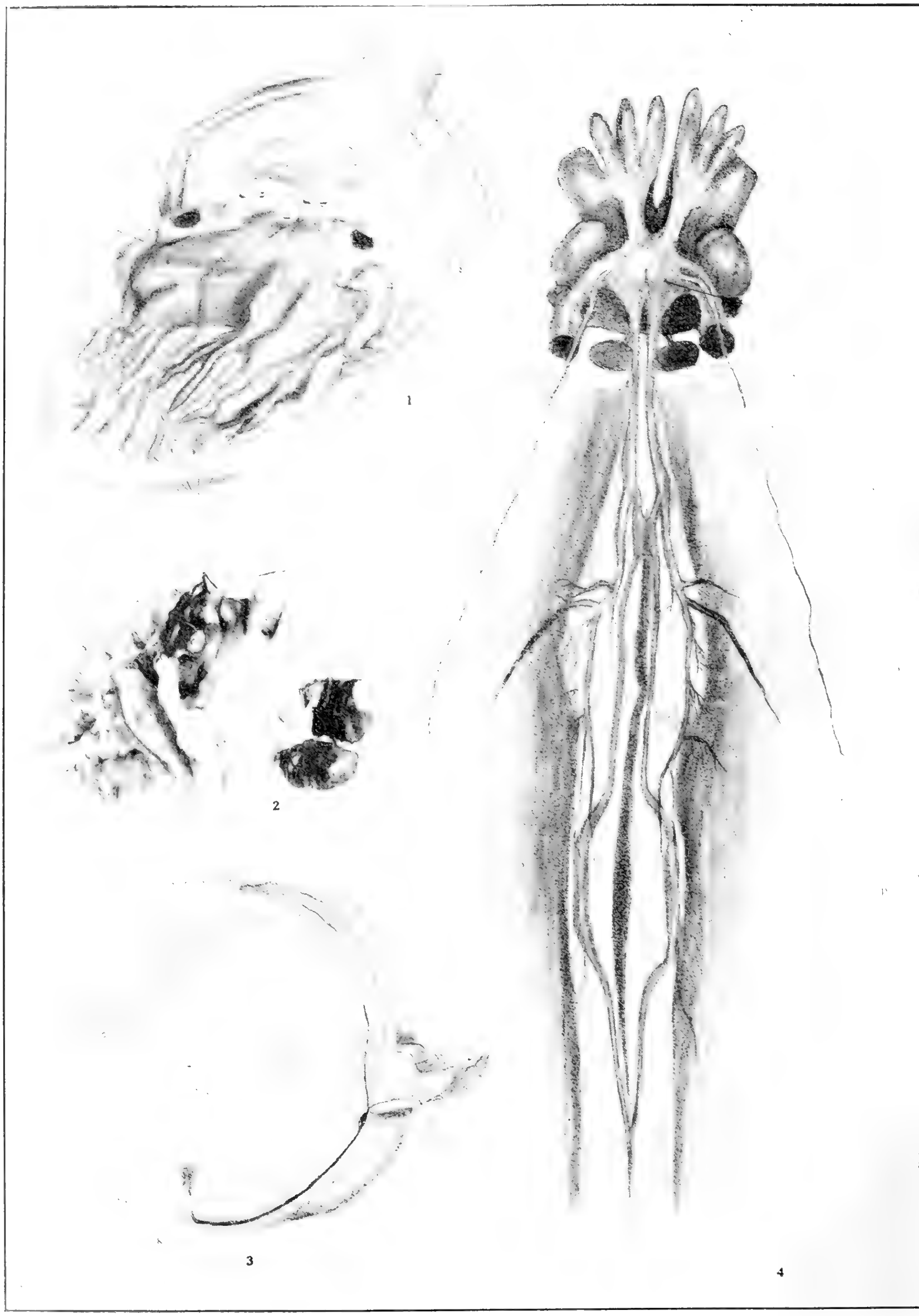

Plate I

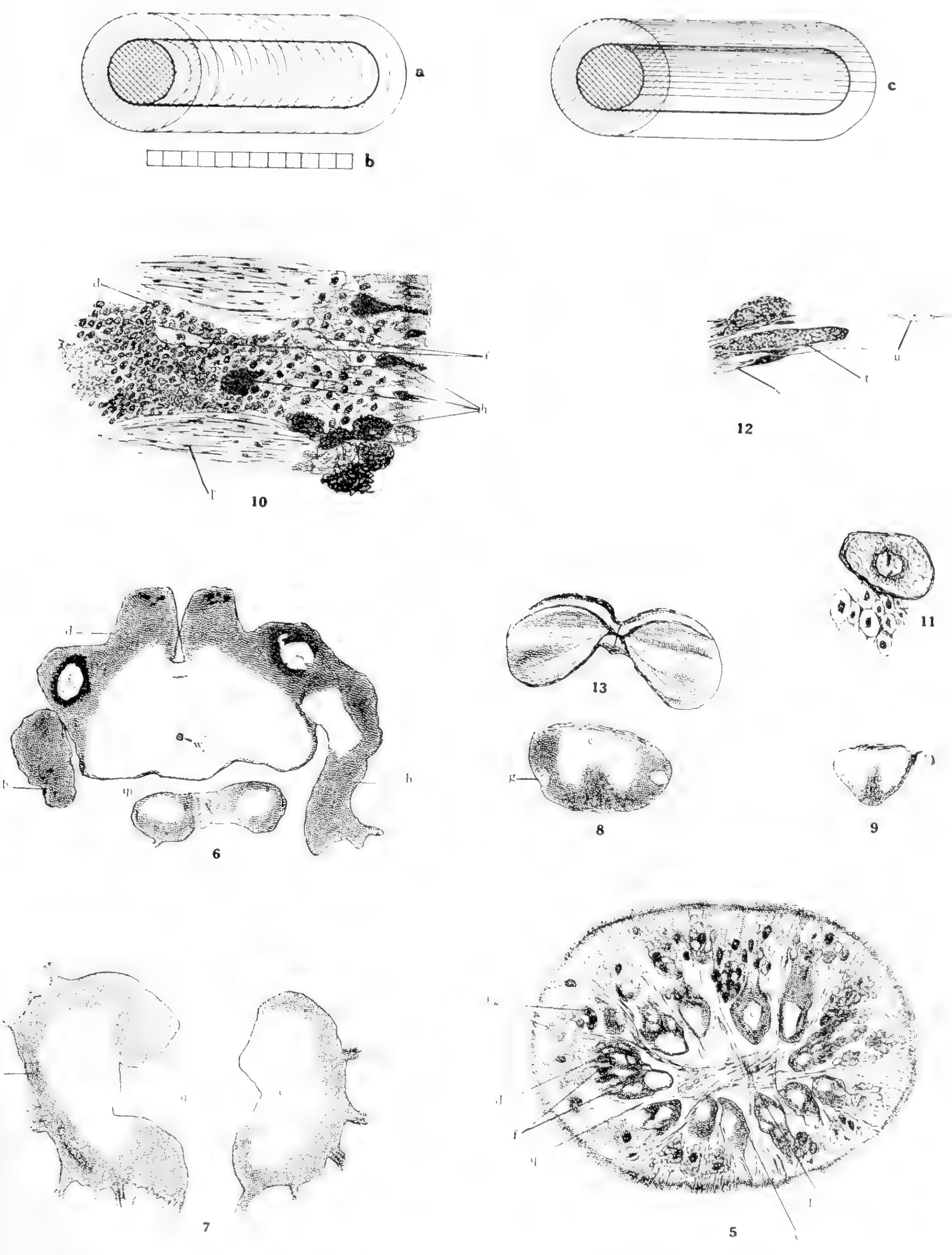

Plate II

1917 Pomona College Journal of Entomology and Zoology, Vol. IX, No. 1, March

The Central Nervous System of a Sipunculid

WILLIAM A. HILTON

A number of specimens of the genus Phascolosoma were obtained at Laguna Beach. These were preserved in various fluids. Flemming's fluid and mercuric chloride, were especially valuable for study. The nerve cords were dissected out and mounted after staining. Some were imbedded, sectioned and stained. The stain which brought out the cells with greatest clearness was copper haematoxylin.

The general character of the nervous system of sipunculids is well known, and the specimens examined at this time were typical as to the form of the brain and cord. The brain is imbedded in the proboscis just below the tentacles. It has a similar appearance in section to the photographs of Spengel, 1912. The brain is small. Two main branches supply nearby tentacles and muscles. There is a pair of small branches from the connectives. Extending from the epithelium of the tentacular region is a pair of tubes leading into the brain, the cerebral organs. These epithelial tubes lead to a pigmented area on each side, and these pigmented areas in section look like simple eyes. A few irregular spots of pigment were found near the larger masses. The epithelium at the outer end of the tube was also deeply pigmented.

Throughout the body the ventral nerve cord kept about the same width, although the muscle bands at the sides increased somewhat. The strands connecting the muscles and nerves to the animal's body were more or less regularly arranged. In specimens with the proboscis drawn in, the nerve cord is of course doubled back on itself. In the specimen drawn at the junction of the two parts, that of the proboscis and that of the ventral body-wall, there is a lack of lateral branches, as shown in the upper portion of the second line of the drawing. Towards the caudal end the lateral branches come off more irregularly.

When the animal is contracted the nerve cord seems to be segmented, but sections show that this appearance is due to the slight folding of the nerve cord within the muscle bands; the nerve tissue does not seem to be elastic.

Very little has been written on the histological structure of sipunculids. Haller, 1889, discusses a number of points, especially in *sipunculus nudus,* relating to the ventral cord only. I find a number of differences in this form. I did not find any very clear evidence of special neuroglia cells, such as described and figured by Haller, such elements may be present, but at least they are not evident, not so evident as in many other invertebrates which I have examined. Nerve cells may anastomose with each other as shown in Haller's figure, but of this I can not be sure. If fibres do not unite they are in very intimate contact.

In the ventral cord no small fibrils were seen only rather small fibers which may have been fibrils. The lack of connective material in part at least, perhaps because the nervous system is often extended and folded, shows the cell processes with great distinctness. This may be why a clearer picture than usual is presented of the relationship of cells.

Cells are abundant on the ventral side of the cord, especially in the middle line. The more dorsal fibrous region is practically without cells of any kind. No very marked tracts of fibers are evident, the fibers are about equally distributed in all directions and may be subdivided as follows:

1. Fibers which enter the fibrous mass from cells and run short distances up and down.

2. Fibers which pass from cells to other cells near by in the celular area.

3. Fibers which leave the ganglion laterally from ventral cells.

4. Fibers which enter from the lateral nerves to end in the fiber area or in among the cells.

There are no indications of long fibers, either ascending or descending. After the examination of the cord of this animal one is impressed with the suggestion that many cells of similar sort act alike, that is groups of cells, not individuals are involved in the simplest transmissions of impulses. This general suggestion which, of course, is not new, comes to mind with great clearness after the study of thin sections of the cord of this animal. Whethei the cells actually anastomose or not is a questions hard to decide, but in the numerous contacts of naked fibers there is, I believe, ample opportunity for the transmission of complex changes from cell to cell, to all parts of the nervous system. In this form there is no particular localization of definite centers.

The brain differs in structure from the cord, the central fibrous mass is more dense, the cells are very much smaller and more numerous. Some cells of the brain send their fibers out directly without the common pathway of a distinct nerve trunk. No special features of the brain were determined except the cerebral organs already described.

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(Contribution from the Zoological Laboratory of Pomona College)

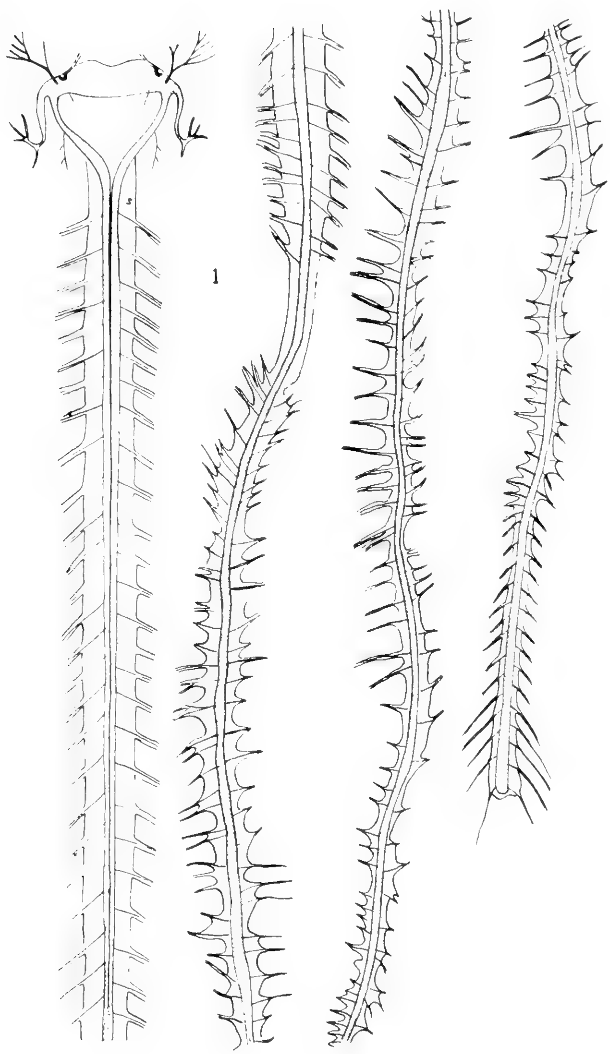
EXPLANATION OF FIGURES

Figure 1. Central nervous system of Phascolosoma X15. The cord is shown in three separate pieces. The lower end of the first or left-hand drawing should join with the second and so on. The central nerve band is shown with the lateral branches of muscle and nerve. The brain is shown attached to the first segment at the left. The pigment spots, cerebral tubes and chief nerves are shown. The brain is drawn from reconstructions made from serial sections.

Figure 2. Cross section of the nerve cord. X75.

Figure 3. Longitudinal section of the nerve cord. X75.

Figures 4 to 6. Drawings of sections taken through the brain at various levels, only one-half is shown in each case. X75.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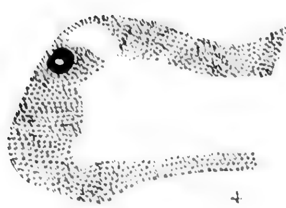

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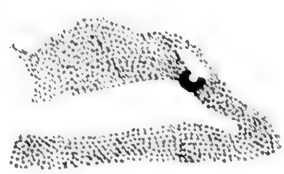

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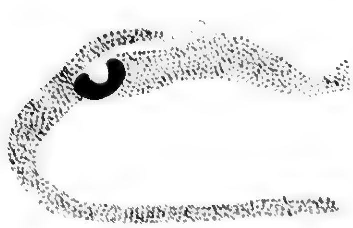

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1917 Pomona College Journal of Entomology and Zoology, Vol. IX, No. 3, September

A Reconstruction of the Nervous System of a Nemertian Worm

WILLIAM A. HILTON

Small specimens of *Carinella cingulata* Cole were fixed in Mercuric chloride and cut in series. A general hematoxylin stain was very satisfactory for general anatomy. For a study of the finer structure other preparations will be necessary.

No attempt will be made to give a complete review of the literature relating to this group. Almost every systematic paper has something, because of the importance of the nervous system in classification and because in many cases the nervous system may be seen through the body-wall without dissection.

One of the first extensive accounts of these animals which also included quite a consideration of the nervous system was McIntosh in 1874. Several of the genus Nemestes were studied and the general form of the nervous system shown. Amphipheris is shown in a similar manner with a single lobe of the brain and with the two brain commissures. Tetrastemma is shown in a similar manner. Hubrecht in 1887 has an extensive paper in which the details of several nervous systems are shown as they show in reconstructions from sections. Eupolia girardi is especially well shown with its small dorsal and large ventral commissure and with three brain lobes. It is in this paper that Hubrecht makes his interesting comparison between the nemertians and cordates. In his paper of 1880 he has shown the structure and position of different parts of the nervous system of nemertians, especially of Cerebratulus of which he gives a very good figure. In this he shows a reconstruction of the brain with its chief nerves, ventral and dorsal commissures, general position of the cells, the two lobes of the brain on each side and the chief nerves. He also treats of nemertian nervous systems of many other forms, but not in so much detail.

Burger in 1890, '91, has extensive papers on the nervous system of the group. He discusses not only the general form, but also the minute structure of the nervous system of a number of different types. In 1895 Burger has another important paper on this group of animals. In it he shows in some forms a marked dorsal ganglion and a ventral ganglion with the typical nerves. Burger showed that all ganglion cells are unipolar, without membranes. Montgomery, 1897, discusses the minute anatomy of the nerve cells. Coe, 1895 and 1910, considers the general anatomy of the nervous system, but nerve details are for the most part not shown.

In a young *Carinella cingulata* Cole which I have studied by means of reconstructions, I find no unusual features. The nervous system is typical of the group. The brain, however, is not very clearly made up of two lobes on each side. This may be because the specimen used was a young one. This may also be the reason why the brain is not sharply marked off from the lateral nerve cords.

Figure 1 shows the brain and part of the lateral cords from the ventral side. From the two halves of the brain come the nerves to forward parts. The small dorsal commissure is shown with its usual median extension. From the larger ventral commissure come the two nerves to the proboscis, lateral to these are the nerves to the intestine, while from the ridge of the lateral cords the lateral nerves are shown.

Figure 2 in the larger drawing at the right shows the nervous system as viewed from the side with the dorsal side to the left. The central core of the ganglion and cord is to indicate the position of the fiber area. The small drawings at the left show various levels of the nervous system as seen in cross section. The ventral side is up. The drawing at the top is through the brain before the commissures are reached, the next lower is through the thickest part of the brain and the lower two drawings are through one of the lateral cords.

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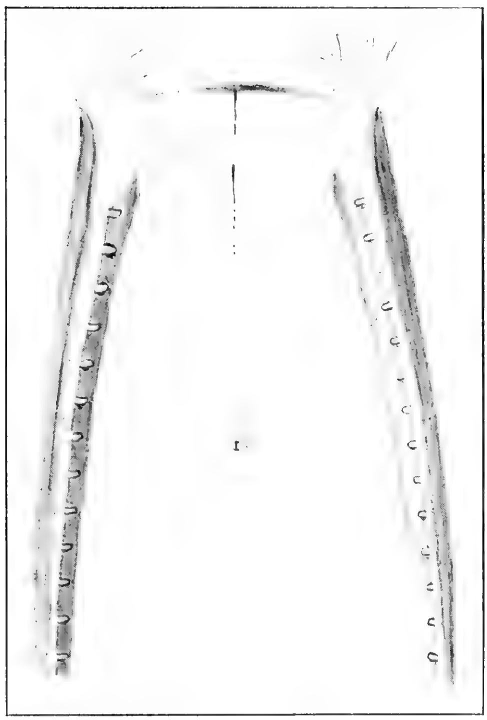
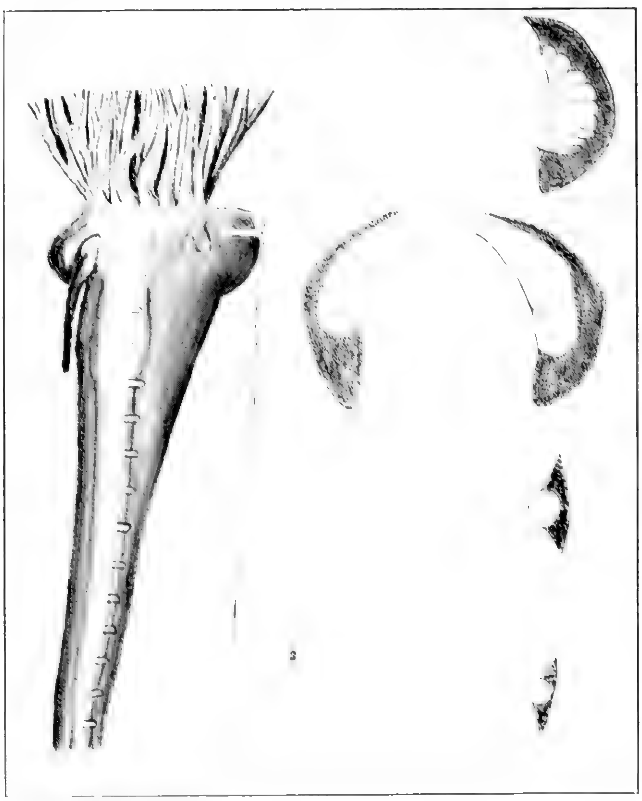
EXPLANATION OF PLATE

Figure 1. Reconstruction of the nervous system of Carinella shown from the ventral side. Explanation in text. X75.

Figure 2. Figure at the left side view of a reconstruction of the upper portion of the central nervous system of Carinella.

The figures at the right are from cross sections taken at various levels. The upper and the two lower figures are from one side only. Further explanations in the text. X75.





Record of Two Pseudoscorpions From Claremont-Laguna Region

WINIFRED T. MOORE

Garypus Californicus Banks

Description: Fig. 1. Length 5 mm.,

Color: Cephalothorax and pedipalps dark brown, abdomen and legs light yellow; each abdominal scutae with a dark central spot; anterior ventral scutae also with dark spots. Cephalothorax emarginate; four eyes; femur of pedipalps longer than cepalothorax, tibiahardly convex on inner side, hand about as long as tibia, fingers longer than hand; legs long and slender.

Habitat: Specimen found under rocks near ocean at Laguna Beach, collected by Walter Sturgis.

Chelanops pallipes Banks

Description: Fig. 2. Length 2 mm. including mandibles.

Color: Cephalothorax light reddish brown, pedipalps darker, abdomen and legs pale yellow.

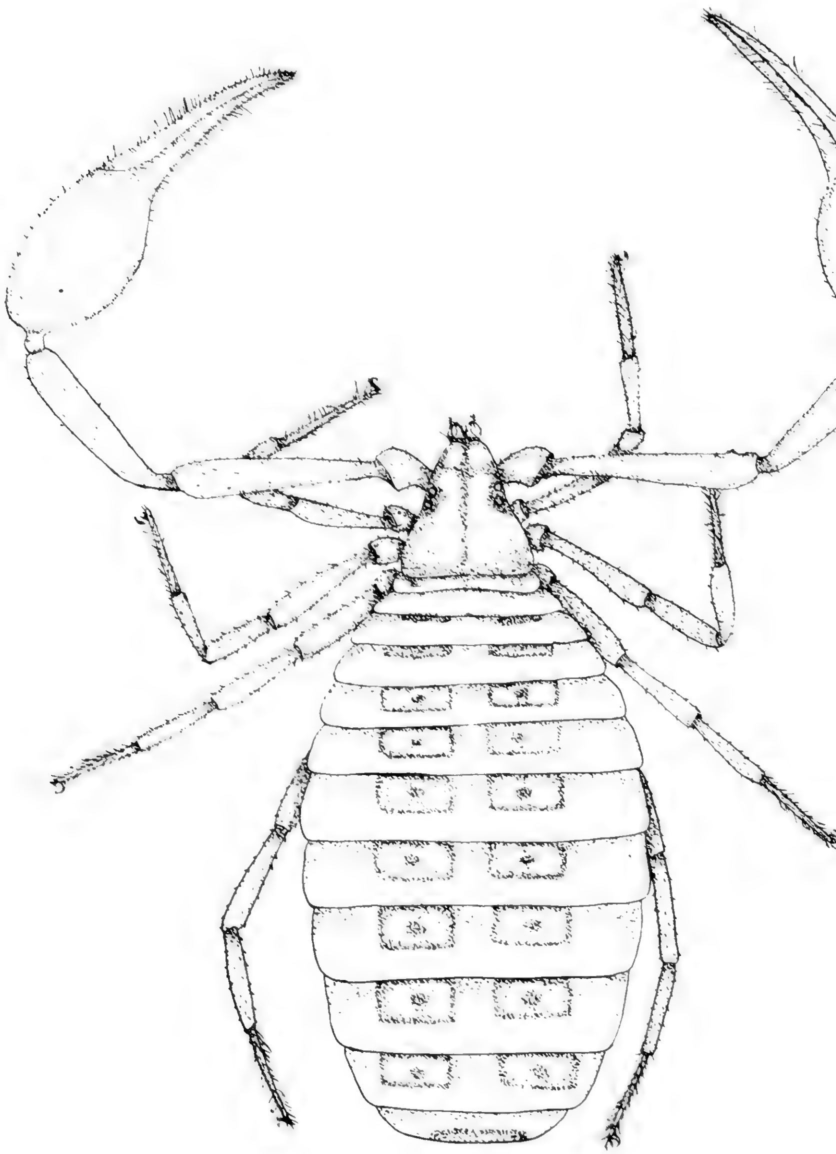
Similar to C. dorsalis, but fingers a little longer than hand; no eye spots, clavate hairs found on all parts of two types, on legs and pedipalps more clavate on one side (Fig. 3) on body evening clavate (Fig. 4). Simple hairs found on under surface of tarsus. All parts covered with small chiton plates.

Habitat: Specimens taken from under stones in wash near Claremont.

(Contribution from the Zoological Laboratory of Pomona College)

EXPLANATION OF FIGURES

Figure 1. *Garypus Californicus.* X20.
Figure 2. *Chelanops pallipes.* X20.
Figure 3. Hair from legs and pedipalps of *C. pallipes* much enlarged.
Figure 4. Hair from body of *C. pallipes* much enlarged.



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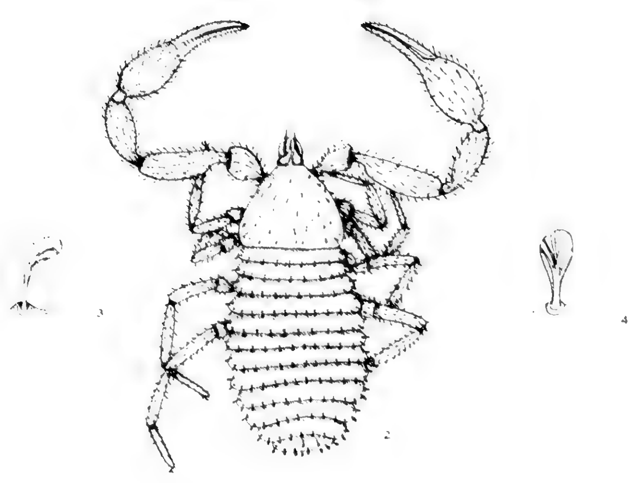


Solpugids From the Claremont-Laguna Region

J. NISBET

The following list of solpugids represents a collection obtained by students and others during the past four or five years. Drawings are given of one large specimen and top and side views of the head region of several others. The determinations are by Dr. N. Banks.

Eremobates formicaria Koch

This species has been taken from our region although such large specimens have been reported only from dryer regions. This specimen, a male is from Brawley, Cal. (Figs. 1 and 2). Figs. 3 and 4 were taken from a young specimen collected at Claremont.

The movable finger of the cheliceræ of the male has two large teeth. Anterior margin of rephalothorix straight. Hind tarsi one segment.

Eremobates californica Sim.

The drawing are from a specimen taken at Laguna Beach (Figs. 5 and 6). Specimens were also taken at Claremont. Movable finger of the cheliceræ with a large tooth. This is not so marked in the female. Hind tarsi one segment.

Hemerotrecha californica Banks

Specimens were obtained at Claremont. Upper finger of chelicaræ without teeth or many small teeth. Male has an elongated flayellow of two parts on the upper finger of chalicera. Hind tarsi with three joints. Specimens obtained were about evenly divided between this and the previous species (Figs. 7, 8, 9 and 10).

(Contribution from the Zoological Laboratory of Pomona College)

EXPLANATION OF FIGURES

Figure 1. *Eremobates formicaria* Koch. X2.

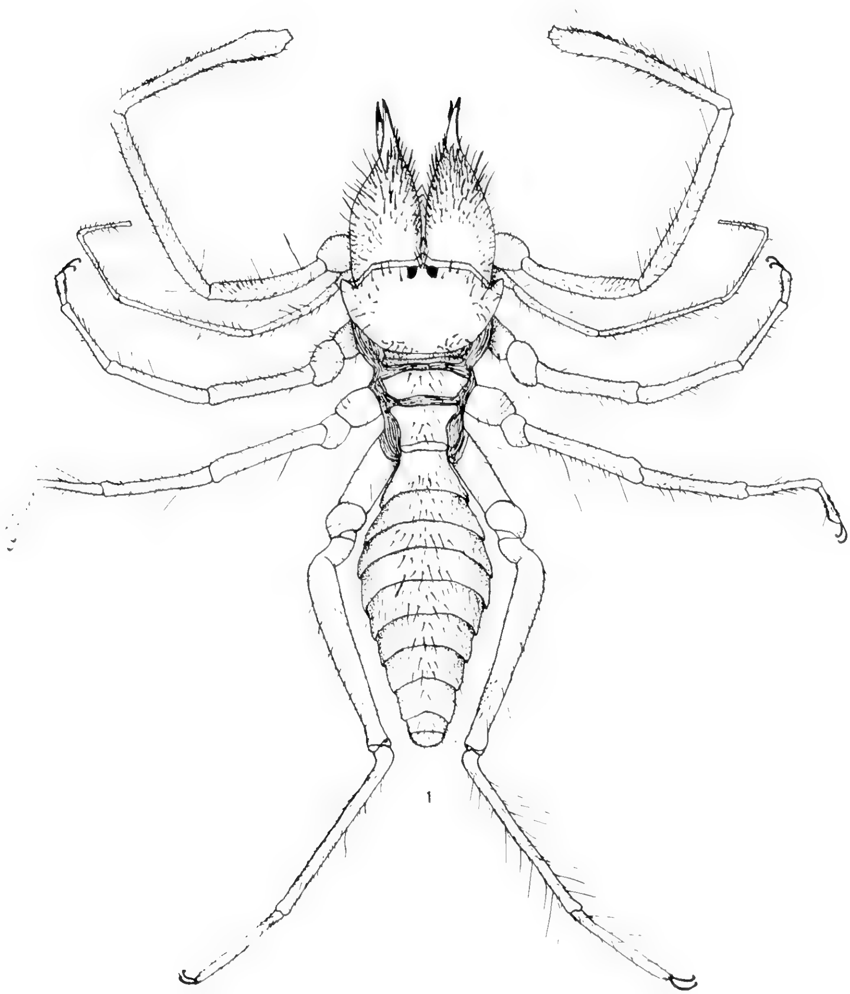
Figure 2. *Eremobates formicaria* Koch, side view of chelicera. X2.

Figures 3-4. Chelicerae from young *E. formicaria.* X2.

Figures 5-6. Chelicerae from *E. californica* Sim. X2.

Figures 7-8. Chelicerae from *Hemerotrecha californica* Banks, views of the chelicerae. X2.

Figures 9-10. *H. californica* views of chelicerae, another specimen. X2.



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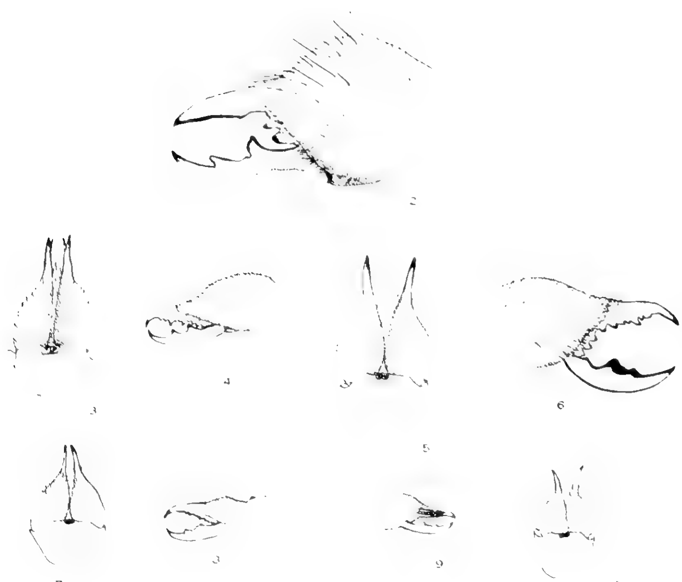

Another Record of a Small Whip Scorpion in California

M. L. MOLES

In April, 1916, Dr. W. A. Hilton collected some small whip-scorpions in the Pomona College Park at Claremont. These creatures were without eyes and yet they seemed to avoid forceps. They were able to run backwards or forwards with equal ease. On examination it was found that there were long hairs on the legs such as shown in the figure. Other specimens were afterwards found in one of the nearby canyons, and two specimens in the college collection were marked "C. Metz, in the mountains near Claremont."

Upon looking through the literature the species was determined to be *Trithyreus pentapeltis* Cook. In 1899 Dr. Hubbard collected some at Palm Springs under stones in the canyon near the stream. Those which we have found this year were under the dried oak leaves some distance from water. Cook gave the generic name *Hubbardia* which has not been sustained.

