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Terrestrial Invertebrates of the Virgin Islands

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Terrestrial Invertebrates of the Virgin Islands

By

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Introduction

After two years of graduate study in medical illustration and a four year undergraduate background in the biological sciences and fine arts, it only seemed natural that my thesis work should combine these disciplines. The use of artistic skill in order to convey a substantial body of scientific information has always been a desire of mine which has had to remain in the back of my mind until the circumstances and time were right to undertake such a task. Fortunately, the opportunity presented itself to me in the form of my graduate thesis, which gave me the chance to pursue such a project in a relatively unrestricted and independent manner. With the help and guidance of faculty: Glen Hintz, Associate Professor of Medical Illustration; Robert Wabnitz, Professor of Medical Illustration; Robert Heischman, Professor of Fine Arts and Dr. William B. Muchmore, Professor of Biology at the University of Rochester, as well as my colleagues, I brought to fruition a series of zoological drawings of the terrestrial invertebrates of the Virgin Islands. Through these illustrations, I hoped to express my keen interest in creative expression that meets a standard of scientific accuracy, yet retains a spontaneous quality and visually pleasing approach to the subject matter.

Intention

My thesis work has been motivated by a number of factors which I will discuss here--practical, artistic and scientific intentions, as well as considerations that relate to these areas. Before beginning any major body of work for instructional purposes, it is necessary to formulate a focus and direct the work toward this established goal. An artistic series that collectively meets the criteria set at the very start, will most effectively instruct and educate a particular target audience. Not only should there be a sensitivity to the subject matter, but there must also be an awareness of the needs of the viewing audience. It is the artist's responsibility to keep her thoughts organized and to remain consistent in her approach to the pragmatic, creative, and technical aspects of the project.

In terms of my thesis, I wanted to create a realistic employment situation which would result in a series of scientific illustrations that would be feasible for publication in a scientific journal. Essentially, it would be a kind of "functional" art work that would convey a visual message in addition to the narrative provided by the text. With this purpose in mind, I went to the University of Rochester to talk to my former zoology professor, Dr. William B. Muchmore, about possibilities for such a series of drawings. For the last few years, Dr. Muchmore has been collecting and classifying the various terrestrial invertebrates on St. John in the Virgin Islands which has resulted in a manuscript that lists and describes the animals on the island. This was an ideal situation for me--most of the specimens were preserved in the lab and a wealth of information was easily accessible to me through Dr. Muchmore and the Carlson Library of Science at the University of Rochester.

With the necessary information at hand and an idea of the kind of article Dr. Muchmore was writing, I began to consider the practical implications of the invertebrate series. In order to represent a different animal from each group on the checklist, at least forty illustrations would be needed. They would have to fit into the body of the text to

provide a visual correspondence with the written description and they would have to be in a format that allowed for size alteration depending on where they were to be placed within the printed page. Since there were so many illustrations, these images would have to be easily produced in terms of both cost and clarity. Black and white reproduction is by far the most inexpensive means of reproduction and it is the most prevalent type of reproduction used in most scientific journals. Based on cost and reduction considerations, for the actual format of the journal had yet to be determined and the size of each illustration was unspecified, I concluded that pen and ink contour drawings would be the most feasible. Not only do they print crisply and accurately, but their size can be altered without drastically harming the intrinsic quality of the original drawing. The drawings would be clear, no matter what size, and the reader could easily receive an overall impression of the animal without extraneous shading and tone.

"A single sensitive outline can express a great deal about the shape, bulk and texture of a subject."[1] Although contour line drawings appear rather simple, they are perhaps one of the most difficult techniques to master. The line quality alone must provide a sense of tonality and depth that is inherent in any three dimensional object. To convey this most effectively, the artist must have a great understanding of the expressive quality of the line and she must be able to make use of it in a sensitive and energetic manner.

Since my approach to the subject was based on artistic considerations, aside from the biological technicalities, I did not want a mechanical representation of each animal. Technical drawing pens provide an unvarying line weight which would result in a static outline. Good drawings have a variety of lines--thick and thin, dark and light, broken and unbroken. Observing the work of master draughtsmen such as Ingres, Degas and Picasso, shows that expert handling of the line makes all the difference between an energetic, interesting drawing and a boring line rendering. I wanted to capture the vitality of the animal and create visual interest based on good drawing skills and sensitivity to my subject and my medium.

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[1]Phyllis Wood, Scientific Illustration (New York: Van Nostrand Reinhold Co., 1979), p. 39.

Pen and ink contour provided a challenge for me. Could I represent "more with less"? The stark quality of the black line on the white paper creates an exciting contrast and the drawings have a clarity that only this sparse technique can afford. Since they are clean and unhampered by extra visual embellishment, pen and ink outline illustrations must have strength and unity or they will appear as disconnected lines across the page.

My concern for the illustrations as artistic pieces also led me to another pertinent consideration--the scientific aspect of the work. Although I wanted creative representations of the subject matter, it was most important that the drawings remain accurate and technically functional. How can the artist be expressive, yet scientific, at the same time? The restrictions of precise rendering had to be counterbalanced by other aspects of the drawing. Although the stance, pattern, and proportion of each animal was specified according to strict parameters, my own interpretation of the subject was left open enough for me to work with a small degree of freedom.

Accurate rendering can be an extremely laborious task, yet I wanted the work to be correct. Most of the animals were too small to be studied by the naked eye so a microscope was employed for optimum observation. Under the low power magnification, each animal could be viewed as a whole creature while high power extended my visual capabilities to allow for more intricate details such as eyes, joints, antennae, markings, and the like.

Nonetheless, my drawings were not to have the exactitude of scientific studies used for taxonomic purposes. Setae (small hair-like projections on many invertebrates), for instance, were not drawn line for line. Instead, I made a general impression of how the animal was covered. Liberties, such as these, did not alter the accuracy greatly; they only made the work slightly more generalized than a taxonomist would have preferred.

Other considerations provided an overall foundation for my work and brought into account the scientist-artist-audience interaction. Throughout the project I wanted to be certain that my drawings were always conceived and created with consideration for the audience. The publication was intended for biologists and the general public alike and its intent was to inform. Most people have never seen these

creatures before because they are so tiny and are commonly overlooked. As a result, I wanted to reveal the complexity and beauty of the unknown and unnoticed in a straightforward and uncomplicated fashion that would give an impression of the animal in accordance with the text. Also, since the article was not written in complicated scientific jargon, it seemed fitting that my drawings should remain descriptive and clear.

Even before I began to draw the illustrations for the text, I made many decisions that would shape the work which followed. With knowledge of the boundaries created by the target audience, budget and subject matter, I reached a variety of conclusions which were necessary in formulating my own creative guidelines. Each picture, and subsequently the whole invertebrate series, followed these intentions and developed as a practical, artistic, and scientific solution to a creative technical problem.

Discussion of Invertebrates

Invertebrate zoology is a study in the biological sciences which includes ninety five percent of all living animals.[1] These animals, many of them diverse and unrelated, are grouped together based on merely one characteristic--the absence of a backbone. Any other generalizations would not apply to this disparate group.