The following are the measurements of two types of the twenty or more specimens found.

Measurements—supposed Male:
Length of whole body, 7.5 mm.
Length of cephalothorax, 2 mm.
Length of abdomen, 3 mm.
Length of tail, 2.5 mm.
Length of first leg, 8 mm.
Length of maxillæ, 1.5 mm.
Width of abdomen, 1 mm.
Width of cephalothorax, 8 mm.

Measurements—Supposed Female and Juvenile, Fig. 1:
Length of whole body, 4.5 mm.
Length of cephalothorax, 1.5 mm.
Length of abdomen, 2 mm.
Length of tail, 1 mm.
Length of first leg, 5.5 mm.
Length of maxillæ, 2 mm.
Width of cephalothorax, 6 mm.
Width of abdomen, 1 mm.

Color of supposed Male—Cephalothorax and maxillæ, dark reddish brown. Abdomen and legs light yellow brown.

Color of supposed Female and Juvenile—All parts bright yellow brown.

Cephalothorax suboval, upper margin strongly concave at the sides and tapering to a point at the median line. Sides convex at upper edge; lower margin strongly convex. The cephalothorax is strongly chitinized, showing two small oval spots. The small suboval area between the chitinized cephalothorax and the abdomen is soft with five chitinized plates.

On the dorsal surface of each abdominal segemnt are two muscle depressions, while on the ventral surface the fourth, fifth and sixth segments have dark colored plates near the segmental divisions which are used for muscle attachments; besides the two muscle depressions.

The book-lungs openings are found on the ventral surface of the first abdominal segment, as is also the epigynum.

The caudal appendage of the juvenile and female is made up of three small joints tapering to a blunt end. It is held in an upright position above the abdomen. Cook in his description supposed this form to be a female or juvenile; Krayselin considers it a different species, but upon close study of the rest of the organs of this form it was finally decided that it was a juvenile and probably a female, the supposition being held that the juvenile took the form of the female, as is often the case, until the last few molts. The epigynum of this form was extremely undeveloped, having only a small epigastic furrow with depressions at either end.

The caudal appendage of the supposed male is made up of two stout joints to which is attached a heart-shaped body tapering to a blunt apex. This body has deep pits both on the dorsal and ventral sides near the base.

On the tibia of the first pair of legs are two long special sensory hairs set in little pits. On the second, third and fourth legs one hair was found, also on the tibia. These hairs are three-fourths as long as the leg.

The mouth parts consist of a pair of strong mandibles and labium. The labium is placed between the two coxæ of the maxillæ.

The long process of the coxa clothed with its long simple hairs seems to have some performance in the work of the mouth parts. The labium is suboval, clothed thickly with simple short hairs, the upper margin having a single row of long heavy straight hairs with many long single curved hairs covering them.

The mandibles are provided with three distinct kinds of hairs or spines. The large subquadrate proximal joint was clothed with long barbed spines, the movable finger having on its median surface a row of fifteen back curved barbed spines. In the space between the movable and stationary finger were long hairs, enlarged in the center and tapering off to a fine point, the tapered portion being barbed. The mandibles are set well down in the sephalothorax.

The sexual openings were found in the usual place; the ventral surface of the first abdominal segment, this being enlarged so as to do away with the second abdominal segment. The epigynum consists of a long epigastric furrow with a large lip-like opening near its median line. Just above this opening and on either side were small longitudinal creases.

Prof. Dr. Friedrich Dahl places the external sexual organs of this family on the legs and in the Thelyphonidæ which is closely related. They are found in the second joint of the tarsus of the first legs. Careful study failed to find any trace of secondary sexual organs in *Trithyreus pentapeltis*.

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(Contribution from the Zoological Laboratory of Pomona College.)

EXPLANATION OF FIGURES

Fig. 1. Drawing of the upper side of a young Trithyereus pentapelti Cook X10.

Fig. 2. Lower or ventral view of T. Pentapeltis X10.

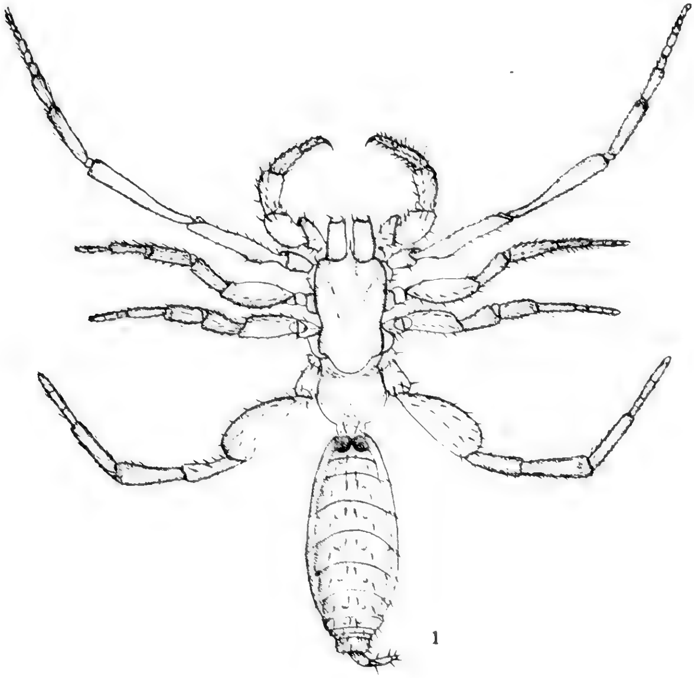
Figs. 3, 4, and 5. Various views of the caudal end of an adult T. Pentapeltia. Much enlarged.

Fig. 6. Labium. Much enlarged.

Fig. 7. Maxilla. Much enlarged.

Fig. 9. Mandible of Trithyereus. Much enlarged.

Fig. 9. One jaw of mandible. Much enlarged.



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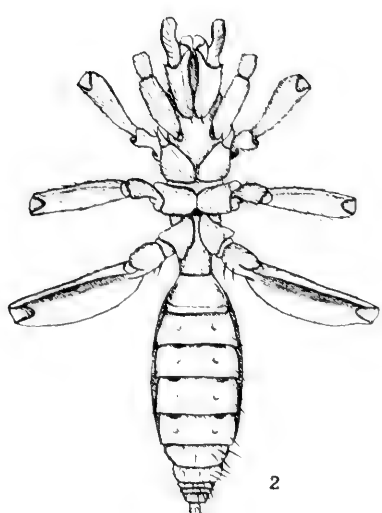

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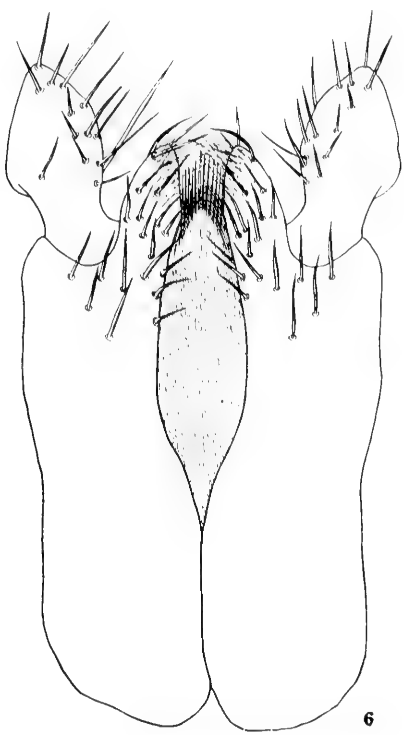

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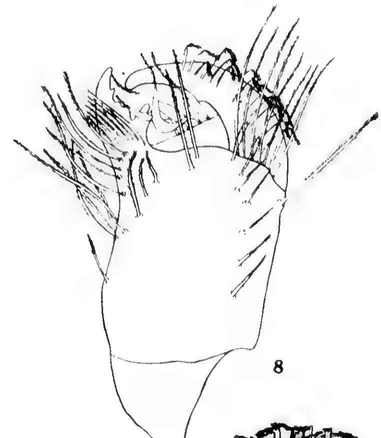

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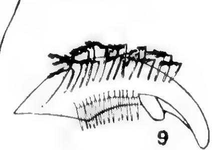

9

The Growth and Color Patterns in Spiders

MARGARET L. MOLES

The growth of immature spiders, from the period of emerging from the egg case to that of the adult were studied. Representatives of seven large families, the Lycosidæ, Attidæ, Aviculariidæ, Epeiridæ, Thomisidæ, Theridiidæ and Oxyopidæ, and the life cycle of one genus and species of each of the families were minutely described and drawn in colors. Besides noting the changes in body developments, coloration and color pattern, the methods of emerging from the egg case, action of spiderlings upon "hatching," the growth of all their parts and especially the growth of the color patterns, was noted. On account of the artificial conditions in which it was found necessary to raise the young, they did not always live to reach maturity, but were almost always raised at least up to the last few moults.

The females were collected with the eggs. The young were placed in glass dishes with cloth tops; leaves and dirt were placed in the jars in order to resemble their natural environments. Food was given once a day. It consisted of large flies whose bodies had been opened. Water in small drops was given each day. Some of the spiderlings such as Lycosidæ and Oxyopidæ were especially fond of the water and congregated around each drop in great numbers. The food given the young seemed to satisfy them. They would crawl all over the fly as soon as it fell among them and soon it could not be seen in the mass of spiders. Small gnats were put in the cages but no attempts were made by the small spiders to catch them. They were able to go for days at a time without food if given plenty of water.

The greater number of female spiders with their egg cases were collected during the months of October, November and December. The cases of the Oxyopidæ were found in the mountain canyons under piles of damp leaves, those of the Epeiridæ were found in the usual garden places under eaves and fastened under the leaves of large vines. Theridiidæ were found in meter boxes and barns; the Attidæ were collected in Imperial Valley under rocks; the Lycosidæ which were collected during the month of April, were found in the grass with the females carrying the egg cases. The young of Thomisidæ were found, no eggs having been collected.

The shape of the egg cases of the several species studied differed materially. Those of *Peucetia viridans* are, as Comstock describes it, "hemispherical in outline with small projecting tufts." The egg sac of *Aranea gemma* is a light brown "loose flocculent mass of silk enclosing the ball of eggs." The egg case of most of the Thomisidæ, Comstock describes as being "lenticular in form" and are usually formed of two equal valves united at the border, which presents a little circular fringe. The egg case of *Philodromus* is made up of two disks which are fastened closely to the bark of the trees and may be more than lenticular in shape. In the subfamily *Misumeninæ* the egg sac is sometimes free and sometimes suspended like a hammock in a retreat formed of leaves rolled or drawn together. In most cases after the egg sac is made, the female stops her wandering habits in order to watch it. The egg sac of *Latrodectus mactans* is made up of a round closely woven silk ball, hard on the exterior and soft on the interior. Dust soon collects on the egg sac which gives it a dirty white color. They are suspended from the web by a few loose threads. The Lycosidæ tie their children to their apron strings. The females were found in great abundance in the early spring holding the flat circular egg case firmly with their mandibles. These cases were held up off the ground when the female moved and were dropped if she was disturbed. In the confined specimens the female upon being disturbed would drop her bundle, but as soon as the disturbance was over she would pick up the case again. The Attidæ were all collected from a valley with a warm climate and seemed to resent the change when they were placed in the cooler atmosphere of the laboratory. Their egg cases were of a very fine soft white silk and were attached to the under side of a rock, using the rock as one side and building the nest around that side. One female laid her eggs in captivity. The case was the same as those on the rocks but one side of the glass was used as a foundation. As there were no eggs of the trap door spider collected, I cannot consider the shape of the egg case and none of the authors of spider life histories describe it. Comstock speaks of finding one in Florida, but does not describe it.

The general shape of the egg cases of the different species studied, seemed to be the same in all of the egg cases of that species. Comstock says in regard to the constancy of the shape of the egg sac of the species, "The egg sac is not merely a covering made in a haphazard way; but is a more or less elaborate structure, made in a definite manner characteristic of the species." While one cannot determine the species or genus of a spider definitely by the shape of its egg sac, yet it is a small factor which might aid in telling the genus.

The young of the different species differed widely in the length of time of emerging. *Peucetia viridans* emerged in a month, *Arenea gemma* in from two to three weeks, *Lycosa* sp. in three weeks, *Phippdus* sp. was kept for seven months and then artificial help was given to open the sack. The eggs of most of these species hatched soon after being laid.

The spiders made one or more moults in the egg sac before emerging from the case. In the case of *Aranea* it was seen that a great pile of shed skins were exuded outside of the sac just before the young emerged and then while emerging from the sac they went through another moult, leaving their shed skins in the case or just outside on a line which they made. From observations it would seem as though this species moulted two or three times before emerging from the sac. "The young attids, having undergone the moult, shift their positions to the opposite end of the cocoon and then moult a second and even third time before egress; as is shown by the fact that one finds within the same cocoon three separate heaps of skins cast at different ages." The young with the aid of a great deal of heat emerged two weeks after the eggs were laid. They had not moulted at all and were very weak, and came from one end of the cocoon. The case that was left for seven months showed that the young had deposited their shed skins in three places before emerging, and having migrated from one end of the egg sac to the other. Wagner ('88) asserts in "La Mue"—

"The young of Lycosa remain in the cocoon until the second moult, after which they emerge and clamber upon the mother's back where the third and fourth moults occur before the little fellows begin independent housekeeping in miniature burrows of their own." With the other species it was difficult to see how many moults occurred before egress from the sac and no accurate data was found upon it.

There was a great difference between the different families in the actual time of emerging. The Attidæ, Lycosidæ, Theridiidæ and Oxyopidæ seemed to pop right out of the sac like ripe peas out of a pod, while the Araneinæ took from one to two days or a few hours, all according to the heat and sunshine. Those egg sacs which were kept in a dark box were very slow in emerging. One little one would force its way out of a corner of the cocoon, spin a line of web to the corner of the box and spend all the rest of the day running up and down that thread. The others might not appear for a day or two. If the box with its one little occupant was placed in the sunshine, inside of two hours every one of the spiderlings would be out spinning. Egg sacs which showed no signs of hatching were placed in the sunlight and within two hours one little one would be out and the rest soon followed. These experiments with the dark and light in reference to the length of time of emerging were only carried on successfully with those of the Araneinæ. The other egg sacs were placed in sunshine each day but it did not seem to force the young from the sac. The Attidæ came out with the application of both heat and sunshine, but seemed to be prematurely "hatched," as they were inactive and soon died. Sunshine alone did not force them out, but the application of heat was sufficient, after a day's application. The natural time of emerging for the Attidæ is in hot summer weather so this in a way explains why heat was so effective. Heat or sunshine had no effect upon *Latrodectus* or *Lycosa* except just at the time of emerging. They could not be forced to emerge. A definite conclusion was reached,—that the young will wait for a sunny day to emerge. This seems to be true of all families. Not one was found which had emerged upon a cold, cloudy day. The house-raised spiders of all the groups studied emerged earlier than the ones out-of-doors in their natural habitat. The difference in time with all of them was from one to two months. This could be accounted for by the fact that they were raised in a steam-heated room and were placed in the sunshine from two to three hours a day even in winter, and so developed quicker. Artificial help was given to some species which seemed to have trouble in emerging. The mother spider in some cases cuts the silk of the cocoon and so when some species were particularly long in hatching, a pin point was inserted and an opening made. Without the help of the female *Lycosa* the young were not able to emerge at all. The young would develop in the egg sac up to the emerging and then would dry up, if not given artificial aid.

The actions of the newly-emerged young of the different species were constant. *Lycosa* upon emerging clambered upon the body of the mother, nearly covering the mother spider. The lycosids which were hatched artificially and had no mother to clamber on died soon after emerging. The young which emerged and were carried by the mother all lived, but the others did not seem to have the necessary strength. The mother often seemed anxious to get rid of the young. If disturbed she threw them off, and if they were too young they died. A female without an egg sac was put with an artificially opened sac and soon the young clambered up on the legs and abdomen of the adult without any response from her. Another female carried her own egg sac and a load of orphans which were placed with her. This double load seemed to be too much for her; for she died before her own brood could emerge. The brood which had lived on her a week while she carried her own case, lived. After she died they started an independent life, but generally the young live on the mother two weeks after emerging. These experiments would seem to show that to some degree the life of the young depended upon the existence of the mother. None of the other families studied had this dependence of the young upon the mother.

The young of *Peucetia* built simply a line of thread and stayed on it or ran around the jar unattached by any silk. The *Thomisidæ* when very small would climb upon the flowers or leaves and bark, seemingly waiting for little mites or flies. *Latrodectus* and

Lycosa built neither web nor thread rope, but ran round and round the jar. No attempt was made to build separate homes or protections. *Phippdus* after one day of outside life built small retreats such as the mature build under the rocks. Of course, the nests were very small and thin, but they were exact duplicates of the large ones. Three or four little ones lived in the same retreat but more often each had his own. Comstock claims they use these nests as places to stay in while they moult. The nests were built along the upper edge of the jars and from the nest to the bottom of the jar was a line of silk thread used as an elevator. The trap door spiders stayed in the bottom of the tunnel except when placed in the sunshine; then they spread all over the sides of the tunnel and especially around the edge of the trap door. As a general thing the young were very slow and sluggish in actions. The young of the trap door spider must be very slow to develop for they showed no signs of silk spinning nor any desire to go out of the parental tunnel. Some of the young were removed when four months old and placed in a jar of dirt in order to see if they would form small burrows of their own. All of them refused to make any burrows and dried up on top of the dirt. The young of about one year of age were found in small burrows. Miss Thompson in her observations on the trap door spiders, says, "After the hatching of the eggs from seventy-five to one hundred black and green spiderlings will be found occupying the maternal nest. When these are a few weeks old they leave the native burrow and begin to excavate in sunny places, minute tubes of their own. Often a dozen such small abodes will be clustered about the old trap door. These vary greatly in size but all are quite perfect in form."

The actions of the young *Aranea gemma* were the most interesting of all the young. The instinct to use the spinnerets and to make webs was strongly developed, for as soon as the young emerged from the egg sac they began to spin. First a small thread was put out and attached to the sides of the jar and as soon as the young had found a suitable place an orb web was begun. These were very perfect, although not as large nor having as many complications as the web of the mature spider. Some of the young were taken out of the jar and soon scattered all over the laboratory. They built their miniature orbs between the legs of chairs, on the lighting fixtures, on the microscopes and in every available place. They would place themselves in the center of these small orbs and stay there all day. This action of the young is quite contrary to that of the adult, who does not remain in the orb but in a hiding place near by. The young of *Aranea gemma* were found all over the top of a rose fence in little webs. They made them in the top in order to get the greatest amount of light and sunshine. A family of *Aranea* was raised in the laboratory windows on the vines. Their actions were not the same as the one raised indoors. They remained in a large clump swung from one of the branches of the vine and only on bright days did they scatter from this mass to return when the wind blew and it became cold. A hard rain storm came and all the spiders disappeared, but when the sun came out the spiders returned, making little orbs of their own, but did not go back into a mass. A great many of these little ones could not have survived the storm, but some must have remained under the leaves and started life anew as soon as it became warm.

Certain conclusions can be drawn in connection with the shape of the egg case, the methods of emerging, and the actions upon emerging, of the immature spiders:

1. All the egg cases of a certain species of spiders were found to be exactly the same. There were large numbers of the egg cases of *Aranea* collected, and none varied in either shape, texture, or method of building. The only variations found were in size and color. The colors varied from light to dark brown.

2. The methods of emerging, the length of time and actions upon emerging varied only according to the weather conditions and situations, so the same statement may apply to them as to the shape of the egg case.

In a general collection a great many specimens taken are immature and very hard to determine on account of the undeveloped sexual organs, and the differences in color pattern between the immature and its adult. It has been the aim of the writer to watch the changes in the color development and color pattern of certain well-known species of large families in order to find some way in which the young may be identified by the color pattern and color. There have been few sources from which any material upon this subject could be found. Comstock in his "Spider Book" makes no note of the color changes, but McCook makes the following observations: "With each moult spiders undergo a change in color and patterns more or less decided; but some undergo such decided changes that different species have been established for the same spider upon specimens taken after different moulting periods. In some species the color and markings of the younglings, after the first moult or two, fairly represent the markings of the adult at maturity; in others the difference is so great between the two stages of life that it is quite impossible to identify young individuals or distinguish the young of several species with accuracy."

The female colors predominate through all the young, the immature males in the most cases taking the colors and markings of the female until the last moult, when they then take on the markings and characteristics of the adult male.

In the following pages of the paper there will be found a description of the different stages of the spiderling of different species, especially in reference to the different color stages... The dorsal side of the spider has the color pattern, therefore it will be the surface which is always described.

Peucetia viridans Hentz. Plates I, II and III

The color markings of the adult female were very brilliant and beautiful. The eye space is black, the cephalic part of the cephalothorax is light yellow with red and brown markings, the thoracic region is a dark green ground color with two red lines running down and around the sides of it. There is a median brown line extending from the eye space to the lower edge of the cephalothorax. The abdomen has a dark brown ground color with four white spots, the lower two of which are edged with red. On the upper half of the abdomen are two orange stripes flecked with red and separated by a light green stripe with a darker one in its center. The lower half of the abdomen has two light green and two yellow green stripes on either side of the median line. There are numerous flecks of red all over the dark green on the abdomen. The spinnerets are dark green, covered with black hairs. The abdomen has black hairs. The legs have a light yellow ground color. The coxa has two red lines near the upper margin of the joint and two black spots below the lowest line. The trochanter is covered with various sized black spots. There are two irregular red bands on the upper margin, while there are scattered over the surface of the joint from three to four irregular red dashes. The femur is orange yellow with an irregular red band both at the upper and lower margin of the joint, the surface of the joint having only two black spots and those placed at the base of the spines. The tibia is yellow gray with dark gray spots and an irregular red band both at the upper and lower margins of the joint. The metatarsus is also yellow gray with dark gray spots and an irregular orange and red band on the lower margin of the joint. The tarsus is dark yellow gray. The joints of the legs with the exception of the coxa, trochanter and femur are covered with fine black hairs. The palpi have the same coloring as the legs, but lack the black spots, which are on all the trochanters. The spines on the legs are very black and long.

The newly emerged *Peucetia viridans* are pale orange. Plate II B. Some of the young emerged and shed a coat after three days, while others emerged with the new coat on. Those which emerged and shed their coats in three days were orange yellow when they first appeared. After three days they acquired a more orange color. The eye space was dark brown, the cephalothorax a light yellow green ground color, the sides red shading into green and a dark brown spot on the upper half of the median surface and a dark brown median line which extended from the eye space to the ending of this dark brown median area. This dark line is the same as in the adult and is lost in the next moult and does not appear until the adult stage again. The abdomen is orange, shading to orange red on the sides and to light yellow on the upper surface. There is a beginning of a light red folium of complicated inner pattern, looking like the construction of a Chinese pagoda. On each section of the pattern there were four little light colored pits, but the upper one had five. The palpi were dark gray, the coxæ of the legs were dark gray, the rest of the joints of the legs were a light apple green shading down to yellow green in the metatarsus and tarsus. Near the upper margin of the tibia were four small red rings. One can very well see that even in this early stage there is a good beginning for the brilliant markings of the adult. The next moult took place in ten days. The coloring of the cephalothorax and abdomen remained the same except where there had been small white pits on the abdomen in the earlier stages there now was a black spine for every pit. It was in the legs where the greatest change took place. The ground color of the legs was light lemon yellow. The coxa was light lemon yellow with three black spots; the trochanter had eight to ten black spots, the upper margin of this joint being yellow green; the femur had from four to seven black spots, with patches of apple green. The tibia, metatarsus and tarsus were orange with darker orange at the upper and lower margin of the joints. The tibia and metatarsus have from two to five black spots, the tarsus of the first two legs has two black spots, the same joint of the last two legs has none. The light yellow palpi have two black spots on the trochanter, femur and tibia; the other joints are bare. The spines appeared on the legs in this stage, while not all that are found on the legs of the adult were found, yet a good portion were started of very good size. No short hairs had appeared yet on the body or legs.

There were two moults between this stage and the next one minutely described, but in either moult there was not any marked external change other than in size. The body changed from a round, short, thick shape to a long oval abdomen with a large cephalothorax to a shape almost like that of the adult. (Fig. C, Plate II.) The next stage in the color pattern development occurred when the young was twenty-two days old. (Fig. D, Plate II.) The eye space is beginning to narrow at the lower margin, the median part of the thoracic portion of the cephalothorax is dark brown with light brown center. This dark stripe has two horns toward the eye space and two small hair lines at the lower margin of the cephalothorax which extends to the edges of the cephalothorax. On the edge of the cephalothorax is a small red line and next to it a dark brown irregular line broken by green spots. The space between the median dark line and the dark irregular brown line on the edge is apple green. The abdomen has the same pattern as in the younger ones, only outlined by a darker red. Around the first two portions of the pattern is a white space. This white space is found in the adult, only separated into two areas. The upper portion of the abdomen has a ground color of orange yellow with darker orange edge, while the lower portion has a great deal more yellow in it. The legs have the same coloring as in the last stage described, only areas of gray coloring have appeared in the lower margins of the femur and the upper and lower margins of the tibia and the end of the tarsus. On the palpi we find the gray on the upper and lower margins of all the joints except the coxa. The spinnerets protrude below the abdomen and are covered with short black hairs. (Fig. D, Plate II.)

The next stage seems almost a retrogression in the color development except for the growth of the cephalothorax. (Fig. E, Plate II.) The eye space has assumed a small position in the center of the cephalic portion of the cephalothorax. The color is brown. On either edge of the upper margin of this portion of the cephalothorax are found two brown spots which are on the adult. The median stripe down the center of the cephalothorax is green with dark brown splotches and the same shape as the others. The edges had a light brown irregular stripe and all traces of the red band was gone. At the joining of the green median stripe and the brown stripe near the lower margin of the cephalothorax was a black spot showing the beginning of the black spot in the same place in the adult. The space around the eye space and on either side of the median stripe was light yellow green. The abdomen had lost nearly all the folium except remains of its outer edges. The upper portion of the abdomen is light yellow, nearly white; the lower portion yellow green; the remains of the pattern in the center of the abdomen. The white space on either side of the folium remained and the lower portion of the sides of the abdomen was a pinkish yellow. The abdomen has become slightly constricted near the upper margin and has assumed a great deal of the shape of the abdomen of the adult. The legs are a transparent color. The coxa has besides the gray at the upper and lower margins, a band of green on the upper margin. The trochanter was light gray, almost white, with a red band near the upper margin of the joint, the femur of the first two legs was yellow green with gray at the upper margin, and a large black splotch at the lower margin on the side; the femur of the last two legs is the same color but lacks the black spots; the tibia, metatarsus and tarsus are yellow gray with darker gray green at the upper and lower margins of each joint. From now on until the last moult there was no change. At the last moult the sex of the spiders appeared and the color pattern was completely formed. Though the young with the complete color pattern were not as bright and brilliant as the mother caught with the eggs, yet they would very likely improve with age. The color pattern of this form was the hardest to follow and understand. At each moult it seemed to be a process such as is necessary in the reproduction of a colored plate, one color placed on top of the other until the final whole is obtained.

A female *Peucetia viridans* with eggs was collected in the early summer (July 1st) on a squash vine. (Plate III.) The female was colored differently from the one just described above, and also different from the one described by Comstock, yet this one is identified by Banks as belonging to this genus and species. The cephalothorax of the adult was a light yellow green with a silver eye space. There were two black lines on the lower margin of the cephalothorax. The abdomen is a dark brown green ground color, with a band of light green on either side of the median line near the upper margin. Near the middle of the abdomen are two white spots. A light brown triangular pattern is found in the median line near the upper margin. The legs and palpi have a light green coxa and trochanter, an orange femur and a yellow tibia, the metatarsus and tarsus with a green band both at the upper and lower margin of each joint. The trochanter is flecked with black spots. The legs are covered with strong spines. The spinnerets are dark brown.

The young emerged after two weeks and were dark brown, the abdomen being darker than the legs and cephalothorax. At this time there was no semblance in the young to the adult in either shape of body or color. The first moult occurred in one week. The shape of the body had changed to the elongate abdomen and large flat cephalothorax of the adult. The cephalothorax was yellow brown with a line of green on the sides of the thoracic portion of the cephalothorax. The pattern along the median line of the cephalothorax is the same as that found in the young of the same age in the other specimen of *Peucetia viridans* described. The cephalic portion of the cephalothorax is yellow brown, the eye space is brown. The abdomen is brownish green with a slight beginning of a folium in red. The legs were yellow green with darker green spots at the upper margin of each joint. The trochanter, femur, tibia and tarsus have a varying number of black spots. After one week there was another moult. The legs and palpi had not changed except in size. The cephalothorax had a little more green, the upper part very bright red at the center and shading down to the gray green of the abdomen. The folium was outlined in red, the upper part very bright red at the center and shading down to a very light red and green in the lower part of the abdomen. The spinnerets were dark, covered with black hairs. In a week another moult took place. The cephalothorax was light green with a band of dark on either side. The eye space was dark brown. The pattern along the median line was in dark green. The abdomen was dark green, the irregular pattern along the median part of the abdomen was in light green brown. The legs were light green, the femur light yellow, the spots being at the base of the spines on all the joints except the trochanter. After the next moult which took place in two weeks, the young were like the adult in everything but size and sex differentiation. Whether this form could be called a variety or not could not be said, but certainly in development of the young and in the adult itself there is a great difference between it and the desscribed *Peucetia viridans*. The time when each was collected, and the difference in location may have influenced the color and color development, but it esems highly improbable that it could have affected the young as well.

Aranea gemma McCook. Plate IV

The next group studied was the *Aranea gemma*. The color pattern of the adult was: The cephalothorax was dark brown, almost black and covered with light yellow hairs. The abdomen was a lighter brown with a broken yellow median line. This line extends from the upper margin, three-fourths of the way down on the cephalothorax. The dark brown abdomen is also covered with yellow hairs. These yellow hairs gave a grayish appearance to the body. The coxæ of the legs and the palpi were dark brown, the trochanter light brown, the femur dark brown; the tibia, metatarsus and tarsus a light yellow with upper margin of each with a dark brown band. The legs were covered with light yellow hairs. The brown spinnerets were covered with dark hairs.

The young when first emerged were a dirty gray brown in the legs, palpi and cephalothorax; the abdomen was a clear yellow brown with a distinct black triangular pattern near the apex. The tarsus of the legs and palpi were dark brown. Some of the spiderlings kept this same coloring and pattern for a month, simply growing in size. Others in the same brood kept this same color and pattern for two weeks and then changed. At this time the legs became a clear light brown, the tarsus being also of the same color; the cephalothorax was the same dirty brown. There were two cervical grooves, one separating the head from the thorax and then at the joining of this groove another one started toward either side at the base of the cephalothorax. The abdomen was the same clear yellow brown, only at the base of the abdomen near the upper margin and on either side, small patches of brown indicated the starting humps of the adult. The black triangular pattern of the one just described was softened to a dark brown pattern fusing into the color of the rest of the abdomen. It was not until the spider was four months old that there was any great change from this one, only of course, the general growth of body. The color remained the same except that at each moult it was darker. At the end of four months the humps had developed into small knobs. The abdomen and cephalothorax had become like the adult female, but the legs had not taken on the gray coloring of the adult. They were still a dirty brown. As both adult male and female are alike in coloring, both sexes of the young remained the same in coloring throughout their life, the female being larger in the last few moults.

As none of the egg cases of *Thomisidæ* were kept in captivity all the observation on the young of this family were made from young collected.

A great number of juveniles of the species *Misumessus asperatus* were collected and only the approximate ages can be stated in the following discussion of them. The adult female is described as "pale yellow in color with dull red markings or the ground color may be greenish. There is a brownish stripe on each side of the thorax, a median light red band on the basal half of the abdomen, two bands or rows of spots on the hind half and a band on each side. The male resembles the female in colors and markings, but is only about one-half as long." The newly-emerged are light yellow in color of abdomen, cephalothorax and legs, with slight reddish markings on the sides of the cephalothorax and the dorsal portion of the abdomen. At the age of three months the males could be separated from the females although the palpi showed no differentiation, but the size of the two were quite distinct. The male at this age has the bright yellow cephalothorax with a brown band on either side of the median space. This band does not go to the side of the cephalothorax but extends around the anterior and posterior lateral eyes. The abdomen is marked the same as the adult, only not so distinctly. The coxa, trochanter and femur of the legs and palpi are light yellow brown with an indistinct reddish band at the upper margin of each joint. The tibia, tarsus and metatarsus are light yellow. In the adult male, the coxa is yellow brown, the trochanter and femur are the same with a small red band at the upper margin of each joint and the upper half of the tibia, the metatarsus and tarsus are dark red. The trochanter is covered with small dark red spots. The spines of the juvenile male had developed at the age of three months to the size of the adult spines. In the matter of size, the juvenile was about three-fourths the size of the adult. The juvenile female of the same age was marked like the adult, only fainter, and the size was about the same proportion as in the other sex.

In following through a life history of *Philodromus pernix*, *Xysticus Californicus* and *Misumena alcatoria* it is found that the color changes that take place from the newly-emerged to the adult indicate the pattern of the adult. The colors may not be as distinct as on the adult, yet on each succeeding moult the pattern becomes plainer. Thus it can be said that the *Thomisidæ* change very little from the immature to the mature in the case of color and pattern.

Latrodectus mactans Fabricus. Plate V

Of the family Theridiiæ, *Latrodectus mactans* was studied. The color of the adult female is coal black, often having a broken row of red spots down the median line of the abdomen; the female is black with four red stripes on the abdomen besides the broken red line down the median line of the abdomen. The female is often lacking the red color and then is pure black. The young are a light yellow gray white upon emerging, but in thirteen days after their first moult outside of the egg case the cephalothorax was bright yellow brown with darker brown sides and a triangular brown spot in the median area of the cephalothorax reaches to the eye space. The abdomen was white with four varying sized black spots on its surface. The coxa and trochanter of the legs were yellow brown with dark gray on the upper margin of each; the femur, tibia, metatarsus and tarsus were light brown gray with dark gray on both upper and lower margins of each joint. The palpi were marked the same as the legs, but with a great amount of dark gray color. The next moult occurred when the spiderlings were twenty days old. The thoracic portion of the cephalothorax was dark brown, the sides had a dark gray band and the lower margin of this part of the cephalothorax had two dark gray spots. The pattern on the median portion of the cephalothorax was more slender and very black brown. The eye space was light brown. The abdomen was a dirty gray ground color. The black spots on the one described before had enlarged and between these rows of spots were two more broken lines of black spots. The pure white color remained only near the margins of the abdomen and as a median stripe. The legs were dark brown with darker black brown on the upper margin of each joint except the coxa. The palpi were light brown having lost all their gray color. At thirty-four days of age the cephalothorax had grown lighter, the margins were black with a brown stripe bordering the very thin black one. The triangular brown pattern on the median area had spread from the eye space to the lower margin of the cephalothorax. The abdomen had the dirty gray ground color except for the pure white median stripe. The abdomen had now three horizontal small black broken lines and four large black spots and two broken black lines bordering the median white stripe. The lower margin of the abdomen was very dark gray. The legs were light brown with dark brown at the upper margins of all except the coxa. The palpi were light brown except the last joint which was dark brown. At forty-one days of age the cephalothorax was a dark brown gray ground color with a black broad stripe around each margin, the legs were dark gray brown with darker gray at each upper margin. The abdomen was black except for a median white stripe which went from the upper margin three-fourths of the way down and a stripe that extended down around the margins the same distance. From this time on until the last moult, the body became suffused with black, the space left on the abdomen which had been white was filled with red, and the males were distinct from the females. Some of the white spaces never filled with red but became black. Comstock states in his Spider Book, 1910, that it is known that the immature females are often marked like the mature males, but this was not found to be so in the artificially raised families which were grown in the laboratory. The red marking and color did not come until late in the last moults.

Lycosa sp. Plate VI

The next large group studied were the Lycosidæ. The genus and species studied were *Lycosa* sp. The adult female and male were alike in color and pattern. The cephalothorax was dark brown with a wide median light brown stripe extending from the anterior eyes to the lower margin. The space between the eyes was shiny black. At the base of the sides of the cephalothorax were two light brown spots. The abdomen was black brown with uneven spots of light brown on the basal half and in the dorsal half were two horizontal light brown stripes. The legs were gray brown with dark bands on all the joints except the tarsus and metatarsus. The young, when emerged, have a dirty gray cephalothorax with a wide light brown median stripe extending from the second row of eyes to the base of the cephalothorax. The color around all the eyes is black. The abdomen is a dirty gray with a few dark spots on the median line. The abdomen and cephalothorax are covered with long black hairs and a few white ones. The legs are light yellow brown with black hairs. At the age of two weeks the cephalothorax was a dirty brown, the sides had a small black line along the edge, there was the same wide median light brown band extending from the second row of eyes down to the lower margin and on either side of this band was a large gray band. The space around the eyes was black. The abdomen was a dark gray ground color with a light brown median band broken by lines and spots of gray. The hairs were long and black, some of the hairs on the abdomen being three-fourths as long as the spider. The legs and palpi were light brown with faint gray band on all joints except the coxa, tibia, tarsus and metatarsus. At three weeks of age the abdomen was the only thing changed. It had changed to that of the adult in color and pattern. The legs, palpi and cephalothorax were the same as at two weeks of age. At the age of one month the *Lycosa* young were miniatures of the adult. They were about one-tenth the size of the adult at this age.

Phidippus sp. Plate VII

The Attidae studied were large undertermined desert forms of the genus *Phidippus* and taken in the winter from under rocks. The adults had black cephalothorax with a red spot between the posterior eyes. The abdomen was a reddish brown ground color with a gray stripe around the upper margin, and a gray folium at the lower half of the abdomen. The young were very hard to raise and lived only a week in some cases. One set emerged in the winter and lived only a few days, but from another egg case, young came forth with artificial aid, after being kept seven months. The cephalothorax of the newly emerged was dark green, the abdomen dark green with two lighter green spots and lines surrounded by black on the forward portion of the abdomen and four dark horizontal lines at the lower part of the abdomen. The coxa and trochanter of the legs were gray green, the rest of the joints were orange yellow.

Bothriocyrtum Californicum. Plate VIII

Of the family Aviculariidae the trapdoor spider was observed. The adult has a chocolate brown cephalothorax with a deeper chocolate brown on the abdomen, the legs being the same color. The newly emerged young were shell pink and shiny. After emerging from the egg sac they moulted and at three days of age had a light brown cephalothorax with black eye space, light brown legs and spinnerets and a reddish brown abdomen. The legs, abdomen and spinnerets were covered sparsely with dark hairs. The trapdoor spiderlings were so slow in changing that the moults occurred about a month apart. At the age of one month and three days the young had grown slightly larger, the cephalothorax was light brown with darker brown in the cervical groove. There was a brown line from the black eye space down to the first groove ending. The legs and spinnerets were the same color as before. The abdomen was colored a little darker brown and six light spots were on the middle surface of the abdomen. The spinnerets were shorter than at the three-day stage. At the next moult (two months and six days), the shape and coloring of the spiderlings had changed considerably. The cephalothorax had elongated, the color was red brown, the eye space black. The abdomen had become smaller and the spinnerets disappeared from sight. The color of the abdomen was dark reddish brown with numerous flecks of lighter brown over the surface of the abdomen. The legs and palpi were gray brown. At three months and six days the whole spider had changed from the reddish brown color to the chocolate brown. The cephalothorax was chocolate brown with black eye space. The abdomen had become the shape of the adult's and was a dark chocolate brown with numerous horizontal ridges. The legs were gray brown. At the age of four months the young had taken all the color of the adult, though their size was only one-tenth that of the mature spider. There is in the collection a specimen of *Bothriocyrtum* of about a year's age. It is three-fourths the size of the adult, and though its sex is not differentiated yet, it has all the adult coloring. From these observations it is concluded that it must take several years for the spider to reach maturity.

The conclusions reached after the study of these families of spiders may be stated in a few paragraphs:

1. The young in all cases resemble the adult in shape of body, placing of eyes and in habit. This was true of the young just emerged from the egg sac as well as the older ones. The shape of

the body might not be exactly as the adult at the beginning, but even then it was in most cases enough like it to help to determine the family. By shape alone could one tell a young attid or young trap-door spider. The position of the eyes was the same as the adult in all cases.

2. Color changes took place without the aid of moulting. It was noted with all the specimens that slight changes took place, such as darkening of the ground color, or a clearing of the pattern between moults. This was not true of body changes, as they only occurred through moulting, but it is true that then, and only then, occurred the great and varied changes of coloration and color pattern. This view of the color changing between moults is not held by most of the writers upon spiders, and it is only through daily observation that this slight changing can be seen.

3. The lack or abundance of food was found to be a great factor in the rapidity of moults and also the color development. The poorly fed spiderling moulted slowly and showed very little difference of color with each moult. The satisfied spiderling moulted at definite periods and showed great development of color as well as development of body. The intensity of the colors always became greater after a meal. Heat and sunshine also were factors with the food. The spiders kept in a dark place had as much color in their bodies as those in the sunshine, but their development was retarded.

4. There was a great difference in the amount of change in the color pattern in different species. Some had a good many, some only one or two. The ones with the greatest number of changes were the brilliantly colored adults or the striking adults. The Thomisidae, Lycosidae and Aviculariidae had very little change, and the young of any of these could be told at once by their close resemblance to the adult. The changes from the immature to the adult in these families were finished after the second or third moult from the egg case. The sexual differences did not appear until later.

5. The young in one brood looked all alike and resembled the adult female. This was true up to the last few moults. McCook in his book states: "Among the young of the *Lycosa* and *Attus,* according to Wagner, these modifications are effected with the

female and male so equally and uniformly during the first four or five moults and with *Trochosa* during the first six or seven moults, that one is scarcely able to distinguish the sex. Among orb weavers generally, and in spiders of various tribes observed, the change in color is not decided in the male; that is, the young male carries the typical color and general shape of the adult female, the younglings of both sexes after the initial moults resemble each other perfectly, and tend to resemble the adult female. Though the young male of *Dictyna* p. bears a close resemblance in color and pattern to the adult female. He concludes that when the adult male is more conspicuous than the adult female, the young of both sexes take after the latter in form and color. On the contrary when the female is more conspicuous the young follow the more modest colors of the male, especially in the earlier moults. When the adult sexes resemble each other the young of both favor the common type."

6. The Adult Thomisidae change color and color pattern according to their environment, but this is not so true of the immature.

7. (a) An adult spider whose ground color is brown, has young whose first ground color is yellow and then later becomes suffused with brown.

(b) The young of an adult whose ground color is green, is first yellow and then green.

(c) A gray spider has gray young.

(d) The black of all spiders, except *Latrodectus mactans,* is brown black, not pure black.

(e) The only color found in spiders, due to refracted light, was in the mandibles of Attidæ.

If the color sequences of all spiders were known, it would be an easy task to determine any immature form, but even without this knowledge it is not impossible to determine to what large family or group an immature specimen belongs. Three things have to be considered in the determination: First, that the young resemble the adult in form; second, that the eye placement of the immature is the same as that of its adult; third, the ground color of the immature is the same as in the adult. In this last it may lack in intensity or differ in shade. This may not be true of the first color, but remains true for the second moult.

If we study the color of the adult, and see how it is made up and how placed, and then apply this knowledge to the study of the immature, it will be found that the latter will usually show something of the adult color and color pattern.

(Contribution from the Zoological Laboratory of Pomona College.)

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A large number of works, both of early and recent writing, have been looked over, but as they had little or nothing upon the subject of the paper, they were not listed.

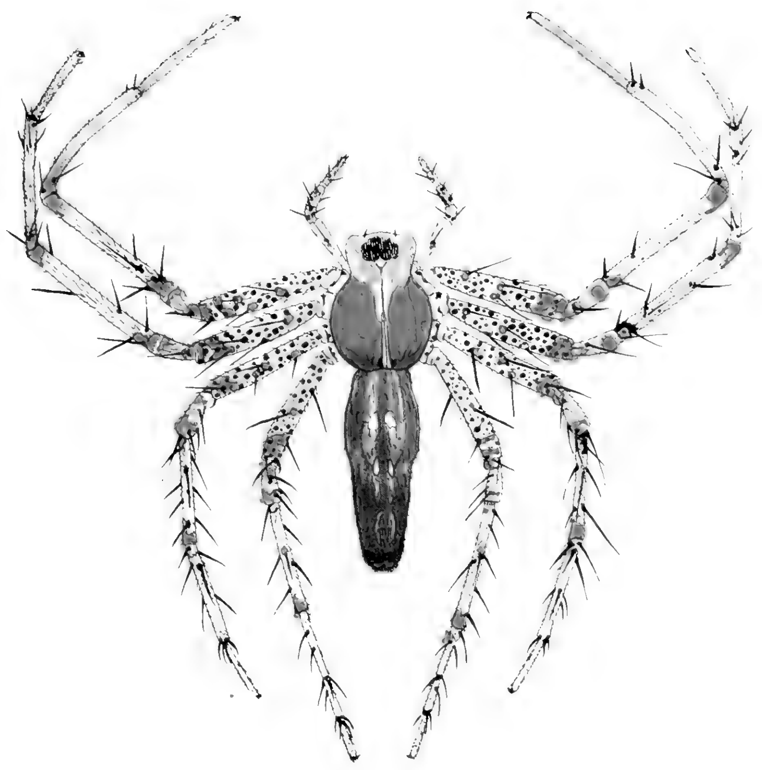


Plate I.

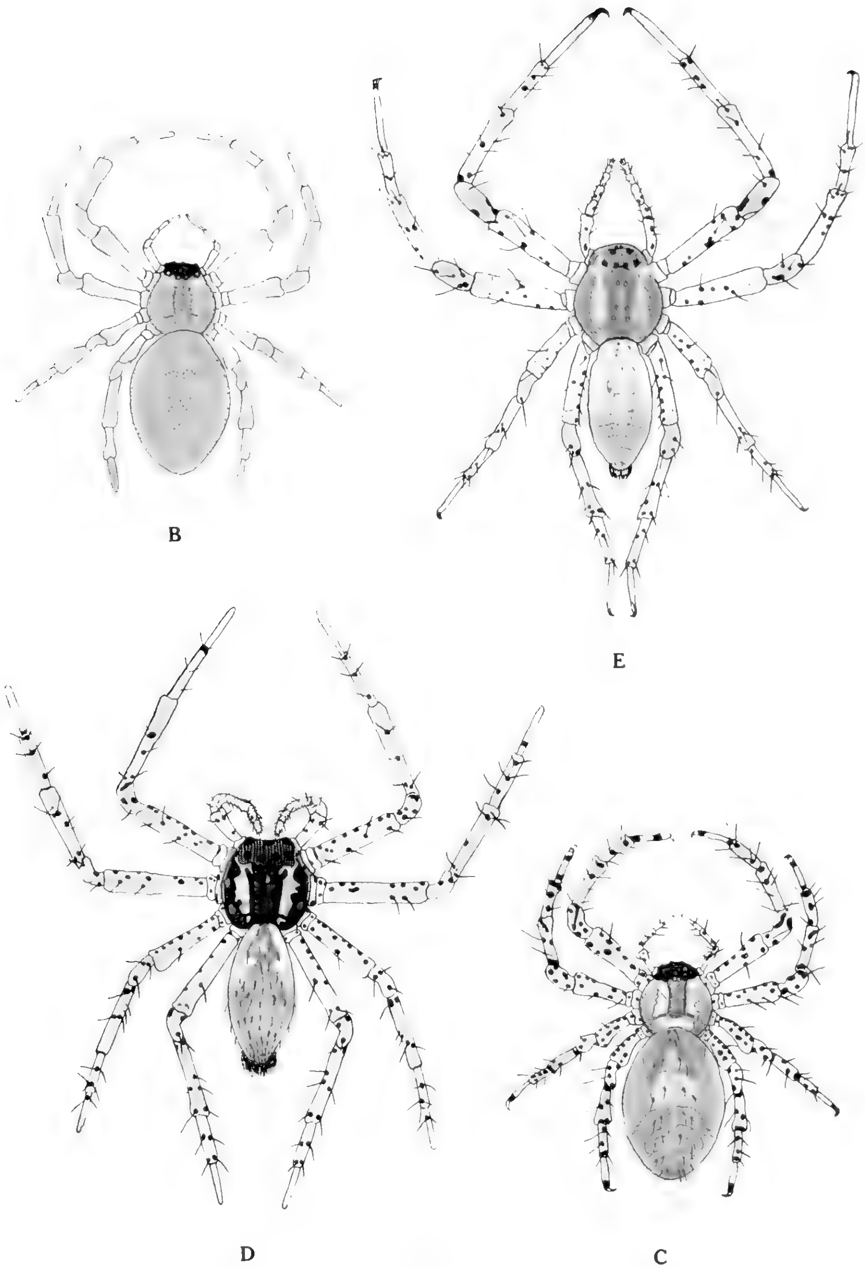


Plate II.

EXPLANATION OF FIGURES

Plate I—*Peucetia viridans:*
Adult female. X4.

Plate II—*Peucetia viridans:*
Fig. B. Young, 3 days old. X20.
Fig. C. Young, 13 days old. X20.
Fig. D. Young, 22 days old. X20.
Fig. E. Young, 39 days old. X20.

Plate III—*Peucetia viridans:*
Fig. A. Adult female. X4.
Fig. B. Young, just emerged. X20.
Fig. C. Young, 25 days old. X20.
Fig. D. Young, 34 days old. X20.

Plate IV—*Aranea gemma:*
Fig. A. Adult female. X2½.
Fig. B. Young, just emerged. X10.
Fig. C. Young, 3 weeks old. X10.
Fig. D. Young, 4 months old. X10.

Plate V—*Latrodectus mactans:*
Fig.A. Adult female. X5.
Fig. B. Young, 13 days old. X15.
Fig. C. Young, 20 days old. X15.
Fig. D. Young, 34 days old. X15.
Fig. E. Young, 41 days old. X15.

Plate VI—*Lycosa sp.:*
Fig. A. Adult female. X4.
Fig. B. Young, just emerged. X12.
Fig. C. Young, 3 weeks old. X12.

Plate VII—*Phidippus sp.:*
Young, just emerged. X20.

Plate VIII—*Bothriocyrtum Californicum:*
Fig. A. Adult female. X2.
Fig. B. Young, 3 days old. X20.
Fig. C. Young, 1 month 3 days old. X20.
Fig. D. Young, 2 months 6 days old. X20.
Fig. E. 3 months 6 days old. X20.

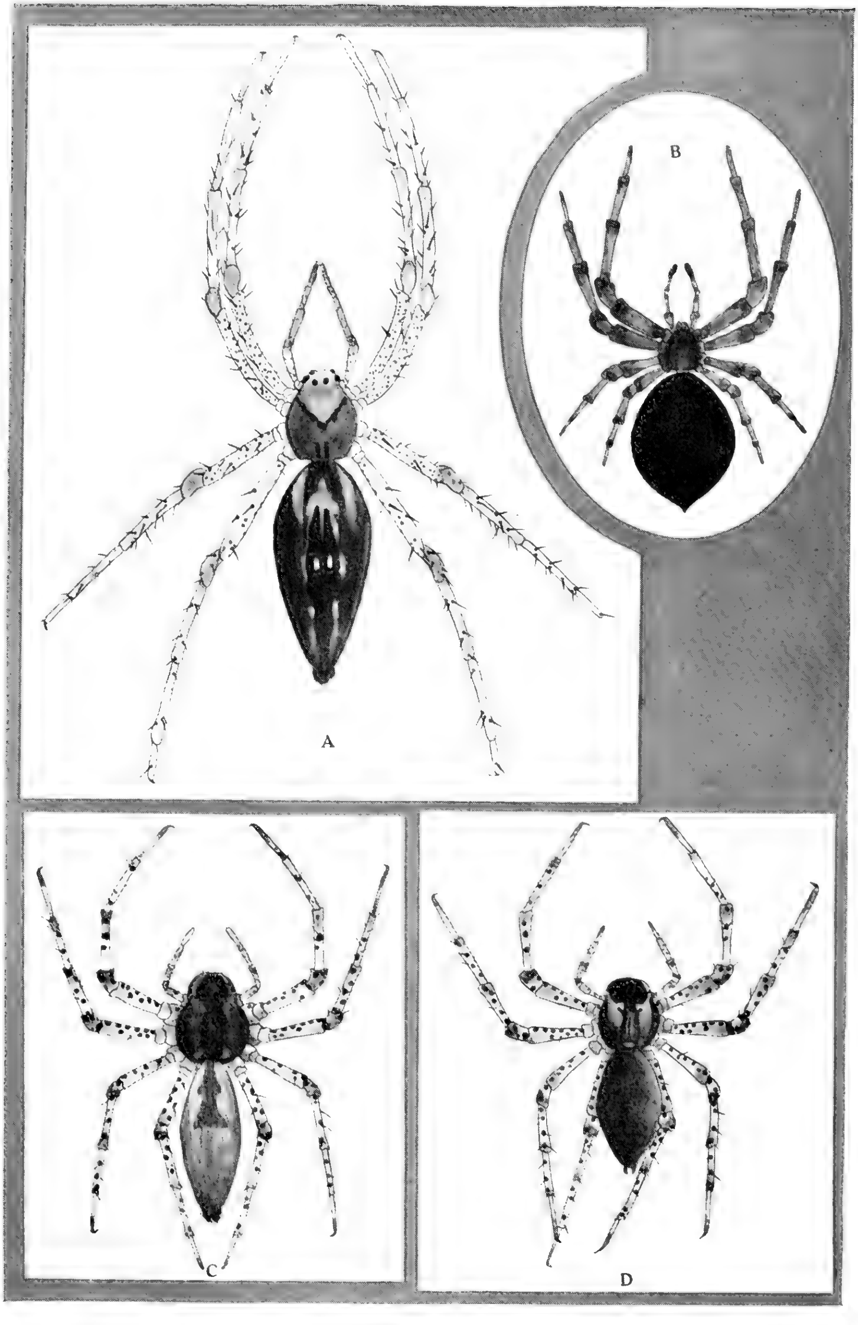
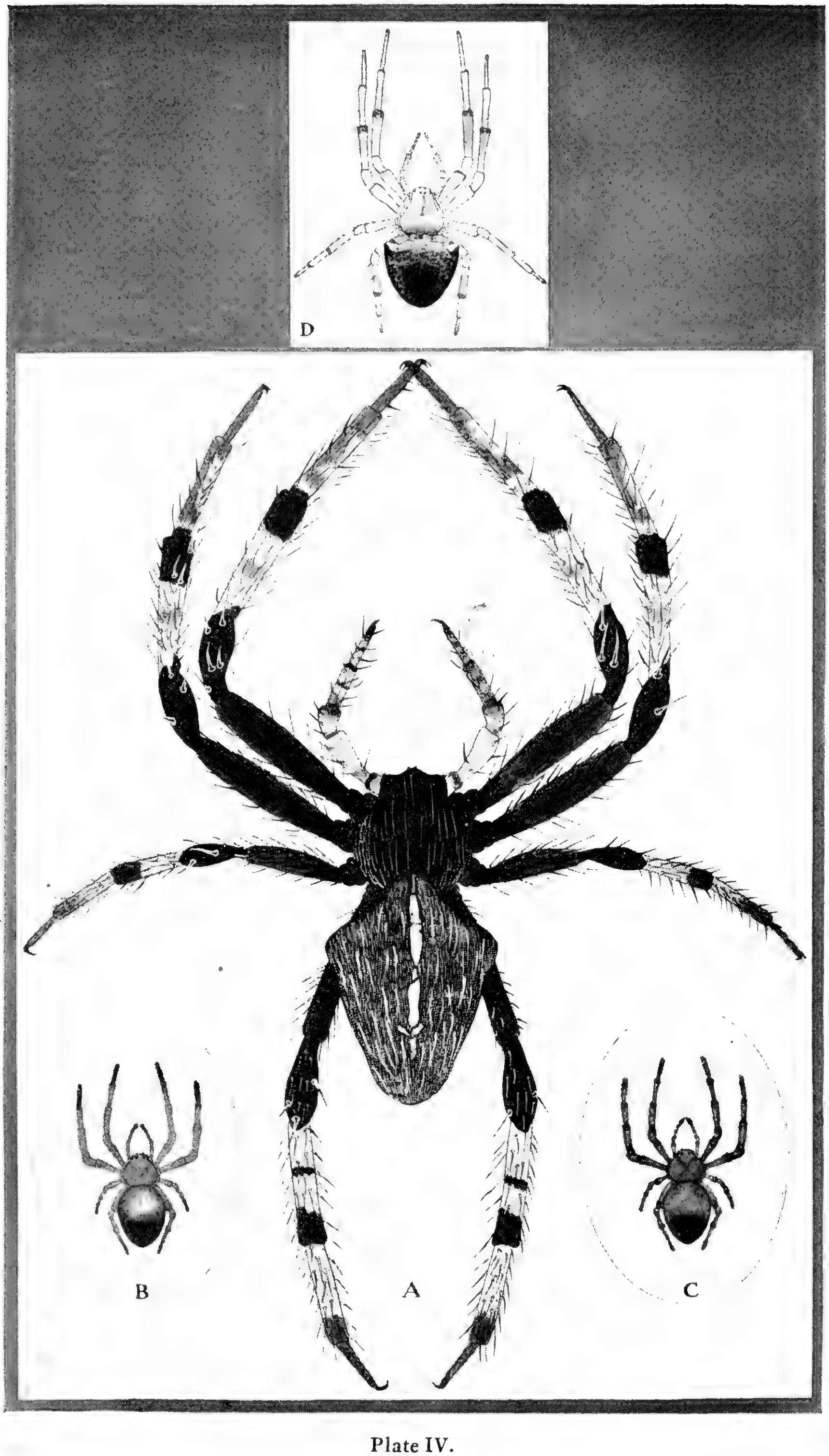


Plate III.



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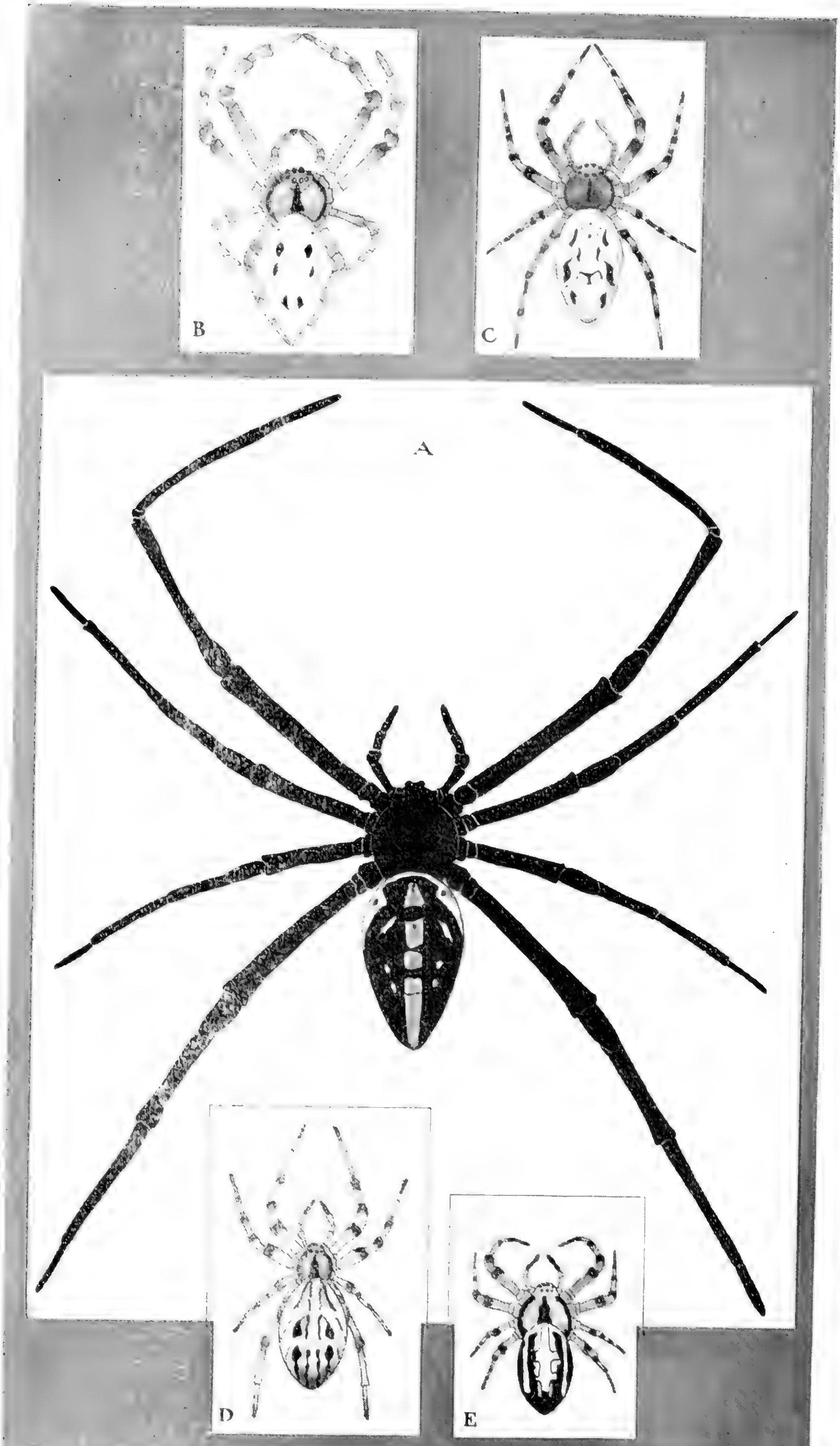

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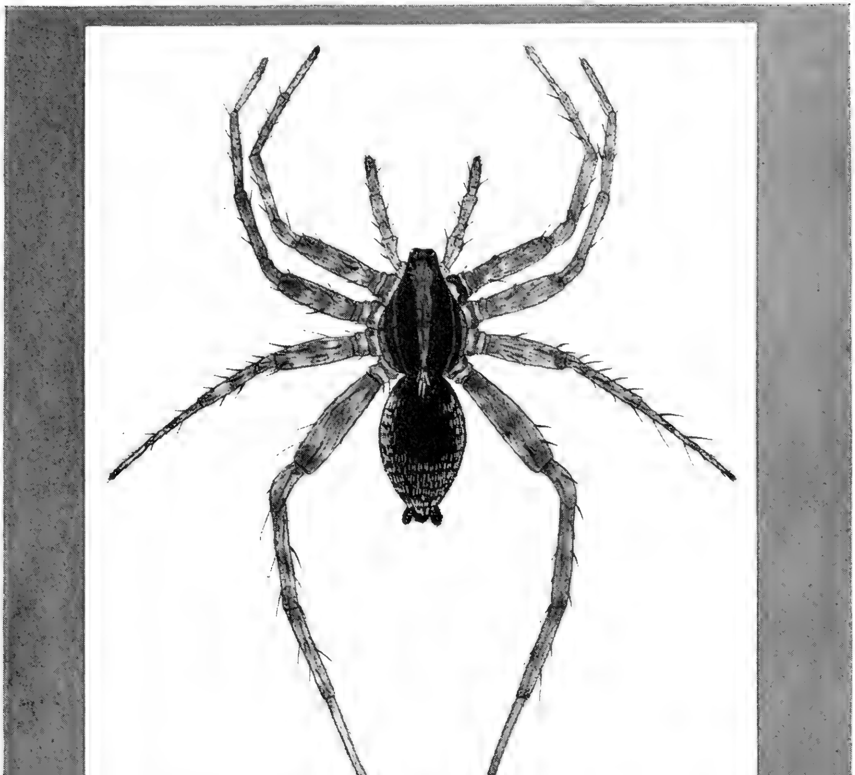

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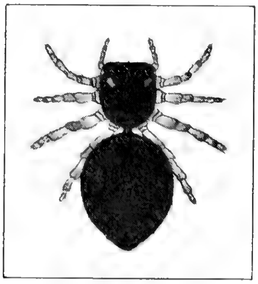

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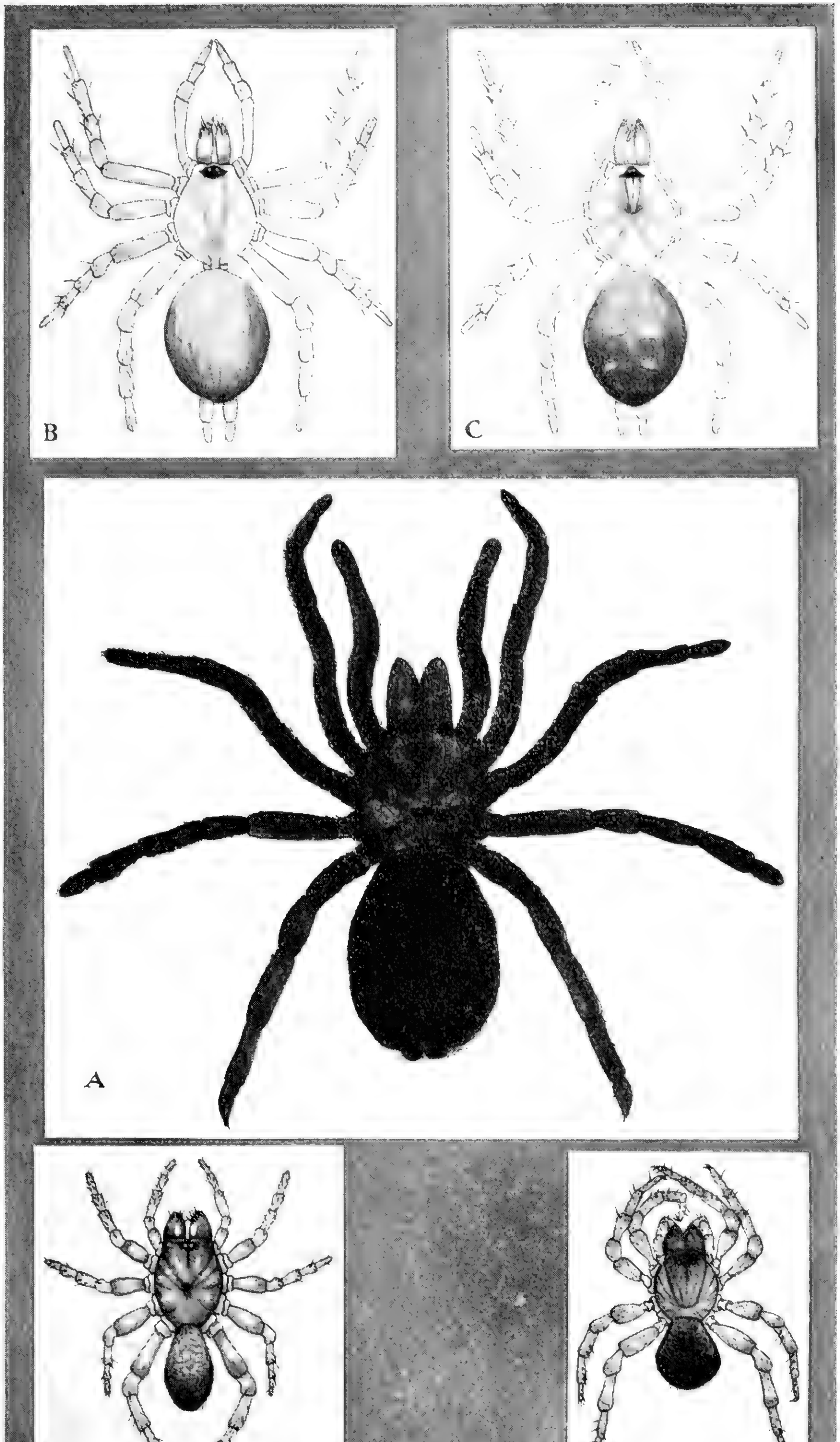

Plate VIII.