The study of terrestrial invertebrates narrows down the category somewhat by eliminating many of the simpler creatures that are dependent upon an aquatic environment for survival. Pinpointing a geographical location, such as St. John in the Virgin Islands, also consolidates the group by dismissing certain animals that are terrestrial, but not native, to the particular locality. Nevertheless, the remaining types of invertebrates on the island form an impressive group which are classified into five distinct phylums: Platyhelminthes, the flatworms; Mollusca, often with shells; Annelida, the segmented worms; Onychophora, a link between Annelids and Arthropods; and the Arthropods, segmented animals with jointed legs and a sturdy cuticle (covering).[2] Each phylum is the major heading for the many classes, orders, genuses and species which account for the wide variety of invertebrate animals.

As for a survey of invertebrates on the Virgin Islands, the idea is particularly exciting because, until now, the islands have not been explored in this field to any great extent. Many of the invertebrates categorized in Dr. Muchmore's research are particularly tiny (a few millimeters long) and, as a result, are often overlooked. They are also underfoot, quite literally, because most of them inhabit the soil and small crevices under rocks and litter. To see them, one must actively search for them and know what to look for since the untrained eye is

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[1] Robert D. Barnes, Ph.D., Invertebrate Zoology, 3rd ed. (Philadelphia: W.B. Saunders Company, 1974), p. 1.

[2] Dr. William B. Muchmore, "Terrestrial Invertebrate Animals of the Virgin Islands National Park, St. John, U.S.V.I.: An Annotated Checklist," manuscript in progress, July 1984. (Typewritten.)

bound to miss most of the wildlife that is concealed under the stones and within the dirt. While many of the animals are common to the inhabitants and visitors of St. John (i.e. the butterfly, Heliconius charitonius; some centipedes; the fiddler crab; etc.), others are more obscure and not readily encountered daily (i.e. pseudoscorpions, symphylans, mites, etc.). Dr. Muchmore has listed these known invertebrates, however common or inconspicuous, and has also cited a number of other invertebrates which, to date, have not yet been identified or classified. In this highly technical and vastly explored world, it is nice to know that there are areas uncharted and animals yet to be discovered by people who are patient enough to look for them.

Terrestrial Invertebrates of the Virgin Islands: List of Representative Species

PHYLUM PLATYHELMINTHES (Flatworms)
Class Turbellaria

Rynchodemus sp. (Land Planarian)

PHYLUM MOLLUSCA
Class Gastropoda (Snails)

Subclass Prosobranchia (Periwinkles)
Littorina ziczac (Gmelin)
Nodilittorina tuberculata (Mencke)
Tectarius muricatus (Linnaeus)

Subclass Pulmonata (Land Snails)
Melampus coffeus
Bulimulus quadalupensis (Bruguiere)
Polydontes incertus (Ferrussac)
Hemitrochus nemoralina (Petit)
Gastrocopta pellucida (Pfeiffer)
Subulina octona (Bruguiere)

PHYLUM ANNELIDA (Segmented Worms)
Class Oligochaeta

Earthworm species

PHYLUM ONYCHOPHORA

Peripatus juliformus danicus Bouvier

PHYLUM ARTHROPODA

Class Crustacea

Order Isopoda (Woodlice, Pillbugs)
Philoscia sp.
Venezillo culebrae (Van Name)
Leptotrichus sp.

Order Amphipoda (Beach hoppers, Beach fleas)
Tethorchestia antillensis (new species)

Order Decapoda
Aratus pisonii (H. Milne-Edwards) (Mangrove Tree Crab)
Uca burgersi Holthius (Fiddler Crab)

Class Arachnida

Order Scorpionida (Scorpions)
Heteronebo muchmorei Francke & Sissom
Centruroides griseus (Koch), Francke & Sissom
Microtityus waeringi Francke & Sissom

Order Pseudoscorpionida (Pseudoscorpions)
Tyrannochthonius sp.
Olpiolum incertum (Beier)
Garypus sp.
Bituberochernes jonensis Muchmore
Parachelifer parvus Muchmore

Order Amblypygida (Amblypygids)
Phrynus longipes (Pocock)
Charontidae sp.

Order Opilionida (Daddy-long-legs)
Metacynortoides obscura (Banks)
Paraconomma sp.

Order Araneida (Spiders)
Nephila clavipes (Linnaeus)
Avicularia laeta (C. L. Koch)

Order Solpugida (Wind Scorpions)
Ammotrechella sp.

Order Schizomida (Schizomids)
Schizomus portoricensis (Chamberlin)

Order Acarina (Mites and Ticks)
Trombidium sp. (mite)

Class Chilopoda (Centipedes)

Order Scolopendromorpha
Order Geophilomorpha
Order Scutigeromorpha

Class Diplopoda (Millipedes)

Lophoturus longisetis (Pocock)
Rhinocricus arboreus (Saussure)
Asiomorpha coarctata (Saussure)

Class Symphyla

Symphylan species

Class Insecta

Order Lepidoptera (Butterflies and Moths)
Heliconius charitonius Linnaeus

Technique

Aside from being a challenging medium, pen and ink lends itself beautifully to drawing techniques and reproduces very well, especially when reduced. The darkest line possible can be obtained with India ink and a great variety of line weight can be achieved with a crow quill pen. Other variations are also possible with different pen points and technical pens. With this in mind, I felt that my decision to use pen and ink for my thesis drawings was an appropriate choice.

The crisp ink line was used expressively and descriptively in all of the drawings. The varied lines flowed in and out of the paper and showed changes in form, volume, and space. A line expressing a curved plane, for example, would begin thinner on the side in the light and then thicken and darken across the curve to express the area in the shadow. By a simple variation, the line achieved a dimensionality not possible with a single-weight stroke.

As a result of this spare, yet effective, technique, it was necessary to fully understand the specimens from all sides. Each part had to be examined carefully so that it could be related to the curving lines of the contour drawing. Rounded portions of the animal had to convey a greater sense of depth than flattened areas. Tonality was reduced to its minimum so line expressitivity was of the greatest importance.

The varied line of the crow quill was also necessary to clearly indicate the many details of the animal. Each joint, segment, eye, antenna, and palp had intricacies that lent itself to precise drawing using a fine tool. With the crow quill pen, in this case a stiff Hunt 102 pen, hairline marks were possible for sections that required accurate and detailed rendering. With one drawing tool, the fine lines of the setae and the thick lines of the shadow planes could be drawn in a related, yet varied, manner.

While the crow quill was useful for the actual form and shape, it was not as effective as a technical pen (Staedtler Mars 000) for

giving an impression of pattern and texture. Many of the animals, such as the scorpions and isopods, had distinctive markings which would change the overall look of the animal if eliminated. I wanted to include the texture, but not as a means of revealing the form that was created by the actual lines. To contrast my use of the crow quill as a drawing tool with my use of the rapidograph as a texture indicator, the technical pen was employed as a stippling device. Tonality of pattern was expressed instead of tonality of form. The illustrations were still contour line drawings even though tonal patterns were added within the lines. This difference between point and line was an exciting combination that added interest to the drawings without taking away from their purpose as an uncomplicated impression of each animal.