1916 Pomona College of Entomology and Zoology, Vol. VIII, No. 4, December

Studies in the Life Histories of Two Carpenter Bees of California, With Notes on Certain Parasites

H. H. NININGER

Xylocopa orpifex Smith

Systematic observation of this species was extended over a period of one year, beginning September 29, 1915.

Methods: The colony chosen for study is located on the summit of a small mountain rising from San Dimas Canyon of the San Gabriels, at an altitude of about 3,500 feet, where it occupies the timbers of a small, deserted cabin. It required two hours of climbing to reach the cabin from the foot of the mountains. About sixteen trips were made at intervals during the whole autumn, winter and spring and one in late summer. Pieces of timber were brought to the laboratory from time to time, and opened. During the breeding season those occupied by eggs or larvæ were carefully preserved and prepared for daily observation by splitting the timber so as to expose the contents of the cells when the parts were separated, and again refitting the parts and holding them in place by means of clamps when not under observation; or, by smoothing the split surface and carefully fitting a piece of glass over the opened cells, which was then held in place by means of glue or other paste. In one case a tightly-fitting sliding glass plate was used quite successfully. A dark cover of some kind was kept over the glass, except during observation, thus preserving as nearly as possible the natural conditions. As a check on the whole study a trip to the cabin was made at the season of their emergence and a number of cells were opened which seemed to corroborate all of the conclusions reached from the experiment, except in the case of certain parasites as noted below.

Habits: Orpifex shows a decided preference for redwood as a medium in which to burrow. Though I found them, in one or two cases, using Oregon pine. It shows no inclination to choose decaying timbers; but, on the contrary, was always found working in the sound wood. This, I think, is a wise choice, for one of its dangerous foes is found abundantly, tunneling through decaying redwood. The surface chosen for making an entrance is generally vertical or slanting. When slanting or, as is sometimes the case, horizontal, the under surface is always chosen. For a short distance the burrow takes a course nearly or quite at right angles to the surface entered, then gradually changes to a course parallel to that surface, and always (with very few exceptions) leads upward in the slanting or upright timber. These tunnels vary in length from one inch to twelve inches and are, as a rule, remarkably straight. I am at a loss to know certainly what guides these interesting little carpenters in the construction of so straight a tunnel. My first idea was that they followed the grain of the wood, but in one case, where a knot occasioned a decided curve in the grain of the wood, the tunnels had been constructed straight as usual (Fig. 7). The most reasonable explanation seems to be that the vibrations of the wood serve to indicate the distance from either surface, for when boring in a plank only $\frac{5}{8}$-inch thick they keep a line remarkably nearly equidistant from the two surfaces and never have I seen where they broke through to the surface. But a fact in the way of this theory is that they sometimes make tunnels just as straight in a 2-inch timber with the distance from one surface several times greater than the distance to the opposite surface. It is an interesting point which I have not yet solved to my satisfaction. My description fits the majority of tunnels. In a very small percentage of the cases studied, the tunnels were short and seemed to be in almost any position.

The excavation of these tunnels is evidently a laborious task, though the little creatures ply their trade with great avidity, and while at work they are not at all easily disturbed. The writer watched one of these patient workers for three hours, during which time she kept her mandibles working away continuously, leaving her work only twenty-five minutes, evidently for "lunch," after which she returned to resume her task. By closest scrutiny I was unable to see that the two and a half hours of labor had lengthened her burrow. I returned six days later to find her still vigorously pursuing her task, but she had advanced less than one inch. Fig. 1 shows this tunnel and the rate of progress. It seemed to be a typical case. I have known one tunnel to be several weeks under construction. Their average length is from four to six inches. Those of greater distance, I think, are the result of more than one season's work, having been lengthened from year to year.

While digging, the bee slowly turns in the burrow, requiring from thirty minutes to an hour to complete the cycle. Observation showed no regularity or uniformity either in rate or direction of turning.

I have never found orpifex except in reasonably large aggregations. If some adventurous female begins work in a new locality, that locality is sought out by others until almost every available timber is honey-combed with tunnels*. From one surface entrance there are usually several tunnels leading away. Figs. 8 and 9 are typical in this respect. This habit doubtless serves well in the reduction of labor and also reduces the danger from enemies. A third advantage gained is the mutual protection against changes of temperature during the winter, for I found these tunnels, on cold days, literally packed full; in many cases two rows of bees lying side by side in the same tunnel.

Other than the points mentioned I find no hint of true community life. Males and females are about equal in number, and in the rearing of young they behave as other solitary bees so far as I am able to learn. No food is stored for winter but on warm days they come forth in search of food, a temperature of about 20 deg. to 21 deg. C. being sufficient to invite them out.

Life History: Having finished her tunnel the female begins to provision it with bee-bread which she makes from pollen and regurgitated nectar. After accumulating a mass about as large as her own body she lays an egg upon it and walls up that part of the burrow with a partition of chips of wood cemented together in the form of a spiral (Fig. 2), as Comstock has described in the case of *Xylocopa virginica.* Examination showed no uniformity in the direction of this spiral. I found among the partitions built by the

*This may be due to the scarcity of redwood in this vicinity.

same bee those in which the spiral turned clockwise and others in which it was the reverse. Five to six such cells are thus provisioned and sealed in about as many days, each occupying about five-eighths of an inch of the tunnel.

These eggs are hatched successively after an incubation period of about one week. The newly-hatched larva is a footless grub about 7 mm. in length. It feeds slowly at first, then more rapidly and has devoured all, or nearly all, of its food in from 22 to 28 days, when it ceases to feed and for a period of from 15 to 19 days shows very little change. During the non-feeding larval stage it spends most of its time in the position shown in Fig 3, but occasionally indulges in a series of writhing movements which last for a half minute or more. At the end of this period the first moult occurs, the beginning of the pupal stage (Fig. 11). The pupa is at first white and manifests even less movement than in the previous stage, but gradually pigment begins to develop and within three or four weeks the jet black color of the adult shows as a slaty blue through the thin white outer skin. About this time the pupa begins to show a bit more activity and within a few days may be found stretching out its legs and antennæ which have thus far been tightly folded against its body. This action is prophetic of emergence and a few days later the second and last molt occurs, which brings it into the adult stage. It remains only for its wings to complete their growth and harden before it is ready for flight.

But there are obstacles ahead of this seeker of the open air. The neatly-formed partitions are yet as strong as the day they were made, and there may be from three to six of them between young orpifex and the light of day. That is not all, for unless some wanton parasite has entered, there lie as many brothers and sisters, all yet in their swaddling clothes—in those chambers which form the only path to the out-of-doors. Some writers have suggested that this first-born politely waits here in this inner chamber for the younger members of the family to emerge and then humbly follows them out; but my observation revealed no such modest altruism. When No. 1 of a family of six emerged during a day of my absence she tore away the enclosing partition, kicked the occupant of the next cell back into the one she had deserted, and repeating this operation in each cell, went plowing through the whole row, and when the timber was opened the next morning No. 1 was found in cell No. 6 ready to tear away the last restraining wall. In some cases the first to emerge did wait for a short time before beginning to dig out, but this was not the rule. I think this matter is probably governed by the food supply. If these was a fragment left from the larval feeding it will satisfy the newly-emerged one for some time, but if not, it soon seeks a way out. These creatures seem to be ravenously hungry upon their emergence (as might be expected after sixty days of organization and development without taking any food) and their first activity is a search for food. After searching through their own tunnel and devouring what fragments remain they do not fly at once but enter adjoining burrows and profit by any morsel which may have been left by the early death of a neighboring larva or the failure of an egg to hatch.

The question has been raised as to a uniform position of the males and females in the brood tunnel (Davidson, Ent. News, Vol. 4, 1892). I noted at least one exception to such a rule, the first of one brood being a male and the first of another brood being a female.

Parasites: The most interesting of the parasites found upon this species was one of the Bombyliidæ, *Spongostylum delila* Loew, which first appears upon the foodmass as a very minute but exceedingly active larva. Even before the egg of the host is hatched this almost microscopic intruder is found industriously creeping about, rearing and stretching as if looking for a foe to conquor. For three weeks or more it thus restlessly creeps about over foodmass, egg and larva, feeding promiscuously, then finally settles down and, fastening itself by means of its hooked beak to the sixth or seventh segment of the Xylocopa larva (Fig. 12), it quietly feeds until its host is devoured unless shaken loose by the writhing movements (noted above) of the larva, when it soon reattaches itself and resumes its quiet feeding. The parasite is four weeks, or more old when it thus attaches itself and is found to be only three to five mm. in length. For nearly two weeks more its growth can scarcely be noted except by careful measurements so that at the age of five and one-half to six weeks its length is but from four to five mm. Here a remarkable change occurs. It now begins to grow at such a rate as to almost double its size within twenty-four hours. The host, which heretofore has betrayed no marked injury from its enemy, now rapidly shrivels up. Only five days of this voracious feeding reduces the once large plump larva to an empty skin and in its place we find the equally large and plump, fully grown larva of the bombyliid (Figs. 3 and 4). This long retarded growth followed near the end of the larval period by a relatively short period of unusually rapid development seems to be a very advantageous adaptation on the part of the parasite. If growth had progressed steadily from the first, death of the host had surely resulted before the full development of the parasitic larva. This larva now rests almost motionless for ten or twelve days (Fig. 4) when it becomes a little more active and moults about two days later, entering the pupa stage (Fig. 5). In this stage it remains for fifteen to twenty days and emerges as an adult (Fig. 10).

The work of this parasite for the season in which it was studied was quite general, about ten per cent. of the cells examined being infected. So far as I observed, its work was also very equally distributed—about half the broods showed one parasitized larva and in only one case was there more than one found in the same brood.

Other parasites found were a phycitid moth and a tenebrionid beetle, both of which began their work upon the bee-bread and when that supply ran short devoured the young bees. These two parasites would doubtless be much more destructive were orpifex a less careful workman; for I found that where cells prepared for study were not tightly sealed the pupæ were in almost every case devoured. But where the partitions were left entirely intact and the glass cover glued on tightly I found only one case in which a cell was entered and in this case the tenebrionid bored through the partition to deposit eggs within the cell. In some cases I used bee-bread to paste the glass cover over the opened cells and in every such case these two parasites found their way in by feeding upon this material and without fail they devoured the pupæ before they emerged. From my examination of cells which had not been opened before the season of emergence I conclude that the injury of these parasites is slight except in case of defective construction of partitions. But they were found occasionally even in the normal brood cells.

Mites of the genus *Trichotarsus* (determined by Nathan Banks) infested a few nests and in some cases destroyed developing bees but often the emerging adult carried them away among the hairs covering the thorax and seemed to be uninjured.

All the parasites have been sent to specialists for determination. The tenebrionid was determined for us by H. C. Fall. It proved to be *Aphanotus brevicornis* Lec.

The bee-fly seems not to be the same species as the one found by Davidson, Ent. News, Vol. 4, 1892. Prof. J. M. Aldrich has determined it for us as *Spogostylum delila* Loew.

The moth sent to the U. S. Museum was in such a condition that it could only be determined to belong to the family Phycitidæ.

Xylocopa varipuncta Patton

This species is much larger than orpifex and exhibits a marked dimorphism, the male being of a golden brown color while the female is jet black. It inhabits the valleys and lower hill regions while orpifex is found in the higher hills and mountains.

Varipuncta seem to prefer wood that is partially decayed in which to burrow. I have found them working several kinds of wood, but most abundantly in live oak, pepper and eucalyptus. Their tunnels are generally from five to twelve inches in length and seem to follow the grain of the wood, sometimes far from straight. Their nesting habits are similar to those described for orpifex. They are not so much inclined to live in groups as the former species; yet in one case I found several individuals using a common surface entrance from which each constructed a separate tunnel for her brood nest.

My study of this species was not so extensive as in the case of orpifex and only one parasite was found, the mite, *Trichotarsus,* which destroyed a small percentage of the larvæ. This mite is often found upon the adult which I think accounts for its presence in the brood chamber. The life history, as far as known, is given in table below:

	Egg-stage	Feeding Larva	Non-Feeding Larva	Pupa	Total
Xylocopa orpifex......	7 days	23-28 days	18-19 days	40-45 days	85-99 days
X. varipuneta........	about 1 week	30 days	20 days	40 days	
Bee Fly (parasite)....	unknown	42-47 days	12-15 days	15-20 days	

DISTRIBUTION (From T. D. A. Cockerell)

X. orpifex: Mountains near Claremont (Baker; Oak Creek Canyon, Ariz. (Snow); Rock Creek, Cal. (Davidson); Strawberry Valley, San Jacinto Mountains, Cal. (Grinnell); Mountain View, Cal. (Ehrhorn). This species occurs from Nevada south to Lower California.

X. varipuncta: Tempe, Ariz. (Irish); Fort Mohave, Ariz. (Junius Henderson); Los Angeles, Cal. (Cockerell), on flowers of *Datura meteloides.* Also reported from Texas and Lower California, but not in New Mexico.

(Contribution from the Zoological Laboratory of Pomona College and Lordsburg College)

PLATE I.

Figure 1. Shows progress in excavating tunnels: *a*, bottom of newly begun tunnel when found; *b*, bottom of same tunnel after six days of work. Nat. size.

Figure 2. One of the partitions as viewed from the entrance of the burrow.

Figure 3. X. orpifex larva in non-feeding stage with bombyliid larva attached. Nat. size.

Figure 4. Same as Fig. 3, but five days later, showing X. orpifex larva reduced to empty skin and parasite larva fully grown. Nat. size.

Figure 5. Pupa of bombyliid. X2.

Figure 6. An egg of X. orpifex with outline of developing embryo inside. X3.

PLATE II.

Figure 7. A tunnel of Xylocopa orpifex showing where the worker did not follow the grain of wood. Nat. size.

Figures 8-9. Show two pieces of ¾-inch boards with one surface hewn away to show work of X. orpifex . X shows position of surface entrances with a number of tunnels from each, reduced.

Figure10. Adult of bombyliid parasite.

Figures 11-12. Larva of X. orpifex with bombyliid larva attached; much enlarged. Pupa of X. orpifex; much enlarged.

Figure 11. Larva of X. orpifex with bombyliid larva attached. Much enlarged.

Figures 11 and 12 from drawings by Margaret L. Moles.

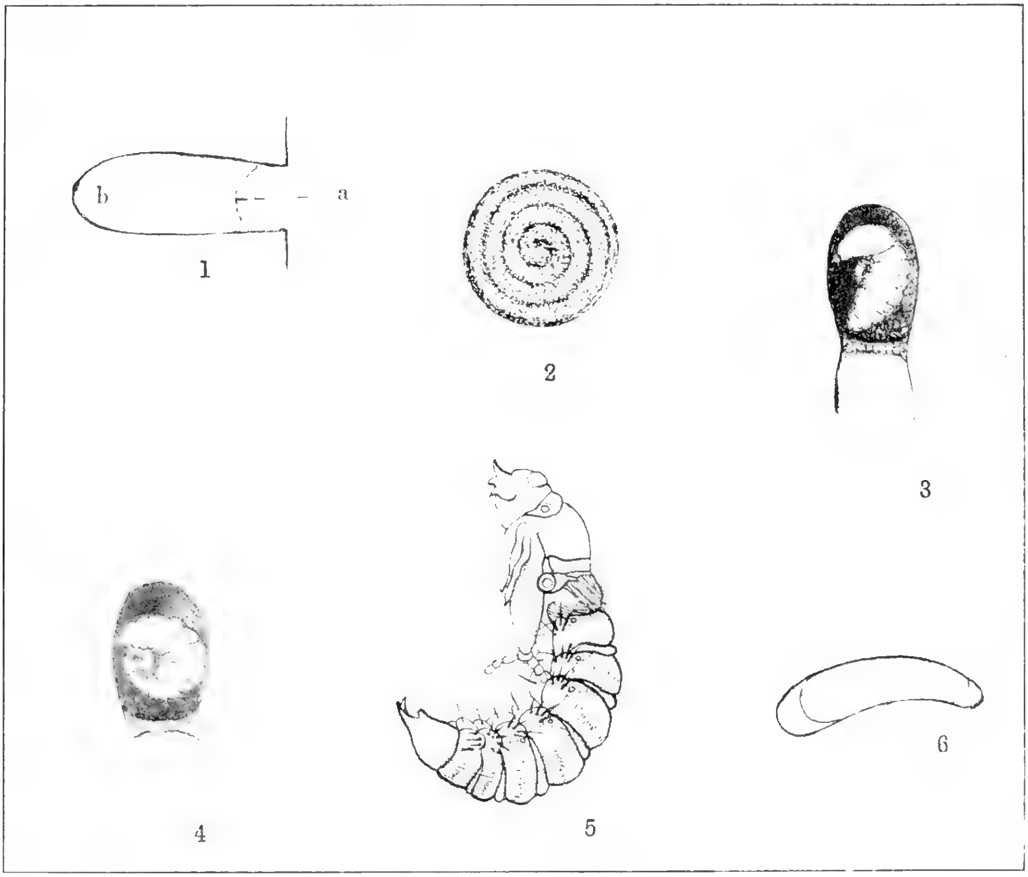

PLATE I.

PLATE II.

Notes on Chalcid Flies, Chiefly From California

A. A. GIRAULT

The following descriptions are chiefly from specimens sent by the Department of Zoology of Pomona College.

Eusandalum californicum n. sp.

Female: Similar in every respect to *coquillettii* Ashmead except as follows: The hyaline cross-stripe between the fuscous cross-stripes of the forewing is distinctly narrower than either fuscous cross-stripe (broader than either in the other); the stylus of the abdomen is a little shorter than the ovipositor valves (their extruded portion), both equal in length in *coquillettii.* Otherwise the same. Antennæ 11-jointed, tapering, the club single and no longer than the pedicel, funicle 1 quadrate, 2 longest, elongate, somewhat compressed, over thrice the length of the pedicel. Types compared.

A female from Claremont (C. F. Baker).

Types: Catalogue No. 20357, U. S. National Museum, the female on a tag, a fore wing antenna and hind leg on a slide.

In the U. S. National Museum a female from the Santa Cruz Mountains, California, part of the type of *coquillettii* (now a single female from Los Angeles).

Eusandalum obscurum n. sp.

The type is one female from Easton, Washington (Kincaid). Catalogue No. 20358, U. S. National Museum, the female on a tag. See table.

Eusandalum alpinum n. sp.

The type is a part of the type of *coquillettii* from the Santa Cruz Mountains, California; Catalogue No. 20359, U. S. National Museum, the specimen on a tag. See table.

Eusandalum georgia n. sp.

One female, pinned, Georgia, Catalogue No. 20369, U. S. National Museum. A second female from Washington, D. C. See table.

Eusandalum arizona n. sp.

A female, Santa Rita Mountains, Arizona (Schwarz), May 27. Catalogue No. 20361, U. S. National Museum, tag. See table.

Synopsis of the North American Species of *Eusandalum*. Females. (From the types.)

1. Wings bifasciate, the distal fuscous band at apex. Legs red except the coxae, the antennae wholly concolorous. Ovipositor extruded for over half the length of the abdomen. Scutellum longitudinally lined.
   Hyaline band of fore wing distinctly narrower than either fuscous band (one on each side of it); stylus a little shorter than the ovipositor. *californicum* Girault
   Hyaline band of fore wing somewhat broader than either fuscous stripe; stylus and ovipositor equal. *coquillettii* Ashmead
2. Wings unifasciate or wholly embrowned or with a large unbroken, fuscous area. Wings wholly infuscated. Scutellum densely punctate like the scutum (in the first species). Propodeum with a lateral sulcus.
   Ovipositor much extruded.
   Legs reddish except the coxae and the first and third femora *ventrad;* more slender than usual, the ovipositor about as in *californicum* but the abdomen is longer, hence the ovipositor is so. Fore wing with a longitudinal white streak caudad of middle. *acmaeoderae* Rohwer
   Ovipositor extruded for less than a fourth the length of the abdomen, the stylus subobsolete.
   Fore wings indefinitely slightly stained; legs reddish except the coxae; scutellum long-lineolated. *obscurum* Girault
   Wings infuscated from the bend of the submarginal vein to apex or nearly. Antennae concolorous (compare *obscurum*).
   As in *californicum* but the scutellum finely puncate; differs from *acmaeoderae* in being more robust, the first and third femora are not metallic ventrad, the costal cell is broader, the tip of the fore wing is hyaline for a short distance. *alpinum* Girault

Legs wholly concolorous except the knees and tips of tibiae narrowly and the tarsi; as in the preceding but stylus and ovipositor subequal. *cyaneum* Ashmead

3. Wings hyaline or subhyaline. Antennæ concolorous except at extreme base.

Ovipositor extruded for about half the length of the abdomen, the stylus slightly short.

Middle legs except coxae, all knees narrowly, tips of tibiae and the tarsi reddish brown. Postmarginal vein subequal to the stigmal. *hubbardii* Ashmead

Ovipositor extruded for less (or not more) than a third the length of the abdomen, the stylus subequal.

Postmarginal vein subequal to the stigmal.

Legs reddish except the coxae and cephalic femora and tibiae. Scutellum somewhat more distinctly lineolated longitudinally, punctate. Ovipositor short. *hyalinipenne* Ashmead

Postmarginal vein distinctly longer than the stigmal.

Legs concolorous except knees, tips of tibiae and the tarsi. Stylus somewhat shorter than the ovipositor which is a third the length of the abdomen. *georgia* Girault

4. Wings subhyaline. Antennae with the basal fourth of the cape honey yellow.

Postmarginal vein distinctly much longer than the stigmal, twice longer.

Ovipositor extruded for nearly half the length of the abdomen, the stylus a little shorter. Legs honey yellow except fore and hind coxae. *arizona* Girault

All the species have the postmarginal vein shorter than the stigmal or no longer, save where noted; the parapsidal furrows are distinct, but very short, joining before the middle of the scutum from cephalad. The club is usually single, the antennae 11-jointed, tapering-filiform.

Dialinus begini Crawford

One female, Santa Clara County (C. F. Baker).

Elachistus coxalis Howard

One pair, San Mateo County, California, the male; and Laguna Beach, Southern California, the female (C. F. Baker).

The following species is an *Eudecatoma* (there being no distinct substigmal spot but only a very minute one) but for the present I include this segregate within the older one.

Decatoma subimmaculata n. sp.

Female: Length, 2.00 mm. Of the usual habitus and sculpture, the punctation not coarse.

Honey yellow, the wings hyaline, the following black markings: Ocellar dots obscurely, upper margin of occiput (a crescent), median channel nearly to apex and cephalic margin of the propodeum (except laterad); abdominal petiole and the median line of abdomen dorsad narrowly, from just before apex of segment 2 nearly to the apex of segment 4. Abdomen compressed, segments 2, 4 and 5 subequal, longest, the abdomen glabrous, its petiole about twice longer than wide. Propodeum openly rugoso-punctate, the median channel single, distinct, no median basin. Pedicel black above, nearly twice longer than wide, a little longer than funicle 1, the other four funicle joints subequal, subquadrate. Club 2-jointed, the first joint shortest.

One female, Claremont, California (C. F. Baker); on oak.

Type: Catalogue No. 20400, U. S. National Museum, the female on a tag, the antennae and a caudal leg on a slide.

Differs from *catesbaei* Ashmead (types compared), in being larger, the median channel of the propodeum is distinct for its whole length and does not consist principally of two large foreae, the cross-carina passing *proximad* of it has an area on each side of the meson which runs at first nearly parallel to the channel (the forking) but in the Florida species, this carina continues more or less parallel with the cephalic margin of the propodeum.

Scutellista cyanea Mots

One female, Claremont, California (C. F. Baker).

Cleonymus californicus n. sp.

Female: Length, 4.00 mm.

Dark metallic green, the tegulae, antennae (except the club and pedicel) and the legs (except the concolorous coxae, the apex of caudal femar lateral and the last two pairs of tibiae dorsad more or less), reddish brown, the venation fuscous, the fore wings bifasciate, the first stripe from the base of the marginal vein and broken distad of the middle, the second from the postmarginal vein, obovate in shape, twice the width of the first. The (triangular) head, the thorax and abdomen, scaly punctate, the propodeum and abdomen 2 subglabrous, the distal margins of the abdominal segments glabrous. Propodeum foreolate along the cephatic and caudal margins, and along the median carina on each side, the lateral carina represented by a distinct, curved, foreate sulcus, the spiracle large, subreniform. Scutellum simple. Antannae inserted near the clypeus, a little below the eyes, 11-jointed, the club pointed ovate, acuminate at apex, embraced by the long projection from one side of the apex of the distal funicle joint which reaches to distal three-fourths of the club. Funicles 1 and 2 narrowest, grading into 3, all subquadrate, 4 longest, a little longer than wide and subequal to the pedicel; 8 wider than long. Postmarginal vein a little longer than the slender, curved stigmal, about a third the length of the marginal. Stigmal vein parallel, in general trend, with the costal margin.

Two females, mountains near Claremont (C. F. Baker).

Types: Catalogue No. 20348, U. S. National Museum, the females on tags, a fore wing and an antennae on a slide.

The abdomen is subpetiolate; it was distinctly, quadrately petiolate in a male specimen of *cleonymus depressus* in the U. S. National Museum.

Entedon occidentalis Girault

Several specimens, Claremont, California (C. F. Baker).

Isosoma grande Riley

One winged female, mountains near Claremont, California (C. F. Baker).

Metapleura spectabilis Westwood

One female, Claremont, California (C. F. Baker).

List of Bees from Claremont-Laguna Region

HENRY BRAY

Through the kindness of Prof. T. D. A. Cockerell and several others I have been able to get large numbers of our local bees determined. The basis of the work was the extensive Cook-Baker collection of the college with additional material of my own and others. Many of the species here listed have been collected by me and others, but unless not represented in the original college collection it is not noted in the list. So far as the relations of bees to plants has been noted by me it is given in the list. Many other species remain to be determined and only a beginning has been made in respect to the relation of the bees to plants.

BOMBIDÆ

Bombus sonorous. Say. Det. Vier. Claremont, Cal., Baker. April, Fl., Nemophila.

Bombus californicus. Sm. Det. Vier. Claremont, Cal., Baker. May, Fl., Phachelia tanacætifolia.

Bombus crotchii. Vier. Det. Cr. Claremont, Cal., Baker. May, Fl., Tar weed.

ANTHOPHORIDÆ

Anthophora anstrutheri. Ckll. Det. Ckll. Claremont, Cal., Baker. April, Fl., Lotus glaber.

Anthophora curta. Prov. Claremont, Cal., Baker. April., Fl., Lotus glaber.

Anthophora urbana. Cr. Claremont, Cal., Baker. April, Fl., Cactus and poppy.

Anthophora washingtoni. Ckll. Det. Ckll. Claremont, Cal., Baker.

Anthophora stanfordiana. Vier. Claremont, Cal., Baker. May, Fld, Amsinckia intermedia.

Anthophora pacifica. Vier. Mountains near Claremont, Cal., Baker. April, Fl., Lotus glaber.

Anthophora simillima. Cr. Claremont, Cal., Baker. April, Fl., Lotus glaber.

Anthophora edwardsii. Cr. Det. Ckll. Claremont, Cal., Baker. April, Fl., Phacelia tanacætifolia.

Mellisodes pallidicincta. Ckll. Det. Br. from Coll. Claremont, Cal., Bray. April, Fl., Phacelia tanacætifolia.

Mellisodes maura. Cr. Det. Br. from Coll. Claremont, Cal., Bray. May, Fl., Amsinckia intermedia.

Mellisodes pullata. Cr. Det. Br. from Coll. Claremont, Cal., Bray. April, Fl., Phacelia tanacætifolia.

Mellisodes menuacha. Cr. Det. Br. from Coll. Claremont, Cal., Bray. May, Fl., Phacelia tanacætifolia.

Mellisodes beltragei. Cr. Det. Br. from Coll. Claremont, Cal., Bray. Fl., Amsinckia interm.

Synhalonia atrientis. Smith Det. Br. from Coll. Claremont, Cal., Bray. May, Fl., Phacelia tanacætifolia.

Diadasia crassicauda sp. n. Ckll. Det. Ckll. Laguna, Cal., R. La Follette.

Diadasia bituberculata. Cr. Det. Cr. Claremont, Cal., Baker. April, Fl., Cactus.

Diadasia australis rinconis. Ckll. Det. Ckll. Claremont, Cal., Baker. May, Fl., Cactus.

Diadasia australis opuntiæ. Ckll. Claremont, Cal., Baker. May. Fl., Cactus.

EUCERIDÆ

Tetralonia actuosa. Det. Cr. Claremont, Cal., Baker.

Tetralonia fowleri. Ckll. Det. Ckll. Claremont, Cal., Baker.

Tetralonia pomonæ sp. n. Ckll. Det. Ckll. Claremont, Cal., Baker.

Tetralonia robertsoni. Ckll. Det. Ckll. Claremont, Cal., Baker.

MELECTIDÆ

Bombomelecta thoracicia. Cr. Det. Cr. Claremont, Cal., Baker. April, Nemophila.

Pseudomelecta californica miranda. Fox. Claremont, Cal., Baker.

Bombomelecta thornica. Cr. Claremont, Cal., Baker. May, Fl., Nemophila.

Zacosmia maculata. Cr. Claremont, Cal., Baker.

Triepeolus ancoratus sp. n. Ckll. Det. Ckll. Claremont, Cal., Baker.

Triepeolus callopus. Ckll. Det. Ckll. Claremont, Cal., Baker.

Bombomelecta maculata. Vier. Det. Ckll. Claremont, Cal., Baker.

NOMADIDÆ

Nomada edwardsii. Cr. Det. Ckll. Claremont, Cal., Baker. June, no Fl.

Nomada beulahensis. Ckll. Det. Br. Claremont, Cal., Bray. From Coll. April, no Fl.

Nomada americana. Kby. Det. Br. Claremont, Cal., Bray. From Coll. April, no Fl.

Nomada crotchii nigrior. Ckll. Det. Ckll. Claremont, Cal., Baker.

Nomada civilis. Cr. Det. Ckll. Claremont, Cal., Baker.

Nomada pyrrha sp. n. Ckll. Det. Ckll. Claremont, Cal., Baker.