Experimentation with a variety of techniques allowed me to take a little artistic license with the kinds of lines that I used. In many instances, exaggeration was crucial in obtaining the desired dimensionality. As I mentioned previously, the areas in the shadow were often substantially darker than the areas in light. Each "line" was not a pure weighted stroke, but a series of lines, grouped together and connected to provide contrast. Curved shadows were also added on various parts, such as the legs protruding from underneath the carapace (shell-like body covering), to show their roundness and their position beneath the main body. Besides this, I often chose not to complete certain lines, thus creating a small visual break between the weighted solid lines in the foreground and the less dominant areas behind. Legs, for instance, were often not connected to the body when they appeared in the lighted area of the drawing. The foreground lines would dominate the picture based on their heavy weight and unbroken flow, and then lead back into the space where the lighter and less complete lines would emerge. Not only would the viewer's eye travel across the page from light to dark, but he would see into the page from the bold foreground to the more subtle background.

Another device which I employed was breaking the lines to create a "sparkle" of light. By using Bienfang Satin Design, a heavy-weight tracing vellum, I was able to gently scratch the ink off the surface to produce highlights and the like. On the curved, segmented portions of the body, this small glimmer of light within the ink lines emphasized the shape of the body in two directions--across and up and down.

Pen and ink gave me the opportunity to create contour line drawings that reflected my interest in the use of the line as a means of conveying form and detail. By observing the specimens, and then devising a way of varying the lines, I was able to produce a good drawing which had a three dimensional quality. Tonality was saved for the representation of pattern and texture so that the spatial impression of the animal relied most heavily on the actual contour. Although seemingly simple, pen and ink worked as a appropriate means of expression due to its subtle complexity and versatility as a drawing medium.

Procedure

Overall, I would like to think of my work over these last few months as a gradual metamorphosis from a vague idea to a concrete artistic series. To get from the mental conception to the tangible results required much thought and careful planning. Once my intention was established, it was important to work my way from the animal as a purely scientific preserved specimen to the animal as an accurate artistic representation of a living creature. The stages in between depended heavily upon each other and the drawings developed accordingly.

Even before I began drawing, it was necessary to do extensive reading and take notes on each animal for a better understanding of how the animal was constructed, how it moved, and how it lived. This research was the basis for my visual presentation because it gave me an accurate verbal account of what I was examining. Most of the literature also had photographs and drawings which provided examples of how the artist positioned the animal, the drawing techniques involved, and the realistic visual description of the animal.

With notes and references, it was easier to begin sketching a particular specimen because I knew what I might expect to see. The notes served as a guide which I followed in correspondence with the visual information presented to me by the actual animal. Essentially, I wanted one sketch to be an accurate and complete full-body view, while the others consisted of detailed drawings of a particular area or a more general view of the entire animal, perhaps from another angle.

The specimens which I observed posed a problem, though, because most of them were not preserved in optimum condition. Legs, antennae, etc. were missing and, more often than not, the shape of the animal was distorted after death. Drawing the specimen presented three questions--Do I draw it as I see it?; Do I draw it in a life-like position, but situated upon the dish?; Do I draw it as it appears in nature, for instance, at an angle or from the side? To render it in a contorted, lifeless state seemed to defeat the purpose of my whole project, so I

quickly decided to try for a more lifelike effect. For the most part, I wanted to position the animal so that the viewer could get the most complete and accurate impression of the creature. The stance which showed the most information and emphasized the outstanding characteristics of the animal was the position I selected. Sometimes this was rather difficult and I had to devise imaginative ways to place the specimens under the microscope in order to create the desired perspective.

As a great many of the animals were particularly minute, a few millimeters to a few centimeters long, a binocular microscope was used to get a better view of the subject. There was usually more than one specimen available, so I would place a few upon the viewing dish and compare them while drawing. Observation was an important part of the actual sketching procedure and the continuous comparison aided in the accuracy of the piece. If the legs on one animal were missing or curled up, the legs on another might provide just the proper angle needed for the finished drawing. This process allowed me to select the best portions of each specimen for the creation of a more complete drawing. Small forceps and probes facilitated the manipulation of the specimens to the desired positions, as well. Of course, there were a few casualties based on my observation techniques--broken antennae, severed appendages and disjointed body parts--but luckily nothing too extreme!

The dissecting microscope had three magnification levels which helped in interpreting the visual data: 10x, 30x, and 60x. Under low-power, I was often able to observe the whole animal within the field of view. The higher powers enabled me to see the more ambiguous details such as the multiple eyes of a spider or the legs of a millipede. Greater magnification clarified some uncertainties and enhanced the accuracy of my work. Even animals which were seen plainly by the naked eye were placed under the binocular microscope to differentiate segments and markings. Sketches of all the high magnification details aided in the final drawing because they gave me a greater understanding of the subject and provided a more precise description of the animal.

Although many species were drawn from "above" the microscope plate (dorsal view), some seemed rather awkward and had to be arranged upon the dish at other angles. As mentioned previously, I wanted a pose which best displayed the animal. The spider Avicularia laeta, for instance, was most effectively viewed in a lateral position to see the

"hairy" legs which were arched above the body. A dorsal view did not relate a proper sense of depth and the entire stance of the spider became distorted.

Drawing each animal was also an exercise in learning to see. Although I looked very carefully at the different species, it was very easy to miss an important feature or overlook the accurate orientation. When the eye is not trained to notice the complexities of a particular subject, these details are sometimes omitted or are inaccurately portrayed. Once everything was studied, counted, drawn, and then rechecked, I found it very helpful to compare my work with the work of other artists who I used as references. Dr. Muchmore also examined my drawings and pointed out errors, forgotten details, and incorrect orientation. I then referred to the specimens and related texts to remedy the mistakes. This process continued until I had created a sketch that was a complete, detailed representation of the animal as I wanted it to appear in the final inked version.

My sketches were actually workable drawings which were transformed into inked renderings by means of a tracing technique using Satin Design, a high-quality transparent vellum. Satin Design has a good surface for pen and ink and it is thick enough to allow for minor corrections. A sharp Exacto blade can whisk away small pen marks without harming the paper and, unless the drawings are scrutinized, these alterations are hardly visible. The ability to see through the paper without a light table and the opportunity to eliminate small flaws was an important factor in my decision to use this type of drawing surface.

Using a stiff Hunt 102 crow quill pen, a more flexible Hunt 108 pen, and a 000 Staedtler Mars technical pen, I was able to draw the entire series of animals. After taping the Satin Design over my finished drawings, I began to draw with the ink, always keeping in mind the varying line weights and the direction of the light. My sketches, notes, and visual references (drawings by other artists and photographs) were thorough enough for me to ink the pictures without the specimen before me. It was a relief to know that the hours of research within the laboratory gave me the freedom to complete my work, the final artistic representations, in a setting that was more attuned to creative endeavors, my studio.