Nomada melanosoma, sp. n. Ckll. Det. Ckll. Claremont, Cal., Baker.

Nomada subvicinalis. Ckll. Det. Ckll. Claremont, Cal., Baker.

Nomada erythrospila sp. n. Ckll. Det. Ckll. Claremont, Cal., Baker.

Nomada odontocera sp. n. Ckll. Det. Ckll. Claremont, Cal., Baker.

Exomalopsis velutinus. Ckll. Det. Ckll. Claremont, Cal., Baker.

Exomalopsis melanurus sp. n. Ckll. Det. Ckll. Claremont, Cal., Baker.

Exomalopsis nitens sp. n. Ckll. Det. Ckll. Laguna, Cal., R. La Follette.

XYLOCOPIDÆ

Xylocopa varipuncta. Patt. Det. Vier. Claremont, Cal., Baker. April, no Fl.

Xylocopa orsifex. Sm. Det. Vier. Mountains near Claremont, Cal., Baker. April, Wood.

Xylocopa californica. Cr. Det. Friese. Claremont, Cal., Baker. April, Nemophila.

MEGACHILIDÆ

Megachile pruina. Sm. Det. Friese. Claremont, Cal., Bray. May, Fl., Cactus.

Megachile grindeliarum. Ckll. Det. Ckll. Claremont, Cal., Bray. May, Fl., Poppy.

Megachile occidentalis. Fox. Det. Ckll. Claremont, Cal., Bray.

Megachile frugalis. Cr. Det. Ckll. Claremont, Cal., Baker.

Osmia erythrosmia remotula. Des. Ckll. Claremont, Cal., Baker.

Osmia quadriceps. Ckll. Det. Cr. Mountains near Claremont, Cal., Baker.

Osmia atrocyanea. Ckll. Det. Ckll. Claremont, Cal., Baker. May, Fl., Amsinckia intermedia.

Osmia propinqua. Cr. Claremont, Cal., Baker.

Osmia kincaidii. Ckll. Det. Ckll. Mountains near Claremont, Cal., Baker.

Osmia bennettæ. Ckll. Det. Ckll. Mountains near Claremont, Cal., Baker.

Osmia integra. Ckll. Det. Ckll. Claremont, Cal., Baker.

Osmia cobaltina. Cr. Det. Ckll. Claremont, Cal., Baker. May, Lotus glaber.

Osmia faceta. Cr. Det. Ckll. Claremont, Cal., Baker.

Osmia clarescens. Ckll. Det. Ckll. Claremont, Cal., Baker. April, Fl., Phacelia tanacætifolia.

Osmia granulosa. Ckll. Det. Ckll. Claremont, Cal., Baker.

Osmia regulina. Ckll. Det. Ckll. Mountains near Claremont, Cal., Baker.

Osmia ednæ, female. Ckll. Det. Ckll. Mountains near Claremont, Cal., Baker.

Osmia playtura. Ckll. Det. Ckll. cotype. Claremont, Cal., Baker.

Osmia hypochrysea. Ckll. Det. Ckll. Claremont, Cal., Baker.

Osmia pumila. Frieze Det. Cr. Claremont, Cal., Bray. May, Fl. Mustard.

Osmia cyanopoda sp. n. Ckll. Det. Ckll. Claremont, Cal., Baker.

Osmia cyanosoma. Ckll. Det. Ckll. Claremont, Cal., Baker.

Osmia nigrobarta sp. n. Ckll. Det. Ckll. Claremont, Cal., Baker.

Hoplitis sambuci. Titus Det. Ckll. Claremont, Cal. April, Poppy.

Hoplitina pentamera. Ckll. Det. Ckll. Claremont, Cal., Baker.

Osmia pogonigera. Ckll. Det. Ckll. Claremont, Cal., Baker.

Alcidamea hypocrita. Ckll. Det. Ckll. Claremont, Cal., Baker.

Osmia melanopleura sp. n. Ckll. Det. Ckll. Claremont, Cal., Baker.

Anthidium maculoscum. Cr. Det. Cr. Claremont, Cal., Baker.

Dianthidium illustri. Cr. Det. Ckll. Claremont, Cal., Baker.

Anthidium palliventre. Cr. Det. Br. from Coll. Claremont, Cal., Baker.

Anthidium tricuspidum. Prov. Det. Ckll. Claremont, Cal., Baker.

Dianthidium consimile. Ashmead Det. Ckll. Claremont, Cal., Baker.

Dianthidium robertsoni. Ckll. Det. Ckll. Mountains near Claremont, Cal., Baker.

Anthidium angelarum. Titus Det. Ckll. Claremont, Cal., Baker.

Dianthidium provancheri. Titus Det. Ckll. Claremont, Cal., Baker.

Dioxys producta. Cr. Det. Ducke. Claremont, Cal., Baker.

Dioxys pomonæ. Ckll. Det. Ckll. Claremont, Cal., Baker.

Coelioxys megatricha sp. n. Ckll. Det. Ckll. Claremont, Cal., Baker.

Coelioxys angulifera sp. n. Ckll. Det. Ckll. Claremont, Cal., Baker.

Xenoglossa angelica. Ckll. Det. Ckll. Claremont, Cal., Baker.

ANDRENIDÆ

Andrena porteræ. Vier. Det. Ckll. Claremont, Cal., Baker.

Andrena mustelicolor. Vier. Det. Vier. Claremont, Cal., Baker.

Andrena prunorum. Vier. Det. Ckll. Claremont, Cal., Baker and Bray. May, Phacelia tana. and Poppy.

Andrena mimecta. Ckll. Det. Ckll. Mountains near Claremont, Cal., Baker.

Andrena texana. Cr. Det. Br. from Coll. Claremont, Cal., Bray. May, Fl., Poppy.

Andrena bipuntala. Lovell Det. Br. from Coll. Claremont, Cal., Bray. April, Fl., Phacelia tan.

Andrena cerasifolii. Vier. Det. Ckll. Claremont, Cal., Baker. April, Phacelia tanacætifolia.

Andrena carlina Ckll. Ashmead Det. Br. from Coll. Claremont, Cal., Bray. May, Fl., Mustard.

Andrene osmoides sp. n. Cr. Det. Ckll. Claremont, Cal., Baker.

Andrena peratra sp. n. Prov. Det. Ckll. Claremont, Cal., Baker.

Andrena auricoma. Sm. Det. Ckll. Claremont, Cal., Baker.

Andrena plana. Vier. Det. Ckll. Claremont, Cal., Baker.

Andrena opaciventris sp n. Ckll. Det. Ckll. Claremont, Cal., Baker.

Andrena chlorura sp. n. Ckll. Det. Ckll. Claremont, Cal., Baker.

Agapostemon splendens. Friese Des. Lange. Los Angeles, Cal.

Agapostemon californicus. Crawford. Claremont, Cal., Baker. May, Poppy.

Agapostemon radiatus. Say. Det. Br. from Coll. Claremont, Cal., Bray. April, Fl., Daisy.

Diandrena beatula sp. n. Ckll. Det. Ckll. Claremont, Cal., Baker.

Diandrena chalybæa. Cr. Det. Ckll. Claremont, Cal., Baker.

Diandrena cyanosoma sp. n. Ckll. Det. Ckll. Claremont, Cal., Baker.

Diandrena clarventris sp. n. Ckll. Claremont, Cal., Baker.

Diandrena scintilla sp. n. Ckll. Det. Ckll. Claremont, Cal., Baker.

Conanthalictus bakeri. Crawford Det. Ckll. Claremont, Cal., Baker.

Conanthalictus macrops sp. n. Ckll. Det. Ckll. Claremont, Cal. Baker.

Augochlora pomoniella. Ckll. Det. Ckll. Claremont, Cal., Baker.

Andrena candida. Sm. Det. Ckll. Claremont, Cal., Baker.

Andrena angustitarsata. Vier. Det. Vier. Claremont, Cal., Baker.

Andrena huardi. Vier. Det. Vier. Claremont, Cal., Baker.

Andrena pallidifæva. Vier. Det. Vier. Claremont, Cal., Baker.

Andrena cyanosoma. Ckll. Det. Vier. Claremont, Cal., Baker.

Andrena nigripes. Prov. Det. Vier. Claremont, Cal., Baker.

Andrena scripta. Vier. Det Vier. Claremont, Cal., Baker.

Andrena subtristis. Ckll. Det. Vier. Claremont, Cal., Baker.

CERITINIDÆ

Ceratina neomexicana punctigena sub. sp. n. Ckll. Det. Ckll. Claremont, Cal., Baker.

HALICTIDÆ

Halictus incompletus. Craw. Det. Mountains near Claremont, Cal., Baker.

Halictus punctatoventris. Craw. Claremont, Cal., Baker.

Halictus nigrescens. Craw. Claremont, Cal., Baker.

Halictus catalinensis. Craw. Det. Ckll. Claremont, Cal., Baker.

Halictus ligatus. Say. Det. Craw. Claremont, Cal., Baker.

Halictus robustus. Craw. Det. Claremont, Cal., Baker.

Halictus mellipes. Craw. Det. Claremont, Cal., Baker.

Halictus farinosus. Sm. Det. Craw. Claremont, Cal., Baker.

Halictus rhoptoides. Craw. Det. Br. from Coll. Claremont, Cal., Bray. April, Daisy.

COLLETIDÆ

Colletes californicus. Prov. Claremont, Cal., Baker.

Colletes guadialis. Sm. Det. Ckll. Claremont, Cal., Baker.

PROSOPIDÆ

Prosopis episcopalis, female. Ckll. Det. Metz. Claremont, Cal., Baker (Rhus laurina).

Prosopis coloradensis. Ckll. Det. Metz. Mountains near Claremont, Cal., Baker.

Prosopis polifolii, female. Ckll. Det. Metz. Mountains near Claremont, Cal., Baker.

PANURGIDÆ

Panurginus atriceps. Ckll. Det. Cr. Claremont, Cal., Baker.

(Contribution from the Zoological Laboratory of Pomona College)

The Central Nervous System of the Amphipod Orchestia

William A. Hilton

Numerous specimens of *Orchestia traskiana* Stim. were collected at Laguna Beach. Some were preserved whole, from others the central nervous system was studied in position or removed in one piece and stained and sectioned or mounted whole. For whole mounts some carmine stain or a light hermatoxylin coloration seemed best. For sections a copper hematoxylin was used with good results.

The brain occupies the forward portion of the head with large branches or lobes to the compound eyes which are somewhat dorsal and caudal from the brain as it lies in the head. Large nerves to the antennæ and smaller ones to the antennules cannot be seen from above as they run from near the connectives in a more ventral and caudal region. The brain is held in place by a band of tissue which perforates it near the center. In the figure the brain is not shown in the normal position. It is pulled out so as to show its parts better. The connectives join the rather small first ganglion, running almost ventrally when not displaced. Including this ganglion there are eight large thoracic ganglia and four small abdominal centers, the last of which is a little larger than the other three.

In whole mounts the brain does not show well. The ventral ganglia from surface views are found to contain a coating of large and small cells, especially on the ventral sides. Some of these are shown in the figures, which give views of a large and a smaller ganglion at one optical section. There are several layers of cells and both large and small are numerous, the latter of several sizes very numerous. The general position of some of the larger cells is shown in the figures.

In section the brain is found to be chiefly composed of fibers and fibrils. Large strands of fibers run long distances and connect widely separated regions. No very large cells were found in the brain, such as found in the ventral ganglia. and no very marked central region of the brain was clearly seen. The cells as compared with the fibers were rather few. Fibrils also were evident, but could not be traced far. Cell groups were most marked in the posterior and lateral regions and fibers from these and to these could be followed as individuals for long distances. Posterior cells were especially numerous connected with the eyes and other parts. The ventral ganglia present no unusual structures in section. In two of the upper ganglia studied there seem to be in each at least two masses of cross fibers or communications.

IMPORTANT PAPERS

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Koehler, R. 1887

Recherches sur la structure du cerveux du Gammarus pulex. Im. M. Anat. Phys., T. IV.

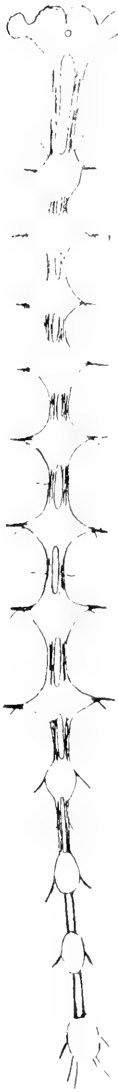
Packard, A. S. 1884

On the structure of the brain of the sessile-eyed Crustacea. Nat. Ac. Sc., vol. III.

(Contribution from the Zoological Laboratory of Pomona College)

EXPLANATION OF PLATE

Figure 1. Central nervous system of *Orchestia*. ×10.
Figure 2. Surface view of one of the thoracic ganglia. ×75.
Figure 3. Surface view of one of the abdominal ganglia. ×75.
Figure 4. Longitudinal section through the brain. Caudal end to the top. ×75.
Figure 5. Longitudinal section of the brain; same as Fig. 4 but deeper. ×75.
Figures 6 and 7. Longitudinal sections of the second ventral ganglion. Caudal end at the top. ×75.
Figure 8. Longitudinal section through the first ventral ganglion. Caudal end at top. ×75.



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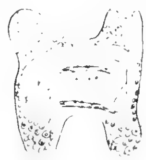

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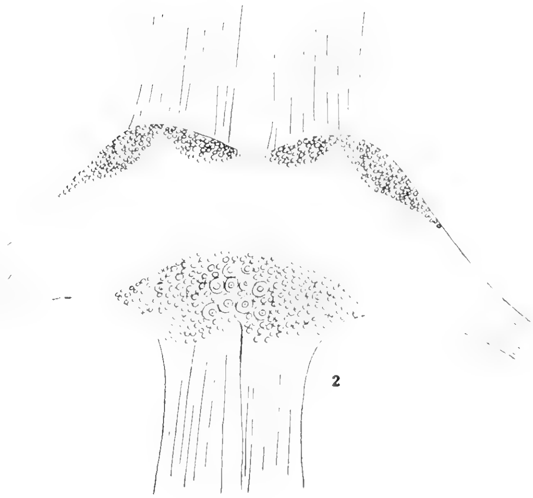

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AUTHOR'S ABSTRACT OF THIS PAPER ISSUED BY THE BIBLIOGRAPHIC SERVICE, OCTOBER 13.

Reprinted from THE JOURNAL OF COMPARATIVE NEUROLOGY, Vol. 28, No. 2, October, 1917

THE CENTRAL NERVOUS SYSTEM OF SIMPLE CRUSTACEA

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THIRTEEN FIGURES

Although the general form of the nervous system of branchiopod Crustacea is well known, there has been very little recent work. Most papers deal with the general form and arrangement of the ganglia and not at all with the structure and arrangement of cells. Zaddach, '41, wrote on Apus. Leydig, '51 and '60, considered Artemia. In 1853 there is the paper of Grube on Limnetis. The work of Claus on Branchipus, Daphnea, Estheria and Apus appeared in 1873, 1876, and 1876, and that of Weismann on Leptodora in 1874. Spangenberg's publication on Limnadia was in 1878. Packard has something of the general anatomy of Estheria and Branchipus in 1883. The well known and often copied work of Lancaster on Apus, '81, was followed by that of Pelseneer on the nervous system of the same genus in 1884. Spencer in 1902 discusses and figures the anterior nerves of the brains of Artemia and Branchipus.

From the various observations the general ladder-like type of nervous system has been described and figured in this group of Crustacea. There is the supraesophageal ganglion with its marked region of optic nerves, while the two other pairs of nerves to the antennae and antennules are less marked and come from more caudal portions of the brain or on or near the esophageal connectives. From the cephalic margin of the brain are the median eye branch and the two small pairs of nerves lateral to it, at least in Branchipus and Artemia, as described by Spencer, '02. Each segment of the body below the brain is ordinarily represented by a pair of ganglia connected across the middle line by two commissures. The number of pairs of ganglia depends largely upon the degree of segmentation of the body of the crustacean.

The fortunate opportunity to obtain a large number of living Crustacea gave much of the material for this study. Methylen blue was tried without success as long as the animals could be obtained alive, afterwards dissections and sections were made from preserved material. Mercuric chloride fixation seemed most advantageous. The whole nervous system was dissected out and lightly stained with a carmine solution or a clear alcoholic hematoxylin. Later the specimens were mounted in balsam. This method had many advantages because all parts of the simple nervous system could be seen at once. The cells and fibers were not numerous enough to greatly interfere with the clearness of the preparations. Especially was it noted that the cells were not distorted as is usually the result after sectioning methods. Some serial sections of whole animals or parts were prepared for comparison.

GENERAL FORM OF THE GANGLIA

In the forms studied, in general no new features of external morphology were noted. Artemia and Branchipus were practically the same except for the larger size of the nervous system in Branchipus. In these the brain has connected with it laterally the two large optic nerves which expand into the optic ganglia (not shown in figures). The antennulary nerves come off from the brain where it joins the esophageal connectives and the larger antennal nerves come off a little farther down. From the cephalic side of the brain a median nerve is connected to the median eye and two pairs of nerves lateral to this supply upper parts of the head.

The first three pairs of ventral ganglia supplying the head, mouth parts and upper portions of the body are much smaller than the more caudal ganglia. The last ganglion or pair of nearly fused ganglia change somewhat as they terminate in abdominal branches (figs. 1 and 2).

Fig. 1. The central nervous system of Branchipus venalis. × 10.
Fig. 2. The central nervous system of Artemia sp. × 10.
Fig. 3. The central nervous system of Estheria californica. × 10.

In Estheria it was very difficult to remove the ganglia intact, so the sketch given is from the nervous system *in situ* for the most part. The brain is of quite a different shape, the optic ganglia are shown in the drawing connected with the compound eyes, which nearly touch each other. Only one pair of antennal nerves is shown in the drawing. The brain is more decidedly

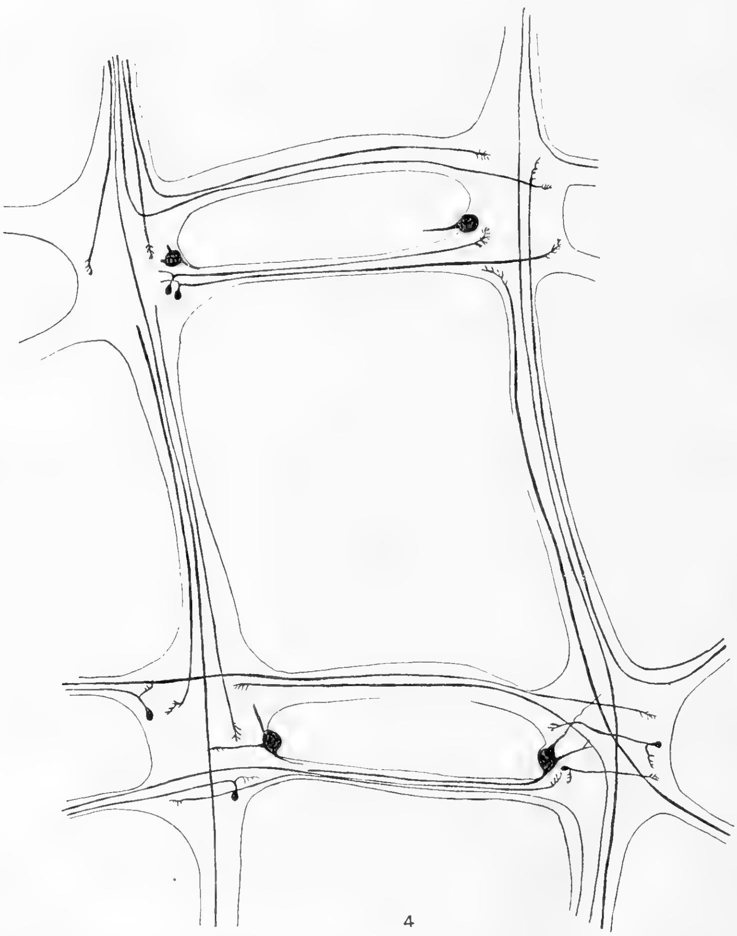

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Fig. 4 Diagrammatic plan of cell arrangement in the ventral ganglia of Branchipus. × 75.

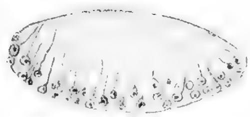
made up of two lateral masses than in the other genera studied. Four commissures may be clearly seen connecting the two lateral parts. Four were also seen in Artemia and Branchipus but not so clearly. The ventral ganglia of Estheria begin with the mandibular and extend to the end of the body with a pair of ganglia to each segment and with two commissures connecting each pair (fig. 3).

Cells of a number of types were found. In Branchipus they are from 0.01 mm. to 0.05 mm. in diameter. The much smaller but similar Artemia has smaller cells, the largest being about 0.02 mm. and the smallest about 0.005 mm. Two divisions of cells may be made, the neuroglia cells and the nerve cells. The neuroglia cells, small or large, were not so deeply stained in the fibrillar area; they usually have granular nuclei. From whole mounts and sections it was evident that the neuroglia nets are much as described in other invertebrates. It is possible that some of the small cells which seem to be nerve cells are neuroglia cells.

CELLS

Practically all the nerve cells, especially of Branchipus, have well-marked cell bodies filled with dark staining material and clear nuclei containing nucleoli. A few nerve cells have much clearer cytoplasm than the others. In the large cells especially, tigroid substance may be seen even in surface views. In the larger cells also the fibrillae are quite evident. The general shape of the cells is spherical, but some are elongate. Most cells are unipolar or bipolar, but a few are multipolar (figs. 5 to 13).

Large, medium sized and small cells are found in the cellular areas with no apparent special order, but the largest cells are found at certain places at the margins of the ganglia. At least one, sometimes two or three of the largest cells are located on each side near the more caudal commissures of each ventral ganglion. These in many cases send or receive processes to or from the connectives. Perhaps they are cells in most cases with long commissural fibers.



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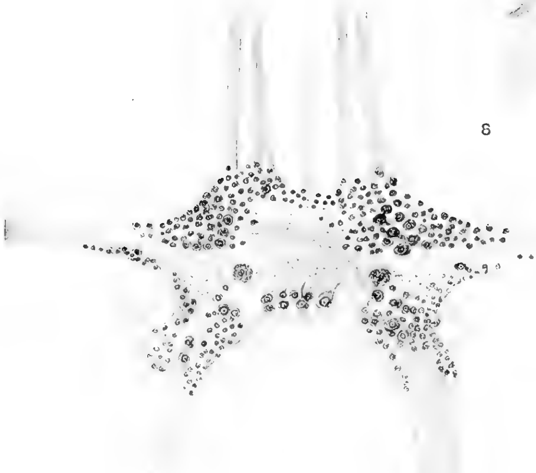

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In each ganglion of each side the cells are arranged in a characteristic manner. In all the middle body ganglia the ventro-mesal cell group is less marked than the ventro-lateral. The outer portion of the ventral-lateral group often has a number of large cells similar to those in the other group. The larger cells in most cases represent those that send their fibers longer distances, but they often have more than one branch and the external and internal mass of fibrillae connected to them seems more complex than on smaller cells. In some cases the larger cells seemed to have their cytoplasm fused, but most of the cells, although near each other, had their cell bodies distinct. Nerve fibrillae are evident between and in cells, although some of the largest cells have one or two large fibers which leave or enter the cells. Some cells of apparently the same type seem to have no very large branch, but fibrillae enter and leave the cell. Many large cells seem to be penetrated on all sides by numerous fibrillae, or if fibrillae do not all penetrate they are closely related to all the peripheral parts of the cell body.

Cells of varying numbers are found in the commissures, these are chiefly medium or small cells and some at least are nerve cells. The number of cells in the ganglia was possible to determine quite well from surface preparations and some comparisons were made between Artemia and Branchipus. The larger species has not only the larger nerve cells, but the larger number of nerve cells. The number of cells in corresponding ganglia was found to be less in the smaller animals. The average number of cells in the middle ventral ganglia on each side ran from 130 to 204 in Branchipus, while Artemia had from 120 to 160 cells in each lateral ganglion. The number of cells in the intermediate ganglia of a number of specimens was counted and, although the count cannot be considered absolute because of

Figs. 5 and 6 Sections through the abdominal ganglia of Branchipus. The dorsal side is to the top of the page. × 75.

Fig. 7 Brain of Branchipus from a surface preparation. The cephalic side is to the top. ×75.

Fig. 8 Upper ventral ganglia of Branchipus, surface view. The cephalic end is at the top. × 75.

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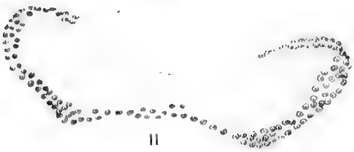

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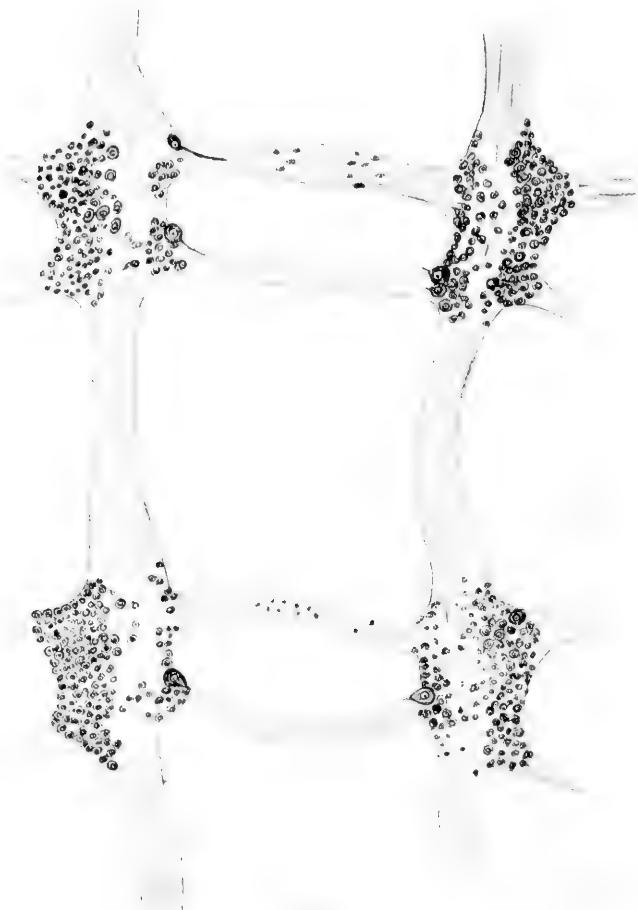

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difficulty in seeing all at one focus, difference in mounting and difference in staining, yet the following seems clear:

1. The cells often differ slightly in number in different similar ganglia of the same animal, both in the same segment on each side and in different segments at various levels.

2. The number of cells is also variable in the same parts of the same ganglia in different animals.

3. The peripheral parts supplied by each of these ganglia do not differ in any way that could be determined.

4. It was even more clear that the cells in the commissures differed widely. The next to the last cephalic commissure in one specimen had 38 cells, the next 20, then, 19, 7, 10, 12, 16, 10, etc. Similar variations were found in other specimens. The lower cephalic commissures as a rule had more cells, while the upper had less.

It was also noted that some of the large cells which have quite a characteristic position are in some places represented by one cell, in others by two. In a few cases noted the large cells have an independent peripheral distribution as compared with the usual indirect distribution through a commissure. It is as though a cell which ordinarily grew out to the periphery by way of a commissure missed it in some way and left the ganglion by a single fiber.

FIBER TRACTS

Branchipus was especially studied because the material was more favorable.

The brain so far as could be determined is united from side to side by four commissures, a dorsal, two medial and a ventral. The last is below a small group of medial cells. The commissure just above this group seems the largest. The ventral commissure is partly from near-by cells and from basal parts of the con-

Fig. 9 Sixth and fifth ventral ganglia of Branchipus. Surface view. Cephalic side at the top. × 75.

Fig. 10 Section through one abdominal ganglion of Artemia. The dorsal side is above. × 75.

Figs. 11, 12 and 13 Sections through various levels of the brain of Artemia, from the base to the region of the optic nerve. The dorsal side is up. × 75.

nectives. Many of the medial fibers may be traced out to the optic lobes. Fibers from the largest median cephalic cells descend the connectives. Fibers from cephalic and lateral cell groups cross in the center of the brain and either run straight into commissures or cross somewhat diagonally. Fibers from the smaller cell groups on the connectives near antennal nerves descend the connectives and ascend into the central parts of the brain to the same side or the opposite side. The small cephalic branches of the brain send fibers for a short distance into the brain and cells near here supply them. The mass of the connective fibers runs straight in to the central parts of the brain. Fibers from cephalic lateral cells cross at angles to relate themselves to various cell groups, to run in the optic nerves and to run into the central part of the brain.

The connections of the optic ganglia were not studied. So far as there is a special center in the brain to which all fibers converge it would be the general region of median cephalic cells. It is from this region that the larger cells probably send their fibers long distances down the connectives to ventral ganglia.

In general the distribution of tracts in the ventral ganglia is as follows:

1. Fibers in the connectives ascending or descending.

2. Fibers from the branches or nerve trunks end, cross in commissures and ascend or descend in the connectives. Many end where they enter the ganglia or on the opposite side in the same ganglion or in the opposite ganglion.

3. Fibers in the commissures cross from cells of either group and end in relation to cells of either group of the opposite ganglion. Fibers in the commissures may also be seen to ascend or descend in the direction of the connectives.

4. Each cell area of each ganglion is probably connected as follows: a) Fibers to other cell areas of each side through the commissures. b) Fibers to cell areas of each side not from the other side through the commissures. c) Ascending fibers. d) Descending fibers.

The commissures are probably made up as follows: a) Fibers from cells in upper levels. b) Fibers from lower levels. c)

From the same level from both sides, especially from median cells. d) Probably fibers to and from lateral branches of ganglia, although this was not clearly demonstrated (fig. 4).

SOME GENERAL CONCLUSIONS

The study of these nervous systems shows certain advantages due to the nature of the material and the method. There is less distortion because with whole mounts no heat was used. There is also a more perfect picture presented than in most methylen blue preparations because all the cells show. When large ganglion cells were at the edge of the preparation quite a little could be seen of their finer structure and the fibers and fibrils were often presented with great clearness. I believe that, although the grosser processes are important, that the fibrillar connections are more important in determining the intimate relationships of cells to each other. It seems probable from these observations that any cell may have its cytoplasm penetrated by fibrils which are directly connected with other cells, while its one or two main branches carry out fibrils in larger masses, break up into fibrils and by usual methods are not followed farther.

The variation in the number of cells in similar segments suggests the probability that the nervous system acts not so much through individual innervation of special areas by special cells, as by a more general innervation by groups of cells. In the course of evolution in more specialized forms it may be that individual functions may more nearly be connected with individual cells or small groups.

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The Central Nervous System of the Parasitic Isopod, Grapsicephon

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Reprinted from the Journal of Parasitology, September, 1917
Vol. IV, pp. 25 and 26

THE CENTRAL NERVOUS SYSTEM OF THE PARASITIC ISOPOD, GRAPSICEPHON

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Some specimens of the genus Grapsicephon of the Bopyridae were obtained from the gill chambers of the common shore crab of Laguna Beach, *Pachygrapsus crassipes* Rand. One of these was sent to the United States National Museum and there determined to be of the genus here given.

Two specimens were sectioned and mounted in series; one was stained in carmine and one in hematoxylin. Only in the latter specimen was the poorly developed nervous system distinguished easily from the surrounding tissues. No supraesophageal ganglion was found and the ventral chain of ganglia was imperfectly developed. The whole central nervous system does not exceed one millimeter in length, or a little less than one twelfth the length of the animal. A wax reconstruction was made of the central nervous system showing the locations of the cellular areas.

There are at least four ganglia represented in the nervous system, but these are very imperfect and irregular ganglia. Beginning at the cephalic end the ganglion is quite well fused and occupies one third the whole length with no branches for some distance; then there are large irregular branches extending laterad. Next there is a division into something like connectives and other branches extending laterad, although these do not show well in the model, because they seem fused with the other parts. Near the caudal end of the ganglionic mass there are other divisions into connectives and near these, short branches. Altogether, there are six very irregular pairs of lateral branches which could be followed only for a short distance from the central nervous system, and four branches which arise from the caudal end.

The distribution of cells is on the whole much like that of other arthropods. Most of the cells are ventral in position, but irregular masses are seen at places on the dorsal side. The cells in many cases seem but poorly developed; the nuclei in some cases are like those of nerve cells, but most of them appear like poorly preserved material, although the general preservation of all parts of the specimen except this was very good.

In conclusion, it might be said that the animal has a degenerated central nervous system with indications of at least four ventral fused ganglia. Branches are not perfectly formed and cannot be traced very far. Although there were a few striated muscle fibers in the animals, the movements of the living forms were very slight. If there is a dorsal ganglion it is so poorly differentiated as to be indistinguishable from the other tissues of the animal.