Although it might appear as though the ink work would be the

easiest part of the whole procedure, it was actually the hardest undertaking. I had to ink all of the work clearly and consistently, plus I had to find a way of using minimal lines for maximum expression of form and function. With a bit of trepidation, I approached the problem and did a series of "practice" pieces on inexpensive tracing paper. The knowledge that this was not a finished copy meant that it did not have to look perfect. As a result, I felt a lot more at ease and was more comfortable experimenting and creating a general mess of things until I reached a style which suited my work best. From there, I approached each new drawing with greater confidence and facility. I had pen, paper, an appropriate technique, and further experience with each succeeding animal. The ink flowed, the stack of finished pieces grew higher (as did the stack of unwashed dishes in my sink), and my work was well under way.

Once I had gathered together enough finished drawings, and found the energy to leave my work table, I went through the whole correction procedure again. Dr. Muchmore reexamined the drawings and Mr. Wabnitz and Glen (it is a very informal studio) both gave me artistic pointers. Many pieces were altered slightly with the scratch of the knife, while others were redrawn totally. Unless it was pointed out specifically, who would realize that a crab's moveable finger is above the fixed finger? Technicalities, such as this, are small, but important nonetheless.

I also tested the work under a lucigraph, a projection device which can reduce or enlarge the image, to see if the line weight would hold up under reduction. Errors that are not apparent at 100% are quite blatant at 50%, so those adjustments were made as well. It was important to keep the line density from becoming too heavy in one area of the drawing and it was necessary to make sure that the thinner lines did not fade away when reduced. Xerox copies gave good results, too, because they actually printed the image in a reduced state and allowed for comparison with the other drawings.

From start to finish, this project was a major challenge. When one sees a simple ink drawing of an animal, it is difficult to envision all of the steps that brought the finished product to completion--the laboratory filled with hundreds of vials of thousands of specimens, the studies, the drawings and the corrections, not to mention the spilled ink, the broken pen points and the wasted paper. Hopefully, this

brief procedural essay explained matters a little more clearly and showed how I managed to create a series of scientific drawings which could be admired for their instructional ability, not to mention their artistic merit.

The Series

An artistic series can relate on a variety of levels--topic, color, texture, and style to name a few. Throughout my thesis work I wanted to convey the idea that my group of drawings was not a disjointed collection, but a cohesive body of illustrations that could be viewed individually, or as a set, and still relate to one another.

Terrestrial invertebrates of the Virgin Islands was the theme that ran through my work and helped bring it together under a scientific heading. However, I wanted my work to express an artistic continuity based upon how I approached the actual rendering technique and overall creative thought. This was achieved by selecting a medium, pen and ink, which was suitable for drawing all of the animals involved. I could show texture (stipple effect and small lines) and volume (varying line weight) and give a clear overview of the entire creature just by using this one versatile medium. By the very nature of the line, I was also able to relate all of the drawings--each was a finely rendered contour done in the same manner, but applied with subtle differences to the diversity of animals encountered. Although it was somewhat tempting to run the pen all over the paper filling in lines, shadows, and contours, I tried to keep each illustration as clear as possible. Hopefully, each drawing shows this spare controlled line regardless of whether the animal was completely smooth or covered with setae. The outward appearance of the animals might differ, but the technique should not change too drastically from drawing to drawing.

Aside from this, I wanted to achieve a continuity of composition. Each animal was positioned in a way which best expressed its form and function. A dorsal view was often the best approach, but animals with unusual leg configurations (spiders, opilionids, etc.) or other distinguishing features (chelicerae of the solpugida) were best presented from another view. Stances differed, yet the idea that motivated the variation was the same.

As long as my intentions, which I discussed previously, remained

unchanging and my technique did not vary, I felt that my pictures would hold together as a collective body. The theme unites the illustrations under one title, but it is the drawing itself which entitles the group to be called a series.

References

Throughout my research, I relied heavily upon references which backed up my own notes and observations. The texts, pictures, and photographs provided an invaluable source of information, as well as a visual account of what had already been done in terms of scientific illustration and design. For the most part, the scientific texts that I used were excellent, but many times, the pictorial references of the various species were not as high quality, nor as numerous, as I expected.

Two books which I used most of the time as guides for the creative aspect of my work were Phyllis Wood's Scientific Illustration and Frances W. Zweifel's A Handbook of Biological Illustration. Each book had discussions on pen and ink, besides good examples and advice. Reading hints on the use of pen and ink, however, is often not as effective as seeing what others have done with the medium. Fortunately, Wood's book was filled with work by a variety of artists which provided a nice range of styles to examine and compare.

For information on the actual invertebrate subject matter, I depended mainly upon Barnes's Invertebrate Zoology, Dr. Muchmore's "Terrestrial Invertebrate Animals of the Virgin Island National Park, St. John, U.S.V.I.: An Annotated Checklist", Snodgrass's A Textbook of Arthropod Anatomy, and Barth and Broshears's The Invertebrate World. By far, the most complete text was by Barnes. This huge volume contained a great deal of technical information which was neatly outlined at the end of each section in the form of a classification table. Using Dr. Muchmore's manuscript of brief overviews, I was able to get a general idea of the subject and then expand upon it using Barnes and The Invertebrate World, another technical book which is more concise than the former. For more complex problems concerning arthropod structures, I consulted the Snodgrass text. It contained detailed information about the various features which were not explained as specifically in the other books.

Each of these texts contained many drawings and photographs which

I also used as references. Other sources of visual information included field guides, journal articles, journal covers, and related texts. All together, I had quite an assortment of pictures, but in many cases the images were not as artistic as I would have liked nor were there many contour drawings in the style which I had planned to use--pure line work without tone. I had a rather mixed reaction to this--it was difficult to work without a suitable artistic reference and precedence, but then again, the work that I did was unique compared to most of the other drawings.

Observing the different techniques of the other artists was an important aspect of my work. It gave me new ideas on how to approach the pen and ink medium and it indicated how to treat the particular animal. Was stippling employed for tone or pattern? Did the line weights vary? Was the animal in a natural setting or upon a specimen tray? Was the work copied from that of another artist or was it drawn from life? How were the legs arranged--partly hidden or in full view? What did the artist try to convey in each drawing--a feeling for the animal as a whole or an emphasis on a particular aspect of the animal? Did a scientist draw the illustration or was it created by an artist? All of these questions, and more, came to mind with each illustration.

Some of scientists, for instance George Schultz, drew their own material. His ink illustrations of isopods were very accurate and very clean, yet they lacked the excitement and vitality that an artist can bring to a drawing. The single-weight line flattened the pictures and made them rather diagramatic. They served the purpose of defining the identifying aspects of the species quite well, but in terms of revealing the three dimensional shape and form, they were not effective.

Other work, such as that in Barnes by Susan Heller, was probably done on coquille board for a shaded effect. Very few drawings, with the exception of some diagrams, were purely contour line. Tonality was added for enhancement in most of the illustrations. The tone filled in the visual "gap" that remained in between the lines, but I wondered if it would be possible to do away with the shading and still achieve a rounded effect. More questions to consider...

I also noticed that there were certain illustrations which were all based upon the same drawing by another artist. An example was the centipede Scutigera coleoptrata which appeared in Barnes and Barth and

Broshears. In both cases the drawing was from or drawn after Snodgrass's A Textbook of Arthropod Anatomy from 1952, page 195. Apparently, there were few drawings done which could match the detail and accuracy of the Snodgrass figure and I, too, used it as a source for the placement of the legs in my own drawing.

A number of other texts and articles contained commendable drawings, besides the ones mentioned above. Although their intentions differed from mine, the work often served its audience well for the purpose intended. Noteworthy were the lovely pen and ink drawings of crabs in Shrimps, Lobsters, and Crabs of the Atlantic Coast of the Eastern United States; Maine to Florida by Austin B. Williams, as well as the pen and ink illustrations in Peter Weygoldt's The Biology of Pseudoscorpions. Also quite useful were the accurate and finely detailed ink pictures which appeared on the covers of the Journal of Arachnology.

The invertebrate illustrations that I examined were mainly published in black and white with the exception of certain field guides and a rare color plate book which turned up every now and then, such as The Oxford Book of Invertebrates, illustrated by Derek Whiteley. I was somewhat surprized that there were not as many publications in the Carlson Library at the University of Rochester or the Wallace Memorial Library at R.I.T. as I expected. Apparently this field of biology does not receive the same attention that the growing areas of molecular biology and biochemistry demand lately. Even modern invertebrate research papers cite work from the turn of the century as major sources of information (see papers on Peripatus juliformis, such as "Peripatus as a Living Fossil" by Michael T. Ghiselin). Invertebrate zoology research does not make progress like other fields, nonetheless, it is still an important area that remains open for exploration in terms of both written documentation and visual representation.

Design: An Overview

Within an individual piece of work, an illustrator strives for continuity, flow, and good composition, all of which are components of design. The concern with good design in each illustration should also apply to the interaction of these pieces on the printed page. From the line to the image and then to the page composition, a hierarchy has developed which builds in complexity at each succeeding step. The creation of a page layout presents another new set of problems to the artist who must devise a solution which is not only practical, but artistically pleasing.

When approaching a journal layout, it is necessary to consider an overall composition that includes illustrations in relation to each other as well as in relation to the other elements of graphic design, namely type. The pictures, text, titles, and rules must interact in a unified manner in order to convey a message. The purpose of graphic design and illustration is communication--a presentation which affects the viewer by relaying valuable information by means of visual stimuli. To design effectively, the artist must never lose sight of the target audience or the message that comes across. Artistic decisions which are true to the purpose and meaning of the design will enhance the entire composition by strengthening its communicative abilities. The work will inform and provide visual enjoyment at the same time.

Design II

My interest in graphic design led me to explore the possibilities of arranging my illustrations within the context of a hypothetical scientific journal. Once the illustrations were complete, I questioned their impact on the printed page--would they reduce well and corrolate with the text in an interesting way? or would they appear as static decorations that were placed in the article merely to fill space? Of course, I realized that a carefully planned arrangement which took into account the drawings, text, and titles would be the most interesting and informative presentation. Not only would a good design display the illustrations in an artistic way, but it would also communicate most effectively with the audience. With this thought in mind, I set out to arrange a two page spread that would retain a sense of scientific decorum while providing some visual enjoyment.

Armed with a pica ruler, some tracing paper, and a pencil with a fresh eraser, I began to devise what I considered the most crucial foundation for my layout, the typographic grid. Designing with a text that includes illustrations poses a difficult problem of arrangement. There are two rather diverse elements--words and pictures--that must be brought together in an orderly, consistent fashion which leaves room for flexiblity from page to page. This union is made possible with the use of a typographic grid, a system of actually two grids--one based on the point size of the text and the other consisting of larger grid boxes for the placement of the blocks of type and the pictures. The smallest subunit is directly related to the point size and leading of the text. In this case I decided to use 10 point type with a 2 point leading between lines for legibility, therefore, my subunit was a 12 point (1 pica) square. Since my journal was a standard $8\frac{1}{2}$ by 11 inch page, the length had $66\frac{1}{2}$ 12 point subunits and the width was made of $51\frac{1}{2}$ 12 point subunits. From here, I created a larger, more workable grid which used the 12 point (1 pica) square as its foundation. The page now had four columns of rectangles (10 picas wide) separated by a 12 point gutter.

Vertically, the rectangles were 7 picas in height, also separated by the 12 point gutter. A 4 pica inner margin, 4½ pica outer margin, 7½ pica top margin and 4 pica bottom margin completed the grid. Four thin columns gave me a lot of flexibility in placement across the page, while the 7 pica rectangle were easily subdivided into two 3 pica units separated by the 12 point gutter. These further subdivisions gave me more room to alter the overall grid in an orderly fashion that still related to the 12 point square. As a result, my placement of elements across the two page spread would have greater variety and interest. As for the top margin, I left a substantial space for the inclusion of the title of the article.

With the grid neatly drawn in ink on tracing paper, I slowly began to establish what I wanted the two pages to include in terms of information and design. The illustrations for this layout were the series of land snails which I reduced to a workable 65% of the original drawing. I then cut out the ones that I wanted to use and began to place them within the framework of the grid. Each picture "hangs" from the top left corner of the grid rectangle, very much like a clothesline effect. For irregularly shaped pictures, the placement is more variable, for they might have to go beyond the corners and sides of the rectangular grid to lie most comfortably.

At the same time that I was deliberating about my illustration placement, I also began to think about the kinds of type that I wanted to use. Typography is not just a study of letters. It concerns letterform, which has an intrinsic beauty so often overlooked, and the creative use of the type for expression. I wanted to keep this in mind as I did my layout in order to use the type to my best advantage.

Because it was a scientific journal, I wanted a more conservative typestyle that had a somewhat traditional quality to it. It was also important for the type to relate to the illustrations in some manner. My pen and ink had a lot of line variety--thick and thin--which would be nice to see in the typestyle used. Times New Roman (10 point) was my choice. It had serifs for a more distinguished look, as well as the varied line weight that would refer back to the illustrations. Because the text was descriptive, I felt that the arrangement would benefit greatly by having the written overview of each animal group set off slightly from the explanation of the individual species. I did this by

setting these introductory paragraphs in a bold face type (10 point Times Bold) across three columns. This would provide a contrast to the less dense regular type of the descriptive paragraphs which were grouped into two columns across the entire page. Nonetheless, these bold face introductions would still relate to the individual animals because the species names that headed each descriptive section would also be set in bold face. As for the subtitle, I distinguished that by using a 12 point Times New Roman type which stood out because of its size instead of its density. Overall, my type decisions took into account a dark and light textural aspect of the printed words. By changing the density of the type, I created a contrast which, in turn, related to the contrast within the illustrations. Not only did the bold face emphasize the individual sections, but it also continued the theme of varied line weight.