Explanation of Plate

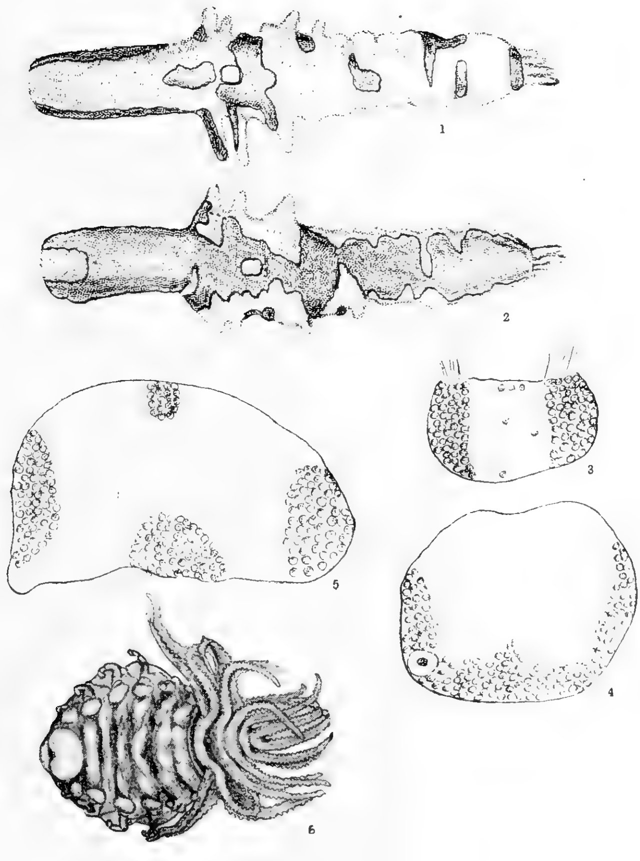
Fig. 1.—Drawing of a model of the nervous system of Grapsicephon, from the dorsal side, showing the cell areas in the more deeply shaded portions. The cephalic end is at the left. × 80.

Fig. 2.—Drawing of a model of the nervous system of Grapsicephon, from the ventral side, showing cell areas by more deeply shaded regions. The cephalic end is at the left.

Figs. 3, 4, and 5.—Sections through various levels of Grapsicephon, central nervous system. The dorsal side is uppermost. × 300.

Fig. 6.—Surface view of the whole body of Grapsicephon. Drawing by Harry Staples. × 3.

HILTON—CENTRAL NERVOUS SYSTEM OF GRAPSICEPHON



A Preliminary List of Shells from Laguna Beach and Nearby

For a number of years past students have collected shells from Laguna Beach, these and the Bradshaw collection form the basis for this list, which includes shells not farther than ten or twelve miles up and down the coast. The earlier collections were by Mabel Guernsey and P. R. Daggs. Practically all the shells drawn and photographed are from the Bradshaw collection because the shells were in better condition. Some of the earlier specimens were determined by the United States National Museum. Suggestions and corrections were kindly made by Mrs. T. S. Oldroyd. The photographs are by Robins and Cooper. Many of the drawings are by Miss Margaret Cate. Doubtful specimens are large omitted in this list, but a few are included and marked by a question.

Plate I, reduced one-half; Plates II and III, natural size; Plate IV, ×10; Plate V, ×6.

BIVALVES

Yoldia cooperi Sabb. Fig. 1.
Mytilus californicus Conr. Fig. 2.
M. stearnsii Pils and Raym. Fig. 3.
Septifer bifurcatus Rve. Fig. 4.
Modiolus modiolus Linn. Fig. 5.
M. rectus Conr. Fig. 6.
Lithophaga plumula Hanl. Rock borer. Fig. 7.
Pectin (Chlamys) monotimeris Conr. Fig. 8.
Pectin (Chlamys) æquisulcatus Cpr. Fig. 9.
Pectin (Chlamys) pastatus Sby. Fig. 10.
Pecten (Hinnites) giganteus Gray. Fig. 11.
Lima dehiscens Conr. Fig. 12.
Ostrea lurida Cpr. California oyster. Fig. 13.
Chama Pellucida Sby. Fig. 14.
Phacoides californicus Conr. Fig. 15.
Phacoides (Lucina california) californicus Conr. Fig. 15.
Phacoides nuttallii Conr. Fig. 16.
Cardium quadrigenarium Conr. Fig. 17.

Cardium (Livocardium) substriatum Conr. Fig. 18.

Tivela (Pachydesma) crassatelloides Conrad. Fig. 19. small specimen.

Chione fluctifrage Sby. Fig. 20.

Chione succincta Val. Fig. 21.

Chione undatella Sby. Fig. 22.

Donax lævigata Desh. Fig. 23.

Tagelus californicus Conr. Fig. 24.

Macoma nasuata Conr. Bent-nosed Macoma. Fig. 25.

Macoma indentata Cpr. Indented Macoma. Fig. 26.

Macoma inflatula Dall. Inflated Macoma. Fig. 27.

Samele rupium Sby. Semele -of-the-Rocks. Fig. 28.

Cumingia californica Conr. California Cuming-shell. Fig. 29.

Mya (Cryptomya) californica Conr. False Mya. Fig. 30.

Spisula planulata Conr. Fig. 31.

Spisula falcata Sld. (?). Falcate Mactra. Fig. 32.

Paphia staminea Conrad. Ribbed Carpet-shell. Fig. 33.

Paphia tenessima Cpr. Finest Carpet-shell. Fig. 34.

Parapholas californica Conr. California Piddock. Fig. 35.

Pholadidea penita Conr. Common Piddock. Fig. 36.

Pholadidea subrostrata Sby. Little Borer. Fig. 37.

Milneria minima Dall. Last Milner-shell. Fig. 38.

Aula (Nucula)casternsis Hinds. Camp Nut-shell. Fig. 39.

FRESH-WATER AND LAND SHELLS UNIVALVES

Physa heterostropha Say. Laguna stream. Fig. 40.

Physa occidentalis Tryon. Aliso Lake. Fig. 41.

Limnophysa palustris Mull. Fig. 42.

Planorbis (Helisoma) trivolvis Say. Fig. 43.

Helix aspera Mull. Fig. 44.

Epiphragmophora Sp. Fig. 45.

MARINE UNIVALVES

Acmea persona Esch. Mask Limpet. Fig. 46.

Acmea spectrum Nutt. Ribbed Limpet. Fig. 47.

Acmea patina Esch. Pale Limpet. Fig. 48.

Acmea scabra Roe. Tile Limpet. Fig. 49.

Acmea incessa Hds. Seaweed Limpet. Fig. 50.

Acmea asmi Midd. Black Limpet. Fig. 51.

Acmaea (Lottia) gigantea. Owl Limpet. Fig. 52.

Acmaea paleacea Gld. Chalf Limpet. Fig. 53.

Tylodina fungina Gab. Fig. 54.

Gadinia reticulata Sby. Netted Button-shell. Fig. 55.

Crucibulum spinosum Sby. Cup and Saucer Limpet. Fig. 56.

Crepidula dorsata Brod. Wrinkled Slipper-shell. Fig. 57.

Crepidula aculeata Gmel. Prickly Slipper-shell. Fig. 58.

Crepidula adunca Sby. Hooked Slipper-shell. Fig. 59.

Crepidula nivea Gould. White Slipper-shell. Fig. 60.

Crepidula onyx Sby. Onyx Slipper-shell. Pl. II. Fig. 19.

Fissurella volcano Rve. Volcano Shell. Fig. 62.

Fissuridea aspera Esch. Rough Key-hole Limpet. Fig. 63.

Fissuraidea murina Dall. White Key-hole Limpet. Fig. 64.

Lucapina crenulata Sby. Great Key-hole Limpet. Fig. 65.

Clypidella (Lucapinella) calliomarginata Cpr. Southern Key-hole Limpet. Fig. 66.

Megatebennus bimaculatus Dall. Spotted Key-hole Limpet. Fig. 67.

Turris (Bathytoma) carpenteriana Gab. Carpenter Turret Shell. Fig. 68. (Laguna Beach, Jahraus.)

Trophon belcheri Hds. Belcher Trophon. Fig. 69. (Jahraus.)

Trophon triangulatus Cpr. Three-cornered Trophon. Dredged off Laguna Beach. Bean. Fig. 70.

Australium undosus Wood. Wavy Topshell. Fig. 71.

Bullaria gouldiana Pisb. Gold's Bubble-shell. Many collected at Balboa much larger than the specimens shown. Fig. 72.

Haminea vesicula Gld. White Bubble-shell. Fig. 73.

Haminea virescens Sby. Green Bubble-shell. Fig. 74.

Cypraea spadicea Gray. Nut-brown Cowry. Fig. 75.

Trivia californica Gray. Little Coffee-bean. Fig. 76.

Trivia solandri Gray. Solander Trivia. Fig. 77.

Erato vitellina Hds. Veally Erato. Fig. 78. (Slightly enlarged.)

Erato collumbella Mke. Dove Shell. Fig. 79.

Marginella varia Sby. Colored Marginella. Fig. 80.

Marginella jewetti. California Rice shell. Much like the last but white.

Olivella biplicata Sby. Purple Olive Shell. Fig. 81.

Olivella pedroana Conr. Pedro Olive Shell. Fig. 82.

Conus californicus Hds. California Cone. Fig. 83.

Macron lividus A. Ad. Livid Macron. Fig. 84.

Littorina scutulata Gld. Checkered Littorine. Fig. 85.

Littorina planoxis Nutt. Gray Littorine. Fig. 86. Turned.

Purpura (Cerostoma) nuttallii Conr. Nuttall's Hornmouth. Fig. 87.

Tegula (Chlorostoma) gallina Fbs. Speckled Turban Shell. Fig. 88.

Tegula (Chlorostoma) aureotincta Fbs. Gilded Turban Shell. Large umbilicus with yellow. Fig. 89.

Omphalus fuscecens Phil. Banded Turban Shell. Fig. 90.

Tegula veridula ligulata Wke. Fig. 91.

Norrisia norrisii Sby. Smooth Turban Shell. Fig. 92.

Thais emarginata Desh. Rock Purple. Fig. 93.

Acanthia lapilloides Conr. Pebbly Unicorn. Fig. 94.

Acanthia elongata Conr. Angled Unicorn. Fig. 95.

Acanthia spirata Blain. Fig. 96.

Murex gemma Sby. Fig. 97.

Murex (Tritonalia) lurida Cpr. Lurid. Fig. 98.

Murex (Tritonalia) gracillima R. E. C. S. Fig. 99.

Murex (Tritonalia) circumtexta R. E. C. S. Fig. 100.

Murex (Tritonalia) poulsoni Nutt. Fig. 101.

Epitonium hindsii Cpr. White Wentletrap. Fig. 102.

Epitonium crenatoides Cpr. Fig. 103.

Actæon puncticælatus Cpr. Barrel Shell. Fig. 104.

Mitra idæ Melv. Ida's Miter Shell. Fig. 105.

Mitra lowei Dall (?). Fig. 106.

Alectrion (Nassa) perpinguis Gld. Fig. 107.

Arcularia (Nassa) tegula Reeve. Cover-lip. Fig. 108.

Turris ophioderma Dall. Pencilled Drill Shell. Fig. 109.

Potomides (Certhidæ) californica Hold. California Horn Shell. Fig. 110.

Myurella simplex Cpr. Simple Auger Shell. Fig. 111.

Amphissa versicolor Dall. Joseph Coat. Fig. 112. Slightly enlarged.

Calliostoma canliculatum Mart. Channeled Top Shell. Fig. 113.

Polynices recluziana Desh (?). Southern Moon Shell. Fig. 114. under side.

Amalthea antiquata Linn. Ancient Hoof Shell. Fig. 115.

Amalthea tumens Cpr. Sculptured Hoof Shell. Fig. 116.

Fossarus fenestratus Cpr. Windowed Isapis. Fig. 117.

Lacuna unifasciata Cpr. One-banded Chink Shell. Fig. 118.

Melampus olivaceus Cpr. Olive Ear Shell. Fig. 119.

Janthina trifida Nutt. Violet Snail. Shell violet. Jahraus collection. Fig. 120.

Leptothyra carpenteri Pilsb. Red Turban Shell. Fig. 121.

Leptothyra baccula Cpr. Berry Turban. Fig. 122.

Calliostoma tricolor Gabb. Three-colored top shell. Fig. 123.

Haliotis rufescens Swains. Red Abalone. Quite common near Laguna.

Haliotis cracherodii Leach. Black Abalone. More common than the red.

TOOTH SHELLS

Dentalium neohexagnum S. and P. Hexagional Tusk Shell. Dredged off Laguna.

CHITONS

Mophia hindsii Sby. Hind's Chinton. Fig. 124.

Mophia mucosa Gld. Mossy Chiton. Fig. 125.

Ischnochiton clathratus Rve. Fig. 126.

Ischnochiton magdalensis Hinds. Gray Chiton. Fig. 127.

Nuttallina scabra Rve. Scaly Chiton. Fig. 128.

Nuttallina californica Nutt. California Chitton. Fig. 129.

Trachydermon dentiens Gld. (Pseudodenturus). Fig. 130.

Lepidopleurus rugatus Cpr. Fig. 131.

Callistochiton crassicostatus Pilsb. Thick-ribbed Chiton. Fig. 132.

Tonicella hartwegii Cpr. Hartweg's Chiton. Fig. 133.

SMALL SHELLS

Wash Drawings by Miss M. Cate

Caecum californicum Dall. Common at Laguna Beach. Pl. IV. Fig. 1 ×10.

Vitrinella williamsoni Dall (?). Pl. IV. Fig. 2 ×10. (This specimen in the Bradshaw collection was so determined, probably at Washington.) Arch Beach, Cal., near Laguna.

Columbella chrysalloidea Cpr. Shell white. Pl. IV. Fig. 3 ×10.

Columbella pencillata Cpr. White shell, cross lines brown. Pl. V. Fig. 1 ×6.

Columbella gausapata Gould. Common Dove-shell. Brown mottled. Pl. V. Fig. 2 ×6.

Liotia acuticostata Cpr. Sharp-ribbed Liotia. Pure white. Pl. V. Fig. 3 ×6.

Seila assimilata Cpr. Dark brown. Pl. V. Fig. 4 ×6.

Turbonilla lammata Cpr. Pl. IV. Fig. 4 ×10. Light brown. (Dunkeria).

Tinostoma supravalata Cpr. (?). Pl. V. Fig. 5 ×6. Clear white. (Ethalia).

Callistoma tricolor Gabb. Pl. V. Fig. 5 ×10.

Phasianella pulloides Gld. Pl. V. Fig. 6 ×6. Mottled red and white.

Tritonalia barberensis Gabb. Pl. V. Fig. 7.

Leptothyra baccula Cpr. Pink to gray. Pl. V. Fig. 8 ×6.

Leptothyra carpenteriana Pilsb. Red Turban-shell. Pl. V. Fig. 9 ×6.

Leptothyra paucicosta Dall. White. Pl. V. Fig. 10 ×6.

Jeffreysia translucens Cpr. (?). Pl. V. Fig. 11 ×6.

Pedipes unisulcata J. G. Cooper. Light brown. Pl. V. Fig. 12 ×6.

Mitromorpha aspera Cpr. Brown. Pl. V. Fig. 13 ×6.

Vermetus anellum Morch. White. Pl. IV. Fig. 6 ×10. This specimen is more coiled than some others.

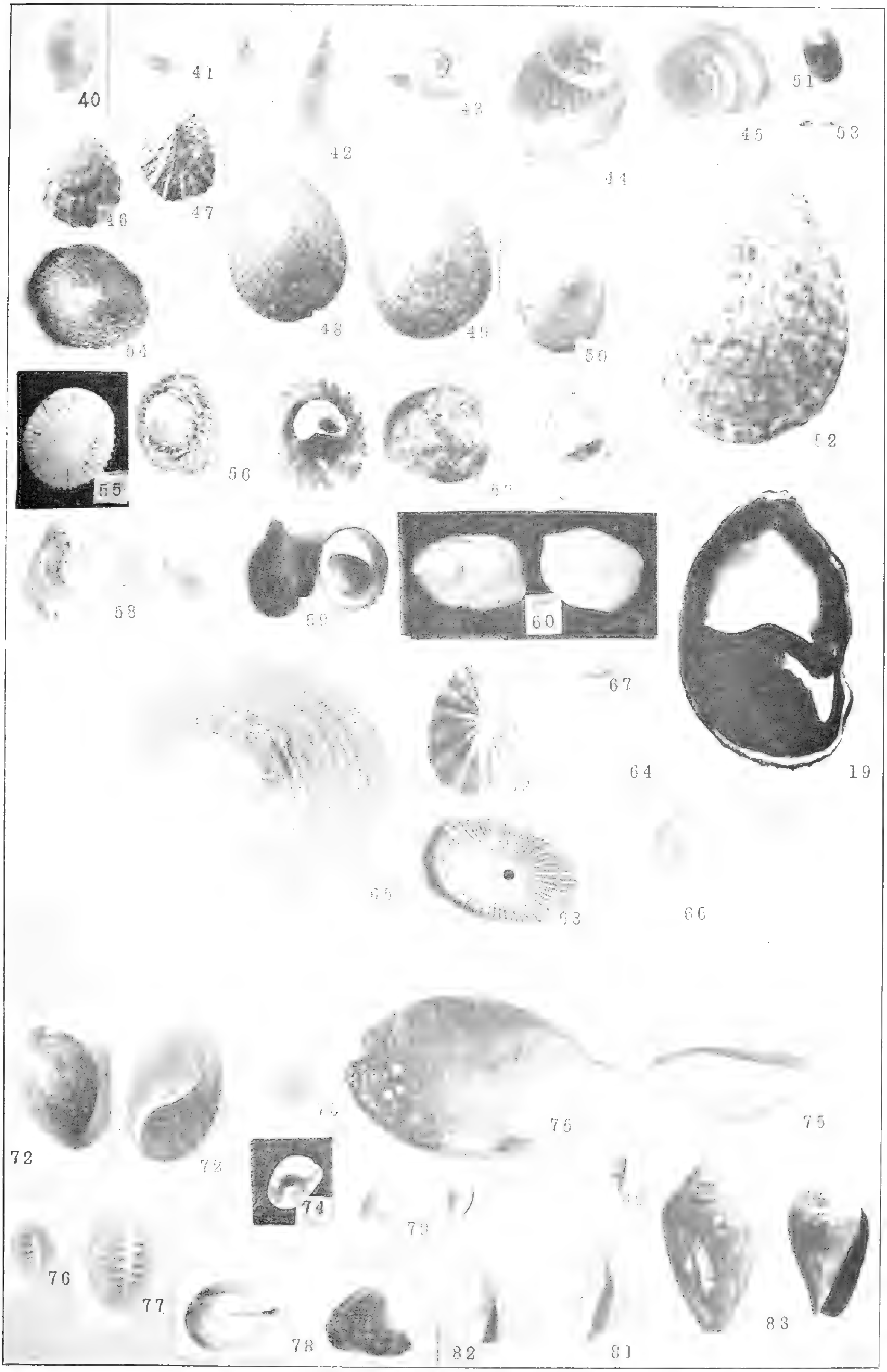
Cerithiopus convexa Cpr. Dark brown. Pl. V. Fig. 14.

Cerithiopus columna Cpr. Light brown. Pl. V. Fig. 15.

Turritella mesalia lacteola Cpr. Pure white. (No figure.)
Bithium aspera Gabb. Brown. Pl. IV. Fig. 7 ×10.
Turbonilla stylina Cpr. (?). Pl. IV. Fig. 8 ×10.
Turbonilla costanea Cpr. (?). Pl. IV. Fig. 9 ×10.
Anachis subturiata Cpr. (?). Pl. IV. Fig. 10 ×10.
Amphissa versicolor Dall. Pink, white, brown. Pl. V. Fig. 16 ×6.
Corbila luteola Cpr. Small bivalve.
Philobrya setosa Cpr. Small bivalve. Pl. V. Fig. 17 ×6.
Acila castrensis Hds. Brownish. Pl. V. Fig. 18 ×6.
Carditanera minima Dall. Brownish-yellow. Pl. IV. Fig. 11 ×10.
Crassatella marginata Cpr. Pl. IV. Fig. 12 ×10.
Lasea rubra Mort. Tinged with red. Pl. V. Fig. 19 ×10.
Arca solida Br. & Sby. (?). Pl. V. Fig. 20 ×10.

(Contribution from the Zoological Laboratory of Pomona College)

Plate I



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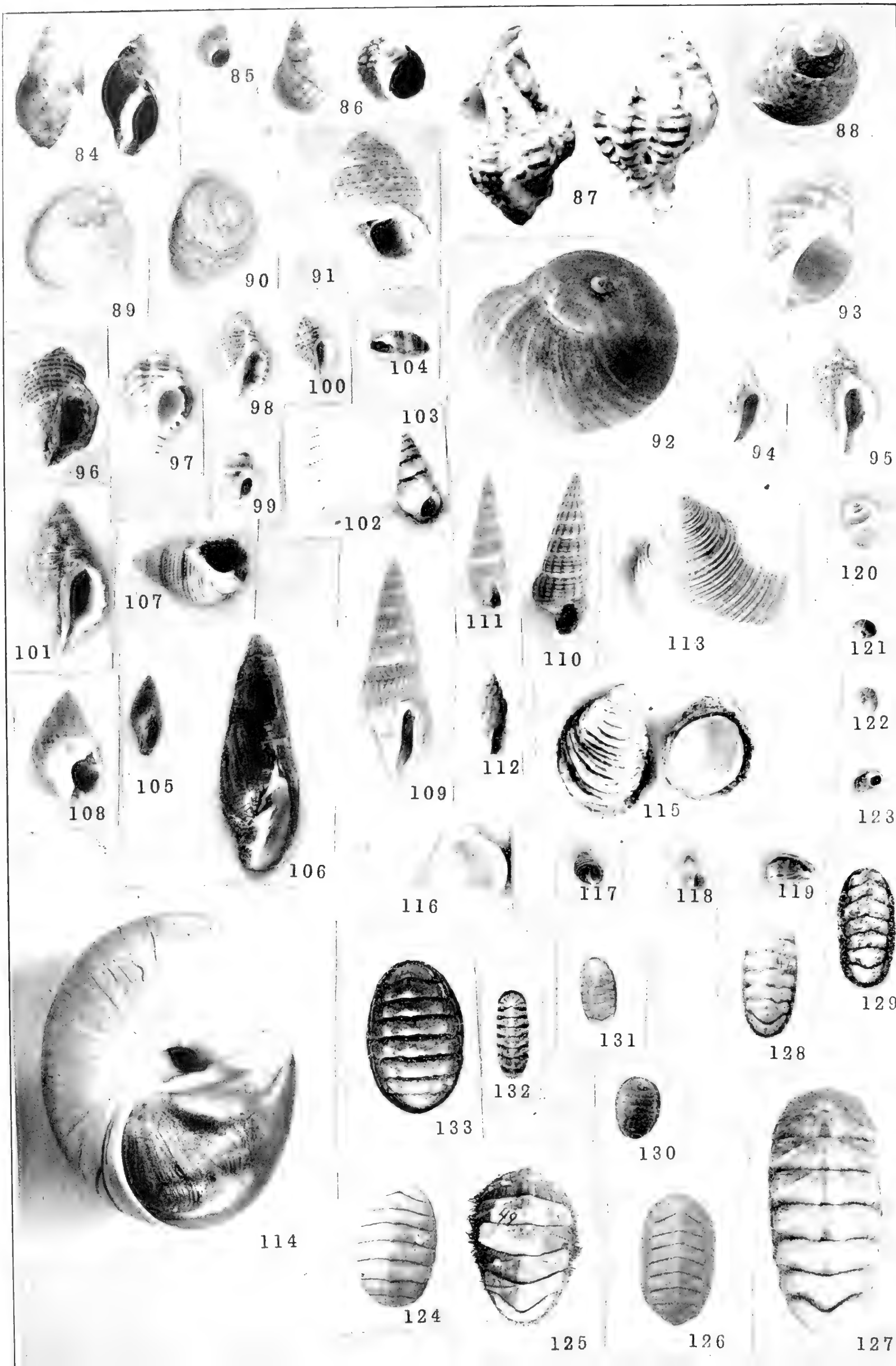
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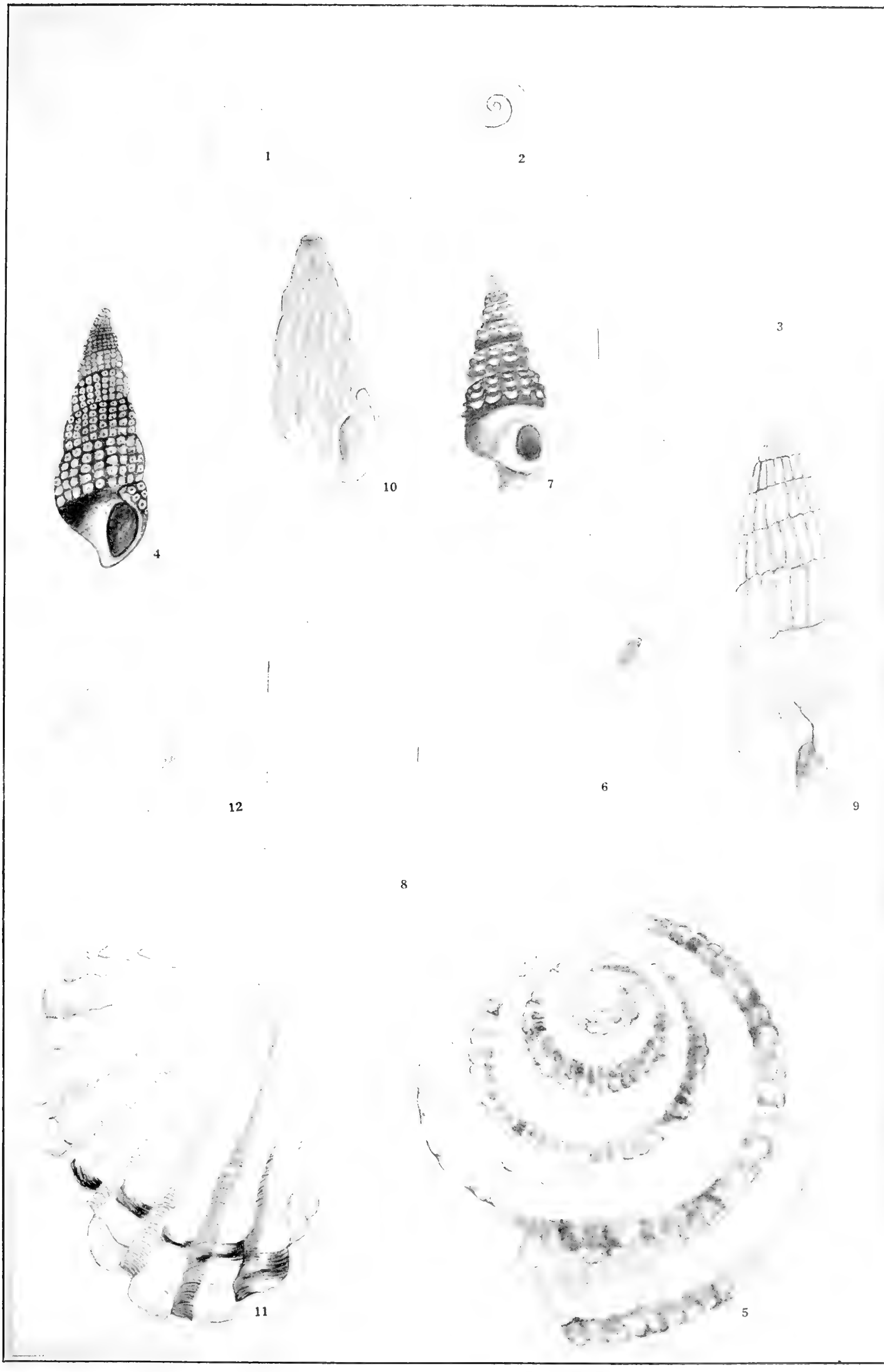


Plate IV

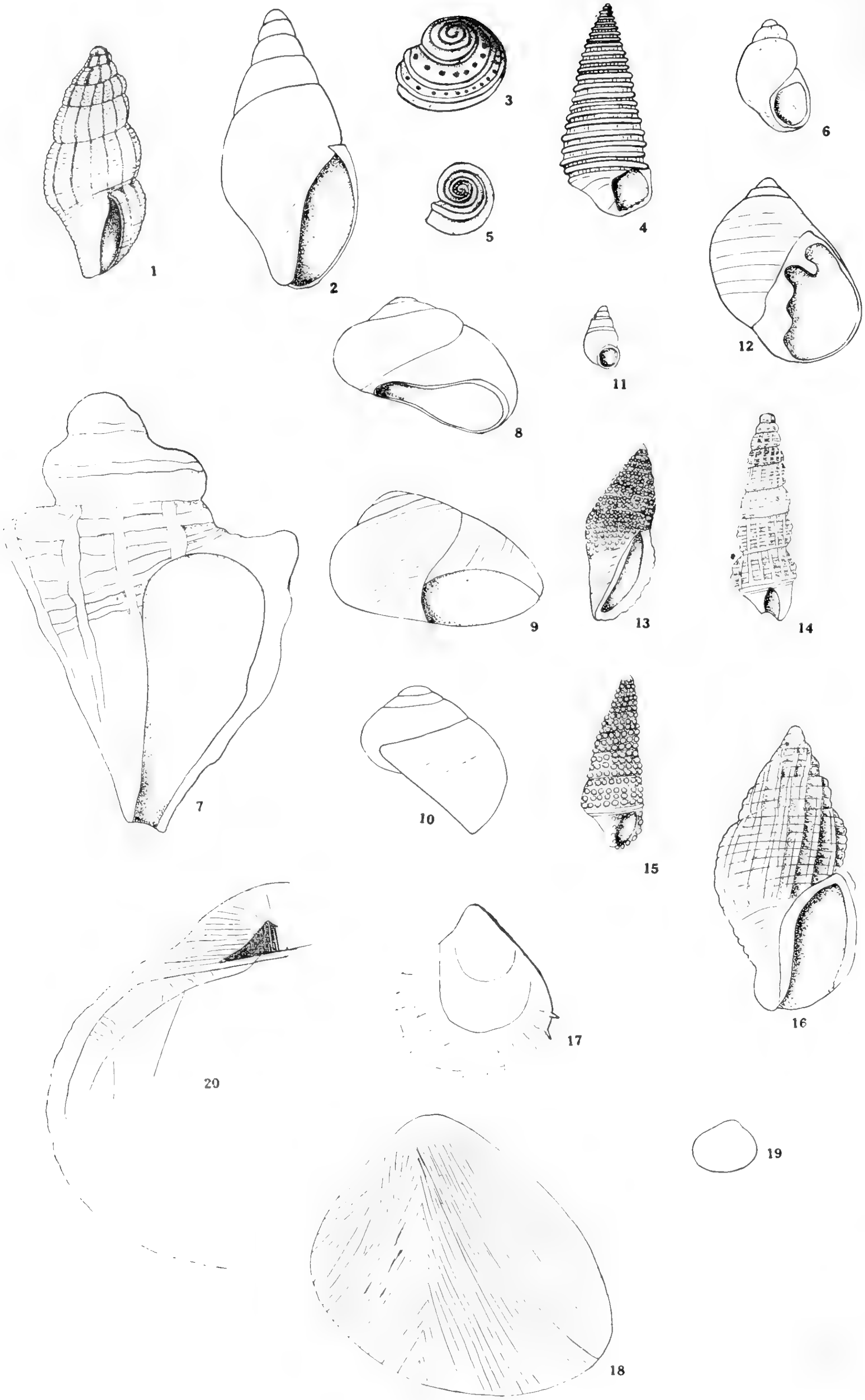


Plate V

Littoral Ascidians Collected at Laguna Beach

The specimens reported upon are from a collection made by P. A. Lichti during the summer of 1915, and from a small collection brought in during the summer of 1916. The determinations of all but the fifth were kindly made by Prof. W. E. Ritter.

Ascidia californica Ritter and Forsythe

These simple forms were found quite abundantly under stones and in kelp holdfests. The form of the body was determined largely by the position the animal took on the stone or seaweed.

Styela barnharti Ritter and Forsythe

The specimens obtained were young, simple, of a redish-brown color and about 4 mm. high. They were found under stones at low tide but not as commonly as some others.

Styla montereyensis Dall

A single specimen of this large, simple species was taken just off shore. It was slender at the base, expanded near the openings and of a redish-brown color.

Euherdmania claviformis Ritter

This slender species was often found in clusters under stones. They were about 2 mm. in diameter and 10-20 mm. long, sometimes free from sand, at other times covered with sand grains.