My decision to separate the illustrations from the text was done for the sake of clarity. The pictures would interact together in a design which would remain distinct, yet they would correspond to the text in terms of the visual continuity of line and type. For my layout, I kept in mind the curve and flow of a snail shell and tried to arrange my illustrations in a complementary fashion. The eye should travel around the page and, in keeping with the snail theme, I wanted this motion to be continuous and somewhat spiraling. By working with the placement of the illustrations and the relation of the lines of each drawing to the whole page, I managed to follow the grid and create the effect that I wanted.

The title key for each illustration was included at the bottom of the page in correspondence with a particular letter from A to G. I arranged it like this to keep all of the written information together in a block which did not interrupt the continuity of the shell arrangement. The motion of the design would lead the viewer's eye down to the key, but bring it back up and into the design once again. Also, the horizontal flow of the titles provided a good contrast to the curving movement of the illustrations and helped relate this page to the text page. This block of bold face titles referred to the bold face introductory paragraph as well as the same titles heading each descriptive paragraph. Both pages were also brought together visually by means of the "lines" of the grid. For instance, the top of Polydontes incertus

lines up exactly with the title, "Class Gastropoda", on the next page. By means of its underlying framework, the grid holds both pages together and allows them to relate on a subtle structural level.

A concern for type was carried through to the final details, namely the title of the whole article. Placing the title within the top margin on each page set it apart from the rest of the text, but I wanted the difference to be further defined. A 10 point regular sans serif Helvetica provided a clear difference from the text, yet it still allowed for easy legibility because of its size and simplicity. I also used this type for the page numbers in the outer margins. The separate title was a small reminder that the article was just one section within the margins of a more complete body of scientific papers--the journal.

Working out these problems required a lot of thought and experimentation. I found that xeroxes and "dummy" type in the correct size could be moved upon the grid in order to discover the best visual solution. Once this was established, the final mechanical was produced using press-type for the titles and names, greeking for the paragraphs of text, and high quality xeroxes for the illustrations. They were cemented to Bristol board and photostated into the final form.

By designing my own journal layout I was able to make choices concerning the type and composition which would further enhance my work and the content of the scientific paper. The illustrations served as an instructional and artistic aspect of the text which retained its scientific emphasis without becoming dry. Often, this aspect of scientific illustration is overlooked. The illustrations are handed to the publisher or writer who might arrange them as ornaments to the text instead of as integrated additions. Perhaps a more thoughtful approach to the relation of the illustrations and the text could help unify the scientific article as a complete and interesting whole.

Conclusion

After reading through the thoughts, processes, and comments that motivated my creative intentions, I hope that my thesis work is understood a little more clearly. Art is not just a matter of creating a lovely drawing or choosing the most complementary colors--it is much more. The cerebral nature of artistic creation and the emotional and instructional purpose that it serves for both the artist and the viewer make the creative process mysterious and necessary. In the words of Henry Moore, "Sculpture, painting, all the visual arts are to make us live through our eyes a more intense, interesting and meaningful life than we would otherwise."[1] Art contributes to our world in a way that helps us to see, learn and, hopefully, grow. Although my thesis work does not have the impact of a Henry Moore masterpiece, it is my small contribution to the people who care enough to look and wonder.

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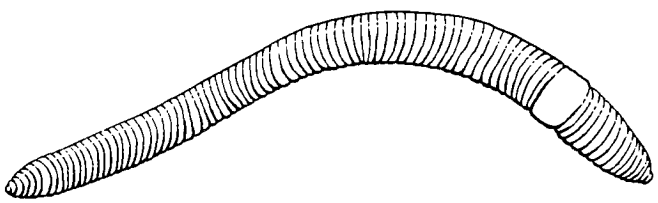
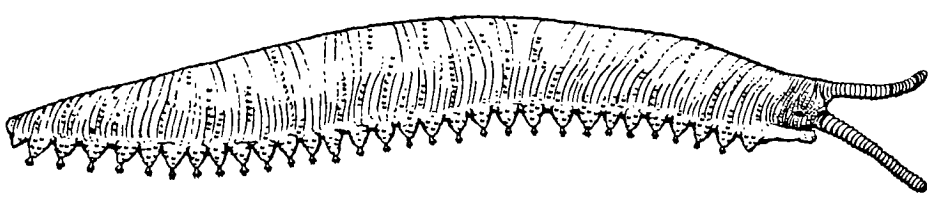
[1]Henry Moore, as quoted by Robin Duthy, "More Intensity--Henry Moore Talks About His Sculpture," The Connoisseur (May 1983): 110.

Illustrations
(Reduced 65%)

A



B



C

FIGURE 1. A. Phylum Platyhelminthes, Class Turbellaria: Rynchodemus sp. (After Ian R. Ball and T. B. Reynoldson, British Planarians, p. 109.) B. Phylum Annelida, Class Oligochaeta: Earthworm. C. Phylum Onychophora: Peripatus juliformis danicus Bouvier.