Goodsiria dura Ritter

Bright red or orange masses of these were often found in bits of seaweed from deeper water. The individuals were 2 to 3 mm. across and often closely massed on the seaweed or other support.

Eudistoma diaphones Ritter and Forsythe

This was the common compound species found closely attached to the lower sides of stones. It was often quite extensive but not thick or colored.

Eudistoma psamion Ritter and Forsythe

Great masses of this tough, pinkish or slightly colored form were found under rock ledges. It resembles one of the sponges in general appearance and is found in among sponges and polyzoans. This was one of the most bulky forms which we found.

Glossophorum planum Ritter and Forsythe

Irregular masses of this species were found under rock ledges and under stones. Our specimens are largely covered with sand grains.

Distaplia occidentalis Ritter and Forsythe

This compound stalked form was found on a rock ledge at low tide near Salt Creek. W. A. H.

(Contribution from the Zoological Laboratory of Pomona College)

Notes on Birds of Laguna Beach and Vicinity for 1916

H. H. NININGER

In addition to the work done by Mr. Leon Gardener and others on the distribution of birds in the vicinity of Laguna Beach I noted the following species in the summer of 1916:

70. *Sturna hirundo* (Common Tern)

This species was found occasionally about the muddy flats at Balboa.

74. *Sturna antillarum* (Least Tern)

The Least Tern is much more common than the former. They were often seen in small flocks diving for fish along the coast from Laguna to Balboa. They probably nest along the sandy shores; but none of their nests were taken by the writer.

95. *Puffinis griseus* (Dark Bodied Shearwater)

These birds were found ten to twelve miles from shore, in flocks feeding over schools of fish. They are called by the fishermen "Barracuda Birds."

210. *Rollus obsoletus* (Calif. Clapper Rail)

Found in the swampy tracts about Balboa.

214. *Porzana carolina* (Sora Rail)

A specimen of this Rail was taken at one of the lakes in Laguna Canyon in the latter part of July.

421. *Chordeiles acutipennis* (Texas Night Hawk)

Either at dusk or at dawn these birds could be found abundantly, in certain localities, feeding over fields, pools and streams to which they came at dusk, from the hills where they spent the daylight hours. Mr. C. C. White found a pair of young almost ready for flight on one of the hills bordering on Laguna Canyon, July 7, 1916.

425. *Aeronautes melanoleucus* (White-throated Swift)

Mr. Charles A. Keeler in "Bird Notes Afield" (1889) records this species from Capistrano. To one accustomed to meeting with this bird only among the high and almost inaccessible cliffs of the mountains it is no little surprise to find it in a district so nearly level as the region about this old mission settlement. But surely it is there. A visit to the place in the latter part of July revealed the fact that they are, seventeen years since Mr. Keeler's writings, still using the same broken walls as a retreat. I think they are nesting at the time we visited the place, for upon the entrance of an adult into one of the crevices there came cries of young birds which seemed to be coming from birds that were being fed.

530a. *Astragalinus P. hesperophilus* (Green-backed Goldfinch)

Common around Laguna and the neighboring hills. Nests with eggs were found, probably the second brood for the season.

634. *Vireo vicinior* (Gray Vireo)

Found along the streams near Capistrano.

685a. *Wilsonia pusilla pileolata* (Pileolated Warbler)

Fairly common in trees along streams near Capistrano.

364. *Pandion haliaetus carolinensis* (American Osprey)

One of these magnificent birds was found on the rocky cliffs bordering the shore between Laguna and Balboa. It was seen several times and was reasonably tame.

BREEDING NOTES

In addition to the nests of the more common birds the following were noted:

Several Raven nests on the cliffs bordering the shore and are in Boat Canyon about a mile from the sea were found deserted, but feathers of their owners and the remains of their food betrayed their identity.

A brood of Ruddy Ducks was seen on one of the lakes in Laguna Canyon several times.

Coots were found breeding about the lakes in abundance.

(Contribution from the Zoological Laboratory of Pomona College)

Preliminary List of Birds From the Claremont-Laguna Region

This list is compiled from many local sources. The earliest records of the Department of Zoology of Pomona College were by Illingsworth, later by Chas. Metz, by Leon L. Gardner and others. There is also included the local records of Wright M. Pierce, and Halsted White. The drawings are all from bird skins from the collections of Pierce and White and from the Department of Zoology of Pomona College. The drawings are by Miss Hazel Burnham. For criticisms, suggestions and much valuable material we have especially to thank Mr. Halsted White and Mr. Wright M. Pierce. Grinnell's "Distributional List of the Birds of California," was used as a basis in the use of the names.

In the list the initials after a record or statement denotes the authorship. Unless otherwise indicated the specimens drawn were males.

The figures on the last two plates are reduced one-half. Other figures are reduced one-third, the figures of the pelicans, condor and vulture are reduced more.

Aechmophorus occidentalis Law. Western Grebe. H.W.

Colymbus nigricollis californicus Heerm. American Eared Grebe. H.W. Seen occasionally in winter on ponds near Santa Ana river near Corona. W.M.P. Pl. I. Fig. 1.

Podilymbus podiceps Linn. Pie-billed Grebe. H.W. Seen at times near fresh water ponds at Corona. W.M.P. Pl. I. Fig. 2.

Gavia immer Brun. Balboa. L.L.G. Common Loon.

Gavia pacifica Lawr. Laguna Beach. L.L.G. Pacific Loon.

Ptychoramphus aleuticus Pall. Cassin Auklet. H.W.. Pl. I. Fig. 3.

Uria troille californica H. Bry. California Murre. One taken in winter at Newport Beach by A. Van Rossen. W.M.P.

Larus glaucescens Naum. Glaucous-winged Gull. Seen. H.W.

Larus occidentalis Aud. Western Gull. Laguna, Balboa. H.W. and L.L.G. Noted at all seasons along the coast, most commonly in fall and winter. W.M.P. Pl. I. Fig. 4.

Larus delawarensis Ord. Ring-billed Gull. Metz and H.W. Pl. I. Fig. 6.

Larus heermanni Cassin. Heermann Gull. Balboa. L.L.G. Pl. I. Fig. 5.

Larus philadelphia Ord. Bonaparte Gull. H.W. Pl. I. Fig. 7. Noted in flocks in spring, Nigger Slough, Los Angeles county. W.M.P.

Sterna paradisæa Brun. Arctic Tern. Near Laguna Beach, May 1, 1915. H.W. Pl. I. Fig. 8.

Sterna antillarum Less. Least Tern. H.W. Laguna Beach. L.L.G. Breeding on beach near Newport, June, 1916. W.M.P. Pl. I. Fig. 9.

Hydrochelidon nigra surinamensis Gmel. Black Tern. H.W. One taken on fresh water pond near Corona, May 18, 1915. W.M.P. Pl. I. Fig. 10.

Puffinus griseus Gmel. Dark-bodied Shearwater. Ten or twelve miles from shore near Laguna Beach, in flocks over schools of fish. H.H.N.

Phalacrocorax auritus albociliatus Ridg. Farallon Cormorant. Seen H.W. Pomona Davenport. Found at all times on reservoirs near Claremont; also seen in fall and winter on fresh water ponds near Corona. W.M.P. Pl. I. Fig. 11.

Pelecanus erythrorthynchos Gmel. White Pelican. Often seen on migrations. H. W., W.M.P., L.L.G. Pl. I. Fig. 13.

Pelecanus californicus Ridg. California Brown Pelican. Often seen at Laguna Beach. Pl. I. Fig. 12.

Mergus serrator Linn. Red-breasted Merganser. Balboa. H.W. L.L.G. Pl. I. Fig. 14.

Lophodytes cucullatus Linn. Hooded Merganser. Specimen, no record. Pl. I. Fig. 15.

Anas platyrhynchos Linn. Mallard. H.W. Fairly common in fall and winter, lowlands near Corona and Santa Ana river. Many specimens taken. A few pairs possibly remain and breed in the same region. W.M.P. Pl. II. Fig. 1.

Chaulelasmus streperus Linn. Gadwall. Seen H.W. Rather rare visitant to fresh water ponds near Corona. W.M.P.

Mareca americana Gmel. Baldpate. H.W. Rather abundant, certain winters, fresh water ponds near Corona, often in large flocks. W.M.P. Pl. II. Fig. 2.

Nettion carolinense Gmel. Green-winged Teal. H.W. Abundant some years, November to March. Always common. Pl. II. Fig. 3.

Querquedula cyanoptera Vieil. Cinnamon Teal. Laguna Beach. L.L.G., H.W. Fairly abundant early fall, less common in midwinter. Scattering pairs breed in marshes near Corona. W.M.P. Pl. II. Fig. 4.

Spatula clypeata Linn. Shoveller. H.W. Abundant, fall and winter Santa Ana river and ponds. W.M.P. Pl. II. Fig. 5.

Dafila acuta Linn. Pintail. H.W. Very abundant from Oct. 15 to Dec. 1, or later. Large flocks seen in spring, Corona, Santa Ana river. W.M.P. Pl. II. Fig. 6.

Marila americana Eyt. Redhead. H.W. Occasionally taken on fresh water ponds near Corona. W.M.P. Pl. II. Fig. 7.

Marila valisineria Wil. Canvas-back. H.W. Occasionally taken on ponds near Corona. W.M.P. Pl. II. Fig. 8.

Marila marila Linn. Greater Scaup Duck. H.W. Pl. II. Fig. 9.

Marila collaris Donov. Ring-necked Duck. One taken Dec. 12, 1915, fresh water pond near Corona. (Recorded in Condor.) W.M.P.

Charitonetta albeola Linn. Buffle-head. Seen H.W. Rare, seen once on pond near Corona. W.M.P. Pl. II. Fig. 10.

Oidemia deglandi Bonap. White-winged Scoter. H.W. Pl. II. Fig. 11.

Erismatura jamaicensis Gmel. Ruddy Duck. Laguna Beach Gardner. H.W. Common in small flocks, pairs or individuals, fall and winter, fresh water ponds near Corona. W.M.P. Pl. II. Fig. 12.

Dendrocygna bicolor Vieil. Fulvous Tree Duck. Claremont, June 30, 1897. Illingsworth. Pl. II. Fig. 13.

Plegadis guarauna Linn. White-faced Glossy Ibis. Rather uncommon. In Oct., 1916, two birds seen on fresh water ponds near Corona. W.M.P.

Botaurus lentiginosus Montag. American Bittern. H.W. Common in marsh and lowland near Corona, Chino, El Monte. Seen as late as April. Probably nests. W.M.P. Pl. II. Fig. 14.

Ardea herodias hyperonca Oberh. California Great Blue Herron. H.W. Laguna Beach. L.L.G. Breeding colony near Laguna Beach, April 23, 1917, eight or ten nests with young one-fourth to one-half grown. One nest with two eggs. Often seen near Corona and Chino standing in barley or beet fields. W.M.P. Pl. II. Fig. 15.

Butorides virescens anthonyi Mear. Anthony Green Herron. H.W. Several seen in San Dimas Canyon in early spring; also seen near Corona in river bottoms. W.M.P. Pl. II. Fig. 16.

Nycticorax nycticorax naevius Bodd. Black-crowned Night Herron. H.W. Claremont. L.L.G. In spring in Santa Ana river bottoms near Corona. W.M.P. Pl. II. Fig. 17.

Rallus obsoletus Ridg. California Clapper Rail. In swampy tracts about Balboa. H.H.N.

Rallus virginianus Linn. Virginia Rail. H.W. Many records, fall, winter, spring, near Chino and Corona. W.M.P. Pl. III. Fig. 1.

Porzana carolina Linn. Sora Rail. H.W. Same records as Virginia Rail. W.M.P. Pl. III. Fig. 2.

Coturnicops noveboracensis Gmel. Yellow Rail. One record, Corona. Pierce Condor XVI, 1914. W.M.P.

Gallinula galeata Licht. Florida Gallinule. Corona. H.W. Seen at times in fall near Corona. W.M.P. Pl. III. Fig. 3.

Fulica americana Gmel. Coot. H.W. Laguna Lakes. L.L.G. Very abundant near Corona. Breeds. W.M.P. Pl. III. Fig. 4.

Phalaropus fulicarius Linn. Red Phalarope. One record from near Corona. W.M.P.

Steganopus tricolor Vieil. Wilson Phalarope. H.W. Three records from fresh water ponds near Corona. W.M.P. Pl. III. Fig. 5.

Himantopus mexicanus Mull. Black-necked Stilt. H.W. Several in spring on fresh water ponds near Corona. W.M.P. Pl. III. Fig. 6.

Gallinago delicata Ord. Wilson Snipe. H.W. Common in fall and winter and spring, in wet fields near Corona and Chino. W.M.P. Pl. III. Fig. 7.

Macrorhamphus griseus scolopaceus Say. Long-billed Dowitcher. Balboa. L.L.G. Pl. III. Fig. 8.

Pisobia minutilla Vieil. Least Sandpiper. Long Beach. Metz. Flocks of twelve or fifteen seen at times on ponds near Corona. W.M.P. Pl. III. Fig. 9.

Ereunetes mauri Cab. Western Sandpiper. H.W. Long Beach. Metz. Pl. III. Fig. 10, female.

Calidris leucophaea Pall. Sanderling. H.W. Pl. III. Fig. 12.

Totanus melanoleucus Gmel. Greater Yellow-legs. H.W. Pl. III. Fig. 13. Corona ponds, fall and winter. W.M.P.

Catoptrophorus semipalmatus inornatus Brew. Western Willet. H.W. Pl. III. Fig. 14.

Heteractitis incanus Gmel. Wandering Tattler. Taken near Laguna Beach by H.W.

Actitis macularius Linn. Spotted Sandpiper. H.W. Fall, winter, spring; rocky coves near Laguna Beach. W.M.P. Pl. III. Fig. 11.

Numenius americanus Bech. Long-billed Curlew. H.W. Seen at Balboa in spring. W.M.P. Pl. III. Fig. 17.

Numenius hudsonicus Lath. Hudsonian Curlew. H.W. Balboa. L.L.G. Fall, winter, spring, Balboa, Newport, Laguna. W.M.P. Pl. III. Fig. 16.

Squatarola squatarola Linn. Black-bellied Plover. H.W. Same localities as last, not so abundant in winter. W.M.P. Pl. III. Fig. 18.

Oxyechus vociferus vociferus Linn. Killdeer. H.W. Laguna Gardner. Near Claremont, fall; Chino, Corona, Newport. Breed near Chino, Newport. W.M.P. Pl. III. Fig. 19.

Aegialitis semipalmata Bonap. Semipalmated Plover. Balboa. L.L.G.

Aegialitis nivosa Cass. Snowy Plover. H.W. Long Beach. Metz. Several pairs near Newport, 1916. Near Balboa at all seasons. W.M.P. Pl. III. Fig. 20.

Arenaria melanocephala Vig. Black Turnstone. H.W. Several records near Laguna. W.M.P. Pl. III. Fig. 21.

Oreortyx picta plumifera Goul. Mountain Quail. H.W. Recorded from Brown's Flats, San Antonio Canyon, Camp Baldy, Bear Flats, Palmers Canyon. W.M.P. Pl. III. Fig. 23.

Lophortyx californica vallicola Ridg. Valley Quail. H.W. Claremont, Santa Ana, Laguna, Lytle Creek up to 5000 ft. Breeds in April, 10 to 24 eggs. W.M.P. Pl. III. Fig. 22.

Colomba fasciata fasciata Say. Band-tailed Pigeon. Oct. 1916. H.W. Claremont. Metz. Abundant in San Dimas Canyon at certain seasons, usually in large flocks, less common than formerly. Found at Glen Ranch in Lytle Creek. W.M.P. Pl. III. Fig. 25.

Zenaidura macroura marginella Woodh. Western Mourning Dove. H.W. Quite abundant, less so than formerly. W.M.P. Pl. III. Fig. 24.

Gymnogyps californianus Shaw. California Condor. One specimen in the department, supposed to have been obtained from hills near Pomona about fifteen years ago. Pl. IV. Fig. 1.

Cathartes aura septentionalis Wied. Turkey Vulture. L.L.G., H.W. Claremont, Chino, Laguna. Abundant. W.M.P. Pl. IV. Fig. 1.

Circus hudsonius Linn. Marsh Hawk. H.W. Noted from foothills near Etiwanda to Santa Ana river bottoms near Santa Ana. Breeding record near Corona. W.M.P. Pl. IV. Fig. 3.

Accipiter velox Wil. Sharp-shinned Hawk. H.W. Common fall, winter and early spring, mountains to lowlands. W.M.P. Pl. IV. Fig. 4.

Accipiter cooperi Bonap. Cooper Hawk. H.W. Resident in small numbers; most abundant in fall and winter. Breeds in mountain canyons. Recorded from Lytle Creek, San Gabriel, etc. W.M.P. Pl. IV. Fig. 5.

Buteo borealis calurus Cass. Western Red-tailed Hawk. H.W., Illingworth, Metz. Common breeding from coast to mountains. W.M.P. Pl. IV. Fig. 7.

Buteo lineatus elegans Cass. Red-bellied Hawk. H.W. Probably becoming scarcer every year. A few pairs still breed in river bottoms near Corona. W.M.P. Pl. IV. Fig. 6.

Buteo swainsoni Bonap. Swainson Hawk. Found breeding in several instances in river bottom near Corona, also near Chino. Large flocks often seen flying north or south. W.M.P. Pl. IV. Fig. 8.

Archibuteo ferrugineus Licht. Ferruginous Rough-legged Hawk. Rather uncommon. One taken near Corona. Another seen in fall of 1916. W.M.P.

Aquila chrysaetos Linn. Golden Eagle. H.W., Metz. In high mountains. W.M.P. Pl. IV. Fig. 9.

Haliaeetus leucocephalus leucocephalus Linn. Southern Bald Eagle. Near Laguna and San Pedro. W.M.P., L.L.G.

Falco mexicanus Schl. Prairie Falcon. H.W. Not common, fall and winter near Chino. W.M.P. Pl. IV. Fig. 10.

Falco columbarius columbarius Linn. Northern Pigeon Hawk. Rather uncommon. Several taken, all probably this form. Pl. IV. Fig. 11.

Falco sparverius sparverius Linn. American Sparrow Hawk. H.W., L.L.G., Metz, Illingsworth. From the mountains to the sea. W.M.P. Pl. IV. Fig. 12, male. Fig. 13, female.

Pandion haliætus carolinensis Gmel. American Osprey. Between Laguna and Balboa, summer, 1916. H.H.N. Seen near Newport. W.M.P.

Aluco prantincola Bonap. American Barn Owl. Metz., L.L.G., H.W. Vefy common, San Dimas Canyon, Claremont, Chino, near Corona, Upland, Laguna. Nests in holes in trees or rocks or in buildings. Eggs from February to May. W.M.P. Pl. IV. Fig. 14.

Asio wilsonianus Less. Long-eared Owl. H.W., Metz. June 7, 1909. One record from Indian Hill, Claremont. Several pairs nesting in willow bottoms near Corona, April, 1915 to 1917. W.M. P. Pl. IV. Fig. 15.

Asio flammeus Pontop. Short-eared Owl. H.W. Hills near Pomona, Nov. 10. Near Corona, Nov. 3. Near Ontario in grain field, Nov. 2. W.M.P. Pl. IV. Fig. 16.

Strix occidentalis occidentalis Xan. Southern Spotted Owl. One record from San Gabriel Canyon, May 1, 1916. W.M.P.

Otus asio quercinus Grin. Southern California Screech Owl. Illingsworth, H.W. Abundant, Claremont, resident breeding. San Dimas and San Antonio Canyons, many records. W.M.P. Pl. IV. Fig. 17.

Bubo virginianus pallescens Stone. Western Horned Owl. One record. Found dead at mouth of San Antonio Canyon, Jan. 10, 1915. W.M.P.

Bubo virginianus pacificus Cass. Pacific Horned Owl. Pair seen at Laguna, 1917; San Antonio Canyon, 1914. Breeding in San Dimas Canyon, Feb. and March, 1917. W.M.P. Pl. IV. Fig. 18.

Speotyto cunicularia hypogæa Bonap. Burrowing Owl. Illingsworth, 1902; Metz, H.W. Near Santa Ana and Irvine. Abundant in fields near Chino and Corona, nesting. Near Claremont, nesting. Nigger Slough, nesting. W.M.P. Pl. IV. Fig. 19.

Glaucidium gnoma californicum Sclat. California Pigmy Owl. One record, San Antonio Canyon. W.M.P. Pl. IV. Fig. 20.

Geococcyx californianus Less. Road Runner. H.W. Claremont. Illingsworth, '96; L.L.G. Laguna, 1914. Formerly much more common. W.M.P. Pl. V. Fig. 1.

Coccyzus americanus occidentalis Ridg. California Cuckoo. Seen H.W. Rather uncommon. Several individuals seen at Corona in willows; one set of three eggs found near Chino. Pl. V. Fig. 2.

Ceryle alcyon caurina Grin. Western Belted Kingfisher. H.W. Noted in migration near Claremont, San Gabriel Canyon, San Antonio Canyon, Glen Ranch, Santa Ana river near Corona. W.M.P. Seen in Pudding Stone Canyon. L.L.G. Pl. V. Fig. 3.

Dryobates villosus hyloscopus Canab. and Hein. Cabinas Woodpecker. H.W. Common in nesting season in higher mountains. Taken in fall in Santa Ana river bottoms and also near El Monte. W.M.P. Pl. V. Fig. 4. Bright red patch on head.

Dryobates pubescens turati Malhe. Willow Woodpecker. H.W. Common in willow bottoms near Corona in spring; also El Monte. One taken in San Antonio and one in San Dimas Canyons in the fall. W.M.P. Pl. V. Fig. 5. Bright red line back of black patch on head.

Dryobates scalaris cactophilus Ober. Cactus Woodpecker. H.W. Several records for Mojave desert. Breeding near Victorville. W.M.P.

Dryobates nuttalli Gamb. Nuttall Woodpecker. Common in canyons up to 5000 feet; also in willow and sycamore groves in lowlands. Nesting, May, 1916, San Gabriel Canyon, Santa Ana river bottoms near Corona, San Antonio Canyon. W.M.P. Pl. V. Fig. 6. Bright red patch back of black patch on head.

Xenopicus albolarvatus gravirostris Grinn. San Bernardino White-headed Woodpecker. Found in the higher mountains of the San Gabriel range, Baldy, Ontario, etc., in summer. W.M.P. Pl. V. Fig. 7. Bright red patch on head.

Sphyrapicus varius daggetti Grinn. Sierra Red-breasted Sapsucker. H.W. Several winter records. W.M.P.. Pl. V. Fig. 8. Head and throat bright red, shaded into yellow on breast.

Melanerpes formicivorus bairdi Ridg. California Woodpecker. H.W., Metz. Nesting and resident. W.M.P. Pl. V. Fig. 9. Bright red patch on back of head, yellow tinge on throat.

Asyndesmus lewisi Riley. Lewis Woodpecker. Common Brown's Flats in spring. H.W. Casual migrant, noted years ago in Blanchard Park, Claremont, in small numbers in spring. W.M.P. Pl. V. Fig. 10. Red spot on front of head, breast streaked with red.

Colaptes cafer collaris Vigors. Red-shafted Flicker. H.W., Metz, H.H.T. Laguna. L.L.G. Abundant, especially fall and winter. Breeds San Antonio Canyon, Santa Ana river bottom. W.M.P. Pl. V. Fig. 11. Red streak on side of throat, under tail and red wing quills.

Phalaenoptilus nuttalli californicus Ridg. Dusky Poor-will. H.W. Fairly common at mouth of San Antonio and San Dimas Canyons in spring. Noted in upper Lytle Creek, Sept., 1915, and Glen Ranch, 1916. W.M.P. Pl. V. Fig. 12.

Chordeiles virginianus hesperis Grinn. Pacific Nighthawk. Found only in Big Bear Valley. Possibly occurs in our mountains. W.M.P. Pl. V. Fig. 13.

Chordeiles acutipennis texensis Law. Texas Nighthawk. H.W. Common about Claremont. W.M.P., Metz. Laguna. H.H.N.

Chaetura vauxi Towns. Vaux Swift. Noted in fall migration, Santa Ana river. W.M.P.

Aeronautes melanoleucus Baird. White-throated Swift. H.W. Capistrano. H.H.N. Noted in migration in fall, Santa Ana river bottoms. Taken along cliffs near Laguna. Spring. W.M.P. Pl. V. Fig. 14.

Archilochus alexandri Bou. and Mul. Black-chinned Hummingbird. H.W. Nestings San Antonio Canyon, near Corona, near Ontario. W.M.P.

Calypte costae Bour. Costa Hummingbird. H.W., Metz. Abundant in mountains and lower. W.M.P. Pl. V. Fig. 15. Throat purple.

Calypte anna Less. Anna Hummingbird. Metz, H.W. Common all year, nests in Claremont. W.M.P. Pl. V. Fig. 16. Red throat.

Selasphorus rufus Gmel. Rufous Hummingbird. H.W., Metz. Common migrant in spring. W.M.P. Pl. V. Fig. 17. Breast brownish, some red spots which are small. Back more brown than others.

Tyrannus verticalis Say. Western Kingbird. H.W. Laguna. L.L.G. Common and nesting, Chino, San Antonio Canyon. W.M.P. Pl. V. Fig. 18. Streak of red on center of head.

Tyrannus vociferans Swains. Cassin Kingbird. H.W. Laguna Gardner. Common migrant near Chino. No nesting records. W.M.P. Pl. V. Fig. 19. Red streak, center of head.

Myiarchus cinerascens cinerascens Law. Ash-throated Flycatcher. H.W. Claremont. Metz. Laguna. L.L.G. Common about Claremont in migrations. Breeding in some of the canyons. W.M.P. Pl. V. Fig. 20.

Sayornis sayus Bonap. Say Phoebe. H.W. Claremont. Metz. Laguna L.L.G. Common, fall and winter; possibly a few pairs breed. W.M.P. Pl. V. Fig. 25.

Sayornis nigricans Swain. Black Phoebe. H.W. Laguna Gardner. Common from ocean to mountains and into canyons. Many nesting records. W.M.P. Pl. V. Fig. 24.

Nuttallornis borealis Swains. Olive-sided Flycatcher. H.W. Claremont. Metz. Common in higher mountains. Found in valleys during migrations. W.M.P. Pl. V. Fig. 21.

Myiochanes richardsoni richardsoni Swains. Western Wood Pewee. H.W. Abundant and nests in canyons, in valley during migrations. W.M.P. Pl. V. Fig. 26.

Empidonax difficilis difficilis Baird. Western Flycatcher. H.W. Summer resident of canyons; many nesting records for Cucamonga, San Dimas, San Gabriel Canyons. W.M.P.

Empidonax trailli trailli Audub. Traill Flycatcher. H.W. Summer visitant to willow bottoms and in less numbers to canyons. W.M.P. Pl. V. Fig. 22.

Empidonax hammondi Xanthus. Hammond Flycatcher. One record San Dimas Canyon. W.M.P.

Pyrocephalus rubinus mexicanus Sclat. Vermilion Flycatcher. One record Santa Ana river bottom near Corona in winter. W.M.P.

Otocoris alpestris actia Oberh. California Horned Lark. H.W. Claremont. Metz. Laguna. L.L.G. Abundant, resident. W.M.P. Pl. V. Fig. 27.

Cyanocitta stelleri frontalis Ridg. Blue-fronted Jay. H.W. Common resident of mountains from 3,000 to 9,000 feet. One breeding date, May, 1915, San Gabriel Canyon. W.M.P. Pl. V. Fig. 28.

Aphelocoma californica californica Vig. California Jay. H.W. Claremont. Metz. Laguna. L.L.G. Abundant, Claremont and lower canyons. W.M.P. Pl. V. Fig. 29. Bright blue.

Corvus corax sinuatus Wag. Western Raven. Seen. H.W. Laguna. L.L.G., H.H.N. and W.M.P. Pl. V. Fig. 33.

Corvus brachyrhynchos hesperis Ridg. Western Crow. H.W. Very abundant on willow river bottoms, Corona, El Monte. Nest on Santa Ana. W.M.P. Also seen near south hills near Pomona. Pl. V. Fig. 32.

Nucifraga columbiana Wilson. Clarke Nutcracker. H.W. Noted on the high slopes of Mount San Antonio. W.M.P. Pl. V. Fig. 31.

Cyanocephalus cyanocephalus Wied. Pinyon Jay. Seen in flocks in spring of 1917 near Box S Ranch on Mojave Desert. Records for San Bernardino Range, not for San Gabriel. W.M.P. Pl. V. Fig. 30. Bluish grey.

Molothrus ater obscurus Gmel. Dwarf Cowbird. Eggs probably of this species found in Santa Ana river flats near Corona on several occasions. W.M.P.

Xanthocephalus xanthocephalus Bonap. Yellow-headed Blackbird. H. W. Collected during migration in spring near Chino, and nesting near Nigger slough. W.M.P. Pl. V. Fig. 34.

Agelaius phoeniceus neutralis Ridg. San Diego Red-winged Blackbird. H.W. Very abundant in lowlands about Chino. W.M.P. Pl. V. Fig. 35.

Agelaius tricolor Audub. Tri-colored Red-winged Blackbird. H.W. Several specimens taken near Corona, Chino, etc. W.M.P.

Sturnella neglecta Audub. Western Medowlark. H.W., Metz. Abundant in lowlands common about Claremont. W.M.P. Pl. V. Fig. 36. Canary yellow on throat, side and breast.

Icterus parisorum Bonap. Scott Oriole. H.W. Quite common on Mojave Desert. W.M.P. Pl. V. Fig. 38. Black and very deep yellow.

Icerus cucullatus nelsoni Ridg. Arizona Hooded Oriole. H.W. Claremont. Metz. Laguna. L.L.G. Locally common at Ontario, Claremont, Pomona, etc. Many nesting dates, usually nesting in palms. W.M.P. Pl. V. Fig. 37. Black and very deep yellow.

Icterus bullocki Swains. Bullock Oriole. H.W. Claremont. Metz. Abundant from ocean to 5,000 feet. Breeding at Hesperia. W.M.P. Pl. V. Fig. 39. Black and orange.

Euphagus cyanocephalus Wag. Brewer Blackbird. H.W., Metz. Especially abundant in Claremont. Many records. W.M.P.

Carpodacus purpureus californicus Baird. California Purple Finch. H.W. Winter visitant to Claremont, San Antonio Canyon. W.M.P. Pl. VI. Fig. 1. Head and throat a rich red.

Carpodacus cassini Baird. Cassin Purple Finch. H.W. Claremont. Metz. Winter migration record for Claremont, Pomona, San Antonio Canyon. W.M.P. Pl. VI. Fig. 2. Top of head rich red, thorax and sides tinged with red.

Capodacus mexicanus frontalis Say. California Linnet. H.W. Claremont. Metz. Laguna. L.L.G. Abundant from ocean to mountains. Less common above 3,000 feet. Nests about buildings and in cactus. W.M.P. Pl. VI. Fig. 3. Head and throat rich red.

Astragalinus tristis salicamans Grinn. Willow Goldfinch. H.W. Claremont. Metz. Redlands, San Antonio Station; very abundant El Monte, Corona. Many nesting records in bottoms. W.M.P. Pl. VI. Fig. 4. Breast and neck canary yellow.

Astragalinus psaltria hesperophilus Ober. Green-backed Goldfinch. H.W. Claremont. Metz. Claremont, San Antonio Canyon, Corona, Laguna. Common. Breeding San Antonio Canyon. Claremont, near Covina. W.M.P. Pl. VI. Fig. 5. Breast canary yellow, back yellowish-green.

Astragalinus lawrencei Cass. Lawrence Goldfinch. H.W. Breeding in Claremont, San Antonio Canyon, near Corona. Found also in upper San Gabriel. W.M.P. Pl. VI. Fig. 6. Canary yellow breast, streaks on wings.

Spinus pinus pinus Wilson. Pine Siskin. Common winter visitant to San Antonio and other parts of mountains. W.M.P. Pl. VI. Fig. 7.

Passer domesticus Linn. English Sparrow. H.W. Noted at Claremont, Pomona, Ontario, San Bernardino, Victorville, Hesperia, El Monte, Box S. Ranch. W.M.P. Pl. VI. Fig. 8.

Pooecetes gramineus confinis Miller. Western Vesper Sparrow. H.W. Several records, fall and winter, Corona, Chino, near Etiwanda. W.M.P. Pl. VI. Fig. 9.

Pooecetes gramineus affinis Miller. Oregon Vesper Sparrow. Probably occurs. H.W.

Passerculus sandwichensis alaudinus Bonap. Western Savanna Sparrow. H.W. Abundant in lowlands, winter and fall. W.M.P. Pl. VI. Fig. 11.