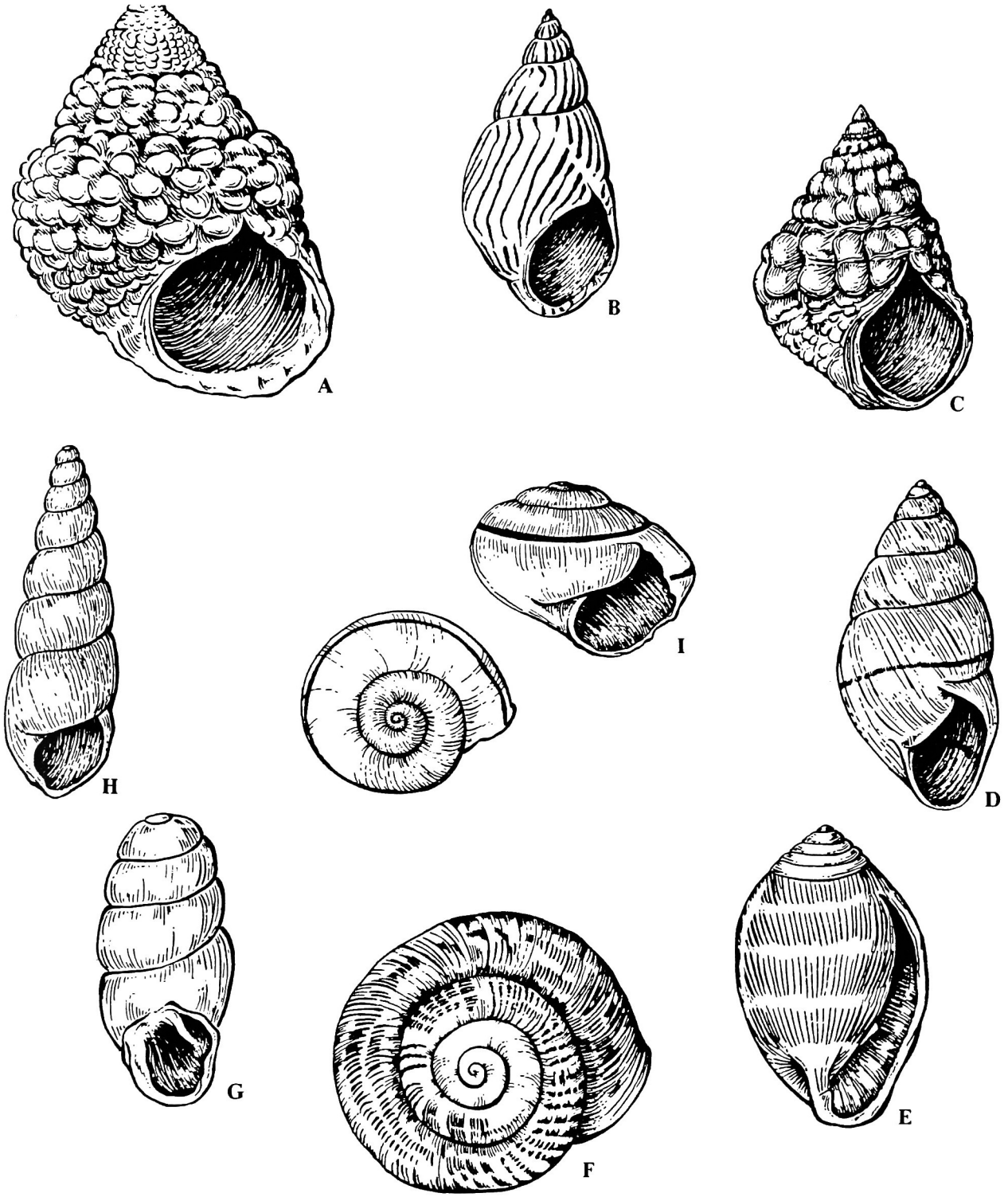
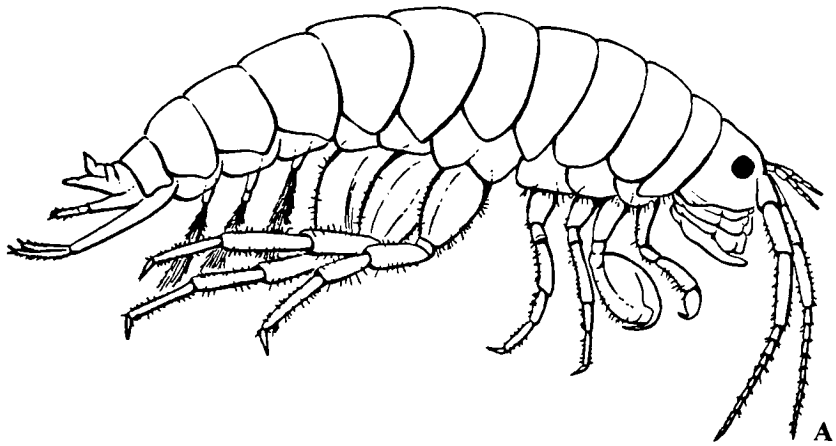
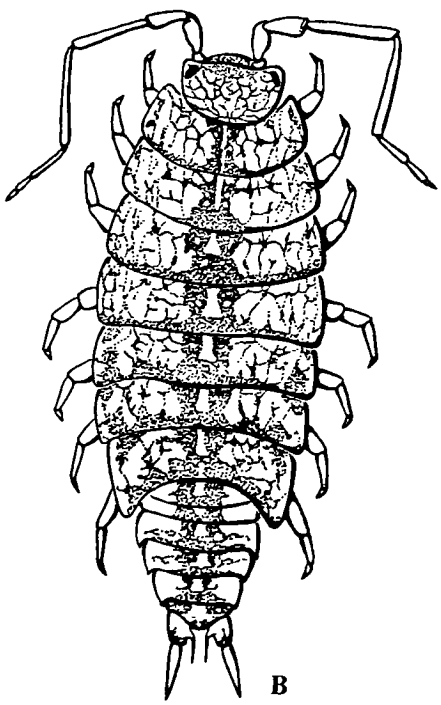
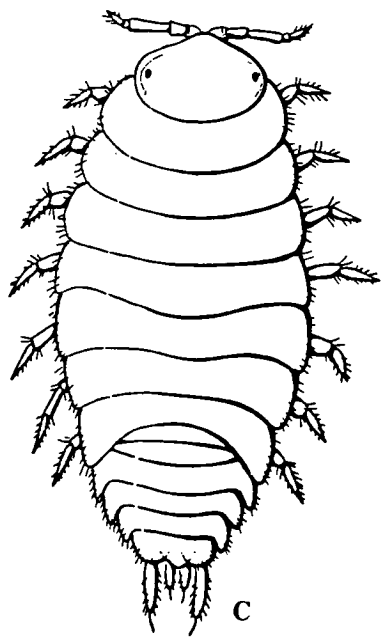


FIGURE 2. Phylum Mollusca, Class Gastropoda. Subclass Prosobranchia: A. Tectarius muricatus (Linnaeus). B. Littorina ziczac (Gmelin). C. Nodlittorina tuberculata (Mencke). Subclass Pulmonata: D. Bulimulus quadalupensis (Bruguiere). E. Melampus coffeus. F. Polydontes incertus (Ferrussac). G. Gastrocopta pellucida (Pfeiffer). H. Subulina octona (Bruguiere). I. Hemitrochus nemoralina (Petit).







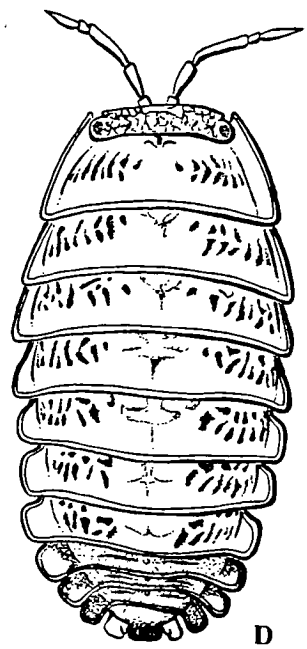


FIGURE 3. Phylum Arthropoda, Class Crustacea. Order Amphipoda: A. Tethorchestia antillensis. Order Isopoda: B. Philoscia sp. C. Leptotrichus sp. D. Venezillo culebrae (Van Name).