Passerculus rostratus rostratus Cass. Found quite commonly near Oceanside. October 19, 1916. W.M.P.

Passerculus beldingi Ridg. Belding Marsh Sparrow. Common at Newport. One breeding record. W.M.P. Pl. VI. Fig. 12.

Ammodramus savannarum bimaculatus Swain. Western Grasshopper Sparrow. H.W. Records as follows: One male, near Corona, Calif.; one female, mouth of Lytle Creek Canyon, September 11, 1915; May 22, 1915, several Nigger Slough, near San Pedro. W.M.P. Pl. VI. Fig. 13.

Chondestes grammacus strigatus Swain. Western Lark Sparrow. H.W. Claremont. Metz. Laguna. L.L.G. Abundant near Corona, Chino, mouth of Lytle Creek Canyon; fairly common Mojave Desert. Claremont. W.M.P. Pl. VI. Fig. 17.

Zonotrichia leucophrys leucophrys Forst. White-crowned Sparrow. North of Claremont. In college collection. H.W. Two records, near Claremont. Specimen from desert in spring. W.M.P. Pl. VI. Fig. 18.

Zonotrichia leucophrys gambeli Nutt. Intermediate Sparrow. H.W. Very abundant ocean to foothills, fall and winter. Recorded late in April from Claremont. W.M.P. Pl. VI. Fig. 19.

Zonotrichia coronata Pall. Golden-crowned Sparrow. H.W. Winter, San Dimas, upper San Antonio, along foothills. W.M.P. Pl. VI. Fig. 15.

Spizella passerina arizonae Coues. Western Chipping Sparrow. H.W. Claremont. Metz. Breeding records, Claremont. W.M.P.

Spizella breweri Cass.. Brewer Sparrow. Migration records in spring, Claremont. W.M.P. Pl. VI. Fig. 16.

Spizella atrogularis Caban. Black-chinned Sparrow. Seen. H.W. Migration records in spring. W.M.P. Pl. VI. Fig. 10.

Junco oreganus thurberi Anthony. Sierra Junco. H.W., Metz. Common; breeds in mountains, in valleys in spring. W.M.P. Pl. VI. Fig. 14.

Amphispiza bilineata deserticola Ridg. Desert Black-throated Sparrow. H.W. One record for Claremont. Specimen in Pomona College collection. Abundant, breeding in desert near Victorville, spring 1917. W.M.P. Pl. VI. Fig. 20.

Amphispiza belli Cass. Bell Sparrow. H.W. Claremont. Metz. Common, breeding near Claremont. Found up to San Antonio Canyon. W.M.P. Pl. VI. Fig. 21.

Amphispiza nevadensis canescens Grinn. California Sage Sparrow. H.W. Fall; common at Glenn Ranch. W.M.P. Pl. VI. Fig. 22.

Aimophila ruficeps ruficeps Cass. Rufous-crowned Sparrow. H.W. Laguna. L.L.G. Resident foothills near Claremont, mouth of San Antonio Canyon. W.M.P. Pl. VI. Fig. 23.

Melospiza melodia cooperi Ridg. San Diego Song Sparrow. H. W. Claremont. Metz. Laguna. L.L.G. Very abundant in river bottoms; many breeding records; Claremont to coast. W.M.P. Pl. VI. Fig. 27.

Melospiza lincolni lincolni Aud. Lincoln Sparrow. H.W. Winter resident to our valleys. W.M.P. Pl. VI. Fig. 24.

Certain of the fox sparrows are very hard to place. The notes that I give are only provisional and further study of this group may place these under different sub-species. Then there are many intergrades that are difficult to correctly place. The sub-species that are hard to differentiate are as follows:

Passerella ilica unalascheensis Gmel. Shumagin Fox Sparrow. Taken in winter, San Antonio Canyon.

P. i insularis Rid. Kadiak Fox Sparrow. Winter, San Antonio Canyon.

P. i sinuosa Grinn. Valdez Fox Sparrow. San Dimas Canyon in winter.

P. i meruloides Vig. Yakutat Fox Sparrow. Several San Antonio Canyon in winter.

P. i altivagans Rid. Alberta Fox Sparrow. Several in winter, San Dimas Canyon. W. M. P.

Passerella iliaca schistacea Baird. Slate-colored Fox Sparrow. Taken in winter, San Dimas Canyon; Lytle Creek in fall. W.M.P.

Passerella iliaca megarhyncha Baird. Thick-billed Fox Sparrow. Recorded in winter, San Antonio Canyon, San Dimas Canyon. W. M. P.

Passerella iliaca stephensi Anth. Stephens Fox Sparrow. H.W. No valley records. W.M.P. Pl. VI. Fig. 26.

Pipilo maculatus megalonyx Baird. Spurred Towhee. H.W. Claremont. Metz. Abundant, breeding in Claremont, Corona, San Antonio Canyon, Laguna. W.M.P. Pl. VI. Fig. 28.

Pipilo crissalis senicula Anth. Anthony Brown Towhee. H.W. Claremont. Metz. Abundant, breeding Claremont to Laguna. W.M.P. Pl. VI. Fig. 30.

Oreospiza chlorura Audub. Green-tailed Towhee. H.W. Breeds on high mountains (about 8,000 feet), Lytle Creek, near Corona in winter. W.M.P. Pl. VI. Fig. 29.

Zamelodia melanocephala capitalis Baird. Pacific Black-headed Grosbeak. Metz. Claremont. H.W. Breeding at Claremont, near Corona. W.M.P. Pl. VI. Fig. 31. Female.

Guiraca caerulea salicarius Grinn. California Blue Grosbeak. H. W. Laguna. H.H.N. Santa Ana river bottom in spring; Brea Canyon. W.M.P. Pl. VI. Fig. 32. Dark blue, rufous on wings.

Passerina amoena Say. Lazuli Bunting. H.W. Claremont. Metz. Fairly common in Claremont, seen in Brea Canyon and near Chino, San Antonio Canyon, San Dimas Canyon. W.M.P. Pl. VI. Fig. 33. Bright blue touched with rufous.

Calamospiza melanocorys Stejn. Lark Bunting. One record near Corona, May 11, 1915. W. M. P.

Piranga ludoviciana Wilson. Western Tanager. H.W. Common in canyons in summer, upper San Antonio, Cucamonga; breeding records; spring migration records for Claremont. W.M.P. Pl. VI. Fig. 34. Head brilliant red shaded over yellow.

Progne subis hesperia Brew. Western Martin. Two specimens in college collection, taken 1896. Pl. VI. Fig. 35. Female.

Petrochelidon lunifrons lunifrons Say. Cliff Swallow. H.W. Long Beach. Metz. Laguna Beach Gardner. Breeding. Very abundant from mouth of San Antonio to ocean; nests on barns, houses, etc.; cliffs near Laguna. W.M.P. Pl. VI. Fig. 36.

Hirundo erythrogaster Bodd. Barn Swallow. Seen. H.W. Migration records for Chino, Corona, Laguna. W.M.P. Pl. VI. Fig. 38.

Iridoprocne bicolor Vieil. Tree Swallow. H.W. Breeds near Corona; seen in winter in same locality less commonly. W.M.P. Pl. VI. Fig. 39.

Tachycineta thalassina lepida Mearns. Northern Violet-green Swallow. H.W. Claremont. Metz. Breeds in San Antonio Canyon.

Riparia riparia Linn. Bank Swallow. Nesting record for Newport, June, 1916. Migration record near Corona in spring. W.M.P. Pl. VI. Fig. 37.

Stelgidopteryx serripennis. Audub. Rough-winged Swallow. Pl. VI. Fig. 40.

Bombycilla cedrorum Vieill. Cedar Waxwing. H.W. Claremont. L.L.G. Very abundant in fall, winter and spring, Claremont, Ontario, Pomona, San Antonio, San Dimas. W.M.P. Pl. VII. Fig. 1.

Phainopepla nitens Swain. Phainopepla. H.W. Claremont. Metz. Breeding records Claremont; winters regularly near Corona in river bottoms. Some winters seen in Claremont. W.M.P. Pl. VII. Fig. 2.

Lanius ludovicianus gambeli Ridg. California Shrike. H.W. Laguna. L.L.G. Resident. Breeds Corona, Chino, Ontario; common at Claremont. W.M.P. Pl. VII. Fig. 3.

Vireosylva gilva swainsoni Baird. Western Warbling Vireo. H.W. Abundant in summer in canyons. Breeds. W.M.P. Pl. VII. Fig. 4.

Lanivireo solitarius cassini Xant. Cassin Vireo. H.W. San Antonio, Glenn Ranch. W.M.P. Pl. VII. Fig. 6.

Vireo huttoni huttoni Cass. Hutton Vireo. H.W. Claremont, San Antonio Canyon. Nests. Resident. W.M.P. Pl. VII. Fig. 5.

Vireo belli pusillus Coues. California Least Vireo. H.W. Laguna. L.L.G. Fairly common Glenn Ranch and near Corona. Breeding notes. W.M.P.

Vireo vicinior Coues. Gray Vireo. Capistrano. H.H.N. Several seen in Cajon Pass, elevation 3,700 feet. W.M.P.

Vermivora ruficapilla gutturalis Ridg. Calaveras Warbler. H.W. Migrates. Glenn Ranch, San Gabriel Canyon. W.M.P.

Vermivora celata lutescens Ridg. Lutescent Warbler. H.W. Glenn Ranch, San Gabriel Canyon, San Antonio and San Dimas Canyons. W.M.P. Pl. VII. Fig. 7. Canary yellow.

Vermivora celata sordida Towns. Dusky Warbler. San Dimas Canyon. Winter. W. M. P.

Dendroica aestiva brewsteri Grinn. California Yellow Warbler. H.W., Metz. Claremont. Breeding near Corona river bottoms. Pl. VII. Fig. 8. Canary-yellow.

Dendroica auduboni auduboni Towns. Audubon Warbler. H.W. Claremont. Metz. Abundant in winter in San Antonio Canyon, Claremont, Pomona, Corona. Breeds in higher mountains. W.M.P.

Pl. VII. Fig. 10. Five yellow spots, top of head, throat, under wings, on rump.

Dendroica nigrescens Towns. Black-throated Gray Warbler. Seen. H.W. Breeds near Camp Baldy and Cold Brook, San Gabriel Canyon. W.M.P. Claremont during migration. Pl. VII. Fig. 9. Small yellow spot in front of eye.

Dendroica occidentalis Towns. Hermit Warbler. H. W. Seen. Migration near Corona, Santa Ana river bottom, upper Lytle Creek. W.M.P. Pl. VII. Fig. 11. Bright yellow on side and top of head.

Oporornis tolmiei Towns. Tolmie Warbler. Migration notes from Cold Brook, Glenn Ranch, Claremont, upper Lytle Creek. W.M.P.

Geothlypis trichas occidentalis Brew. Western Yellowthroat. H.W. Taken in migration at Claremont. Breeds on river bottoms near Corona, Chino and El Monte. W.M.P. Pl. VII. Fig. 12. Bright yellow throat, back greenish grey.

Icteria virens longicauda Lawr. Long-tailed Chat. H.W. Breeds near Corona. W.M.P. Pl. VII. Fig. 13. Bright yellow throat.

Wilsonia pusilla chryseola Ridg. Golden Pileolated Warbler. H.W. Migration near Claremont. One breeding record. Santa Ana river bottoms. W.M.P. Pl. VII. Fig. 14. Canary-yellow throat. Back greenish-grey.

Wilsonia pusilla pileolata Pall. Alaska Pileolated Warbler. Capistrano. H.H.N.

Anthus rubescens Tunst. American Pipit. H.W. Long Beach. Metz. Abundant fall and winter, Corona, Chino, Ontario W.M.P. Pl. VII. Fig. 15.

Cinclus mexicanus unicolor Bonap. American Dipper. H. W. Resident San Antonio, San Dimas, Cucamonga, Lytle Creek. W.M.P. Pl. VII. Fig. 16. Female.

Oreoscoptes montanus Towns. Sage Thrasher. Taken fall and winter in Corona, near Etiwanda. Seen in early May, upper Cajon Pass. W.M.P. Pl. VII. Fig. 17.

Mimus Polyglottos leucopterus Vigors. Western Mockingbird. H.W. Claremont. Metz. Laguna. L.L.G. Breeds in Claremont. W.M.P. Pl. VII. Fig. 18.

Toxostoma redivivum pasadenense Grinn. Pasadena Thresher. H.W. Claremont. Metz. Laguna. L.L.G. Breeds at Claremont. W.M.P. Pl. VII. Fig. 19.

Toxostoma lecontei lecontei Law. Leconte Thrasher. Seen on Mojave Desert. H.W. Resident, breeding, limited numbers, Mojave Desert. W.M.P.

Heleodytes brunneicapillus couesi Sharpe. Northern Cactus Wren. H.W. Claremont. Metz. Common resident, breeding. W.M.P. Pl. VII. Fig. 21.

Salpinctes obsoletus obsoletus Say. Rock Wren. H.W. Many records, Claremont, San Antonio Canyon; higher mountains in summer. W.M.P. Pl. VII. Fig. 23.

Catherpes mexicanus punctulatus Ridg. Dotted Canyon Wren. H. W. Laguna. L.L.G. Nesting at San Gabriel, Cucamonga. Fairly common. W.M.P. Pl. VII. Fig. 22.

Thryomanes bewicki charienturus Oberh. San Diego Wren. H. W. Claremont. Metz. Breeding at Claremont, San Antonio, San Dimas Canyons. W.M. P. Pl. VII. Fig. 20.

Troglodytes aedon parkmani Audub. Western House Wren. H.W. Breeding up as far as Camp Baldy. W.M.P. Pl. VII. Fig. 25.

Telmatodytes palustris paludicola Baird. Tule Wren. H. W. Abundant and breeding in Santa Ana river bottom. W.M.P. Pl. VII. Fig. 24.

Nannus hiemalis pacificus Baird. Western Winter Wren. One record, San Dimas Canyon, Jan. 21, 1915. W.M.P.

Certhia familiaris zelotes Osg. Sierra Creeper. Lytle Creek. Glenn Ranch. W.M.P. Pl. VII. Fig. 26.

Sitta carolinensis aculeata Cass. Slender-billed Nuthatch. Seen. H.W. Recorded upper Lytle Creek, Glenn Ranch. W.M.P. Pl. VII. Fig. 27.

Sitta pygmaea pygmaea Vigors. Pigmy Nuthatch. Upper Lytle Creek. W.M.P. Pl. VII. Fig. 28.

Baeolophus inornatus inornatus Gamb. Plain Titmouse. H.W. Oaks near Claremont. W.M.P. Pl. VII. Fig. 29.

Penthestes gambeli baileyae Grinn. Baily Chickadee. H.W. Common higher mountains. Sometimes occurs in winter in valleys. Recorded several times from foothills near San Antonio and San Dimas Canyons. Pl. VII. Fig. 34.

Psaltriparus minimus minimus Ridg. Coast Bush-tit. H.W. Claremont. Metz. Common, breeding at San Dimas, San Antonio, Claremont. Pl. VII. Fig. 30. May be A.O.U. 743A. W.M.P.

Chamaea fasciata henshawi Ridg. Pallid Wren-tit. H.W. Laguna L.L.G. Abundant and breeding Claremont to Laguna, also up in mountains some distance. W.M.P. Pl. VII. Fig. 35.

Regulus satrapa olivaceus Baird. Western Golden-crowned Kinglet. Recorded in winter, San Antonio Canyon. W.M.P.

Regulus calendula cineraceus Grinn. Western Ruby-crowned Kinglet. H.W. Claremont. Metz. Recorded in winter, San Antonio, San Dimas Canyon, Corona. W.M.P. Pl. VII. Fig. 33. Bright red line on top of head.

Polioptila caerulea obscura Ridg. Western Gnatcatcher. H.W. Claremont. Metz. Common and breeding San Antonio Canyon, San Dimas, San Gabriel Canyon, Claremont. W.M.P. Pl. VII. Fig. 32.

Polioptila californica Brew. Black-tailed Gnatcatcher. H.W. Claremont. Metz. Many breeding records. Claremont. W.M.P. Pl. VII. Fig. 31.

Myadestes townsendi Audub. Townsend Solitaire. H.W. Taken in winter. Fairly common in San Antonio Canyon and San Dimas Canyon. Seen in Claremont in winter. W.M.P. Pl. VII. Fig. 36.

Hylocichla guttata nanus Audub. Dwarf Hermit Thrush. H.W. Breeds near Corona, Glenn Ranch. W.M.P. Pl. VII. Fig. 37.

Hylocichla guttata nanus Audub. Dwarf Hermit Thrush. H.W. One bird taken in winter near Claremont which Grinnell thinks is this. W.M.P.

Hylocichla guttata guttata Pall. Alaska Hermit Thrush. H.W. San Dimas Canyon, Claremont. W.M.P.

Hylocichla guttata sequoiensis Baldy. H.W. Sierra Hermit Thursh. Lytle Creek. W.M.P

Planesticus migratorius propinquus Ridg. Western Robin. H.W. Common in winter, Claremont. W.M.P. Pl. VII. Fig. 38.

Ixoreus naevius meruloides Gmel. Varied Thrush. H.W. Winter records, San Dimas Canyon and Claremont. W.M.P. Pl. VII. Fig. 39.

Sialia mexicana occidentalis Towns. Western Bluebird. H. W. Claremont. Metz. Breeding record, San Dimas Canyon. Common in winter in valley. Breeds in higher mountains. W.M.P. Pl. VII. Fig. 40. Purple-blue, rufus on wings.

Sialia currucoides Bechst. Mountain Bluebird. H.W. Many records for winter, Etiwanda, Corona, Chino, Pomona. W.M.P. Pl. VII. Fig. 41. Light blue, greenish blue on throat.

(Contribution from the Zoological Laboratory of Pomona College)

Plate I

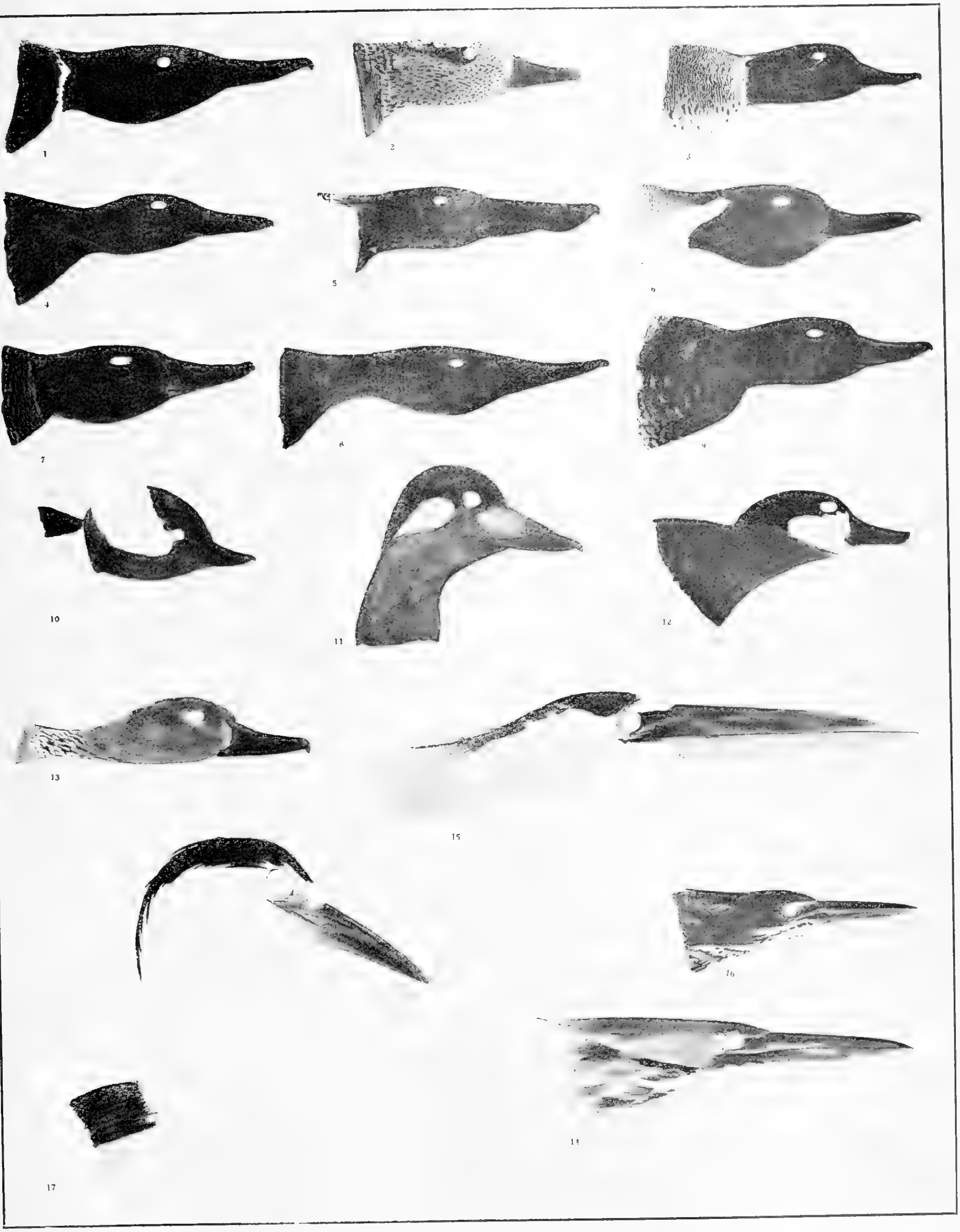
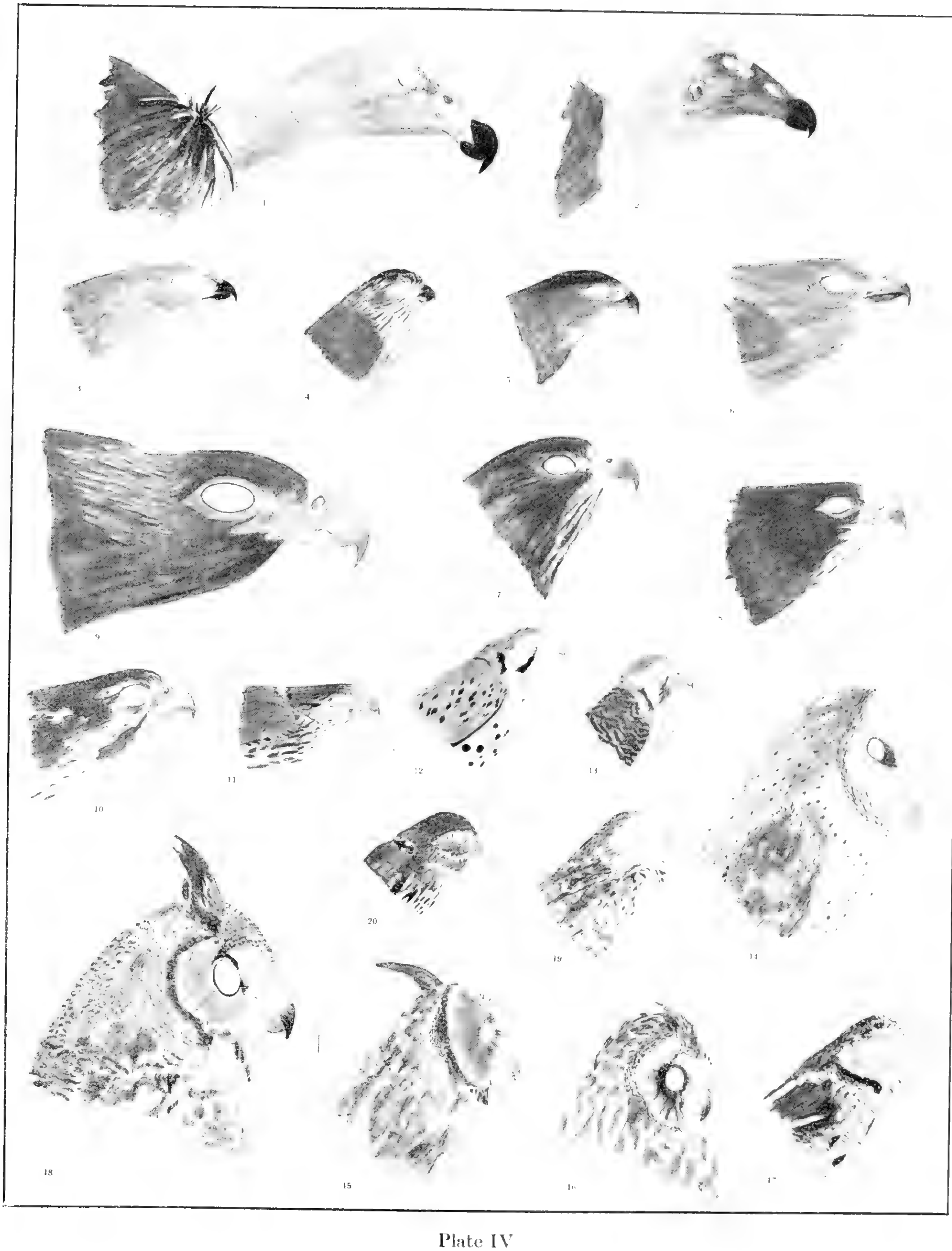


Plate II

Plate III



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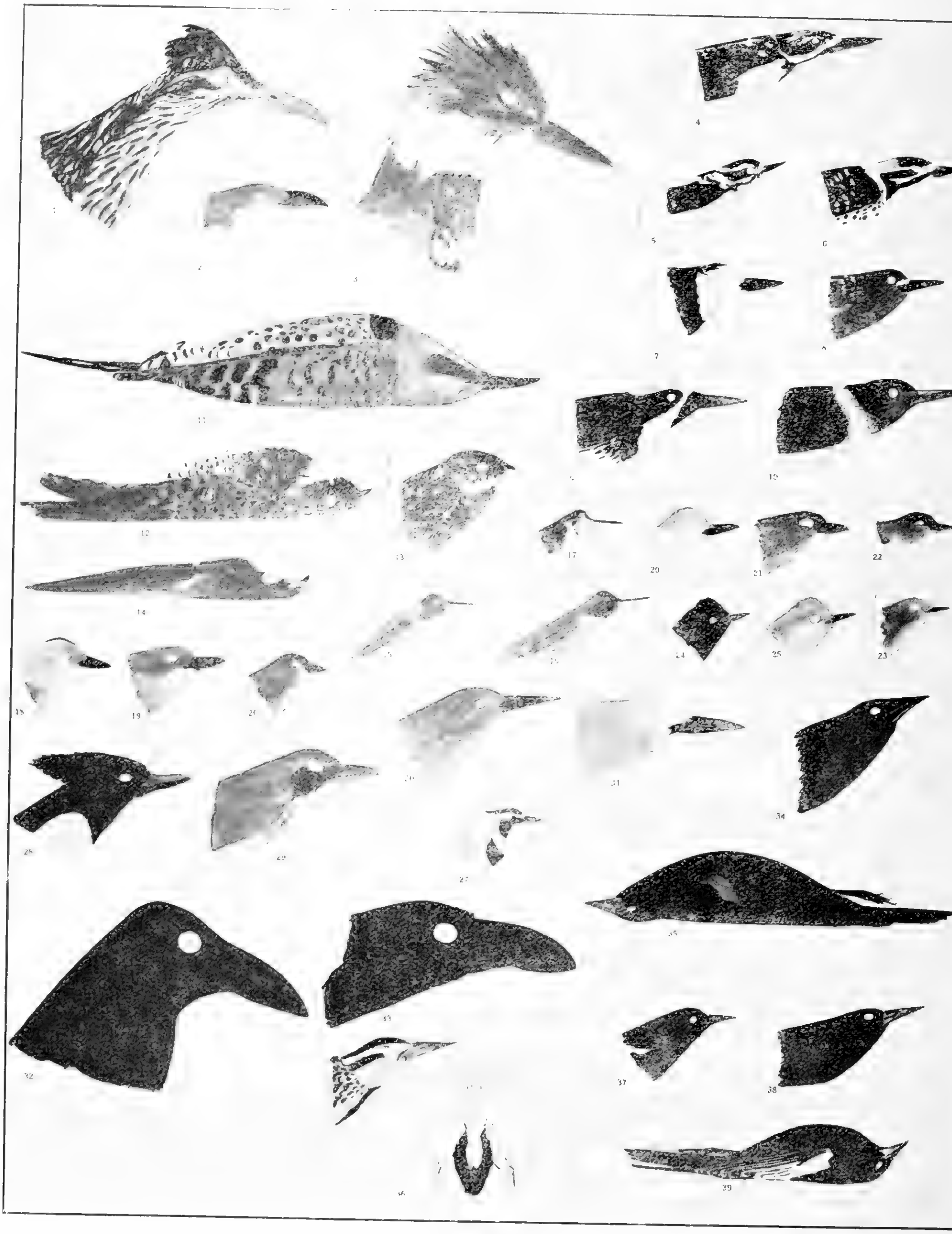

Plate V


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Plate VI

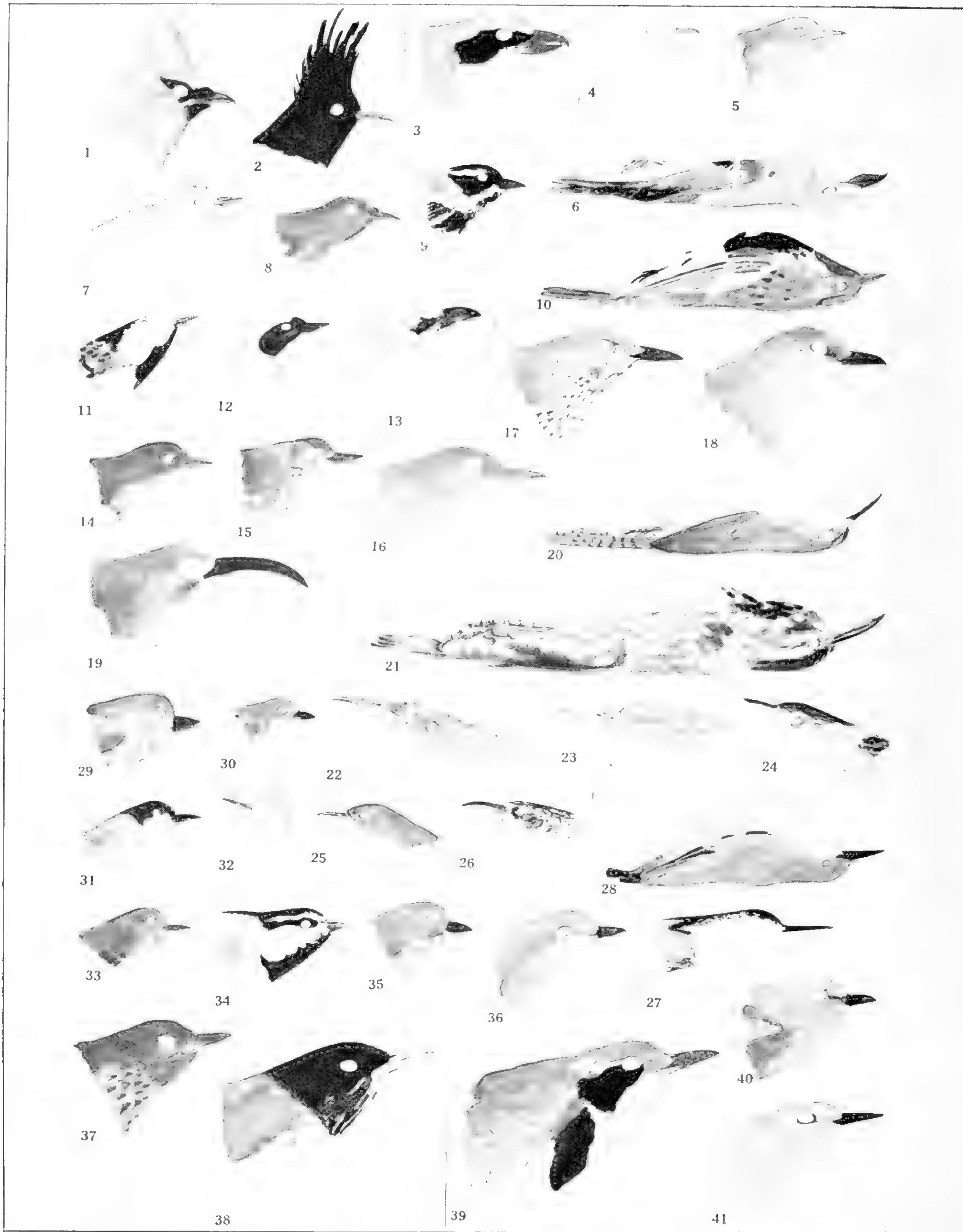
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Plate VII