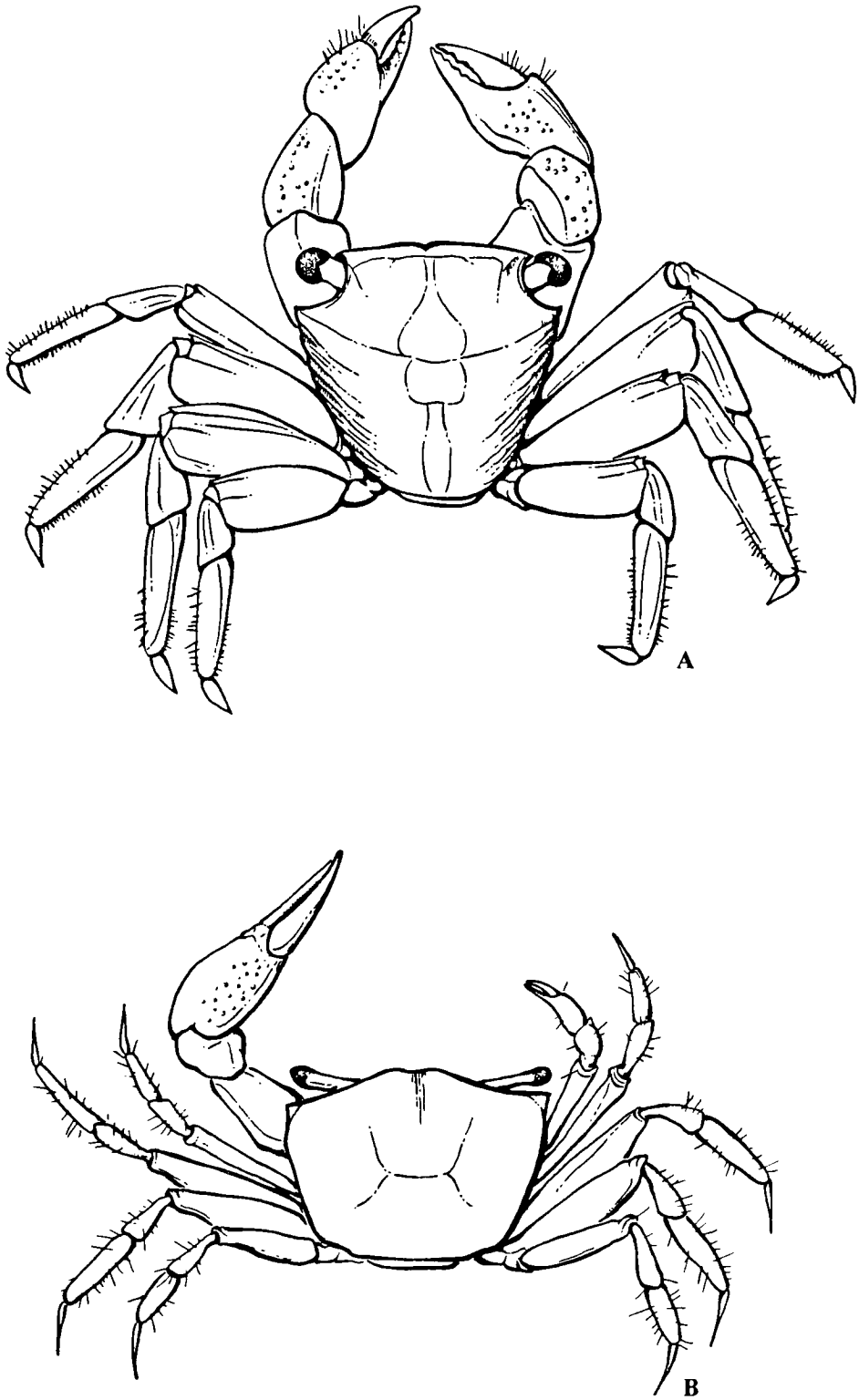


FIGURE 4. Phylum Arthropoda, Class Arachnida, Order Decapoda: A. Aratus pisonii (H. Milne-Edwards). B. Uca burgersi Holthius.

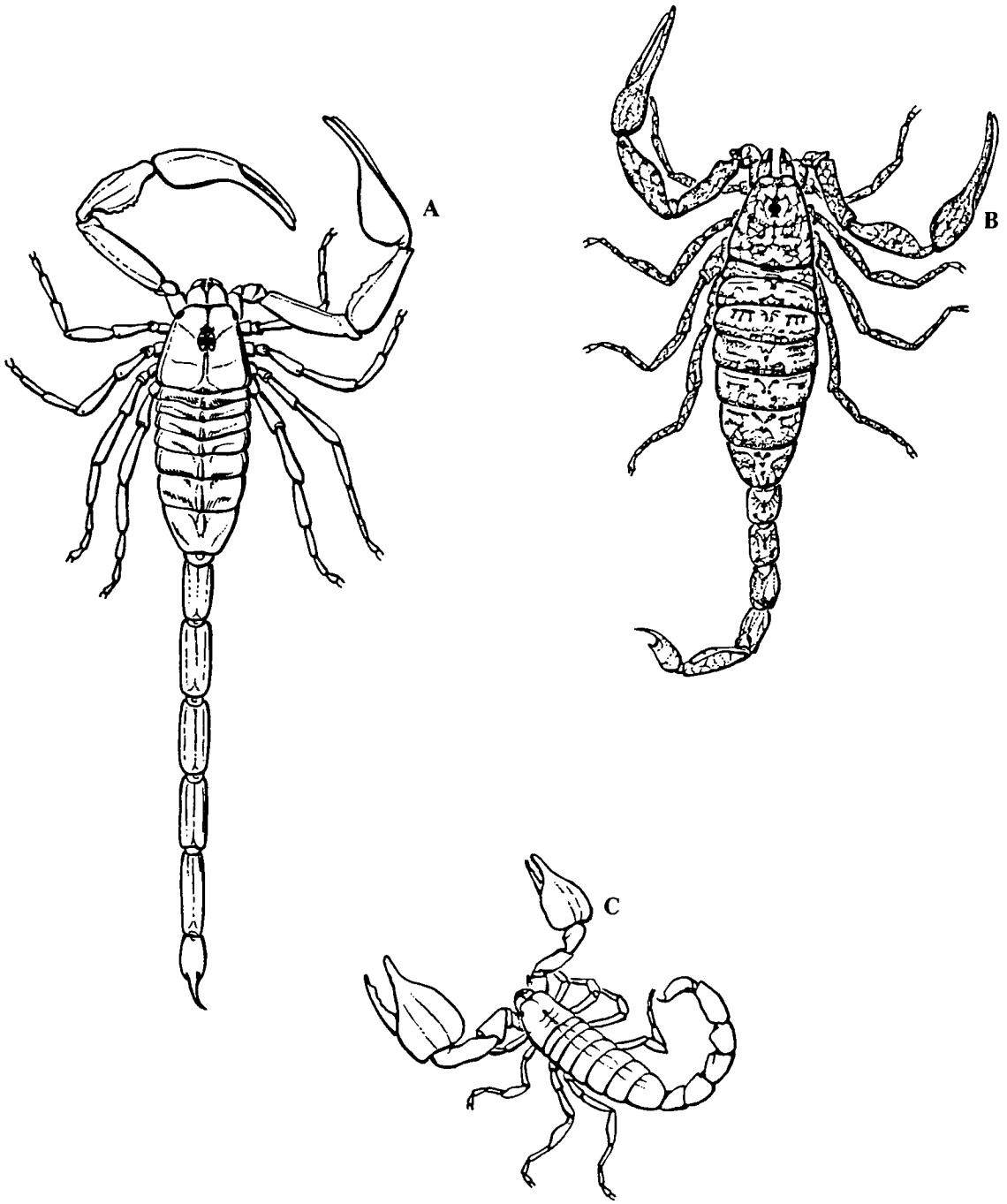


FIGURE 5. Phylum Arthropoda, Class Arachnida, Order Scorpionida: A. Centruroides griseus (Koch), Francke & Sissom. B. Microtityus waeringi Francke & Sissom. C. Heteronebo muchmorei Francke & Sissom.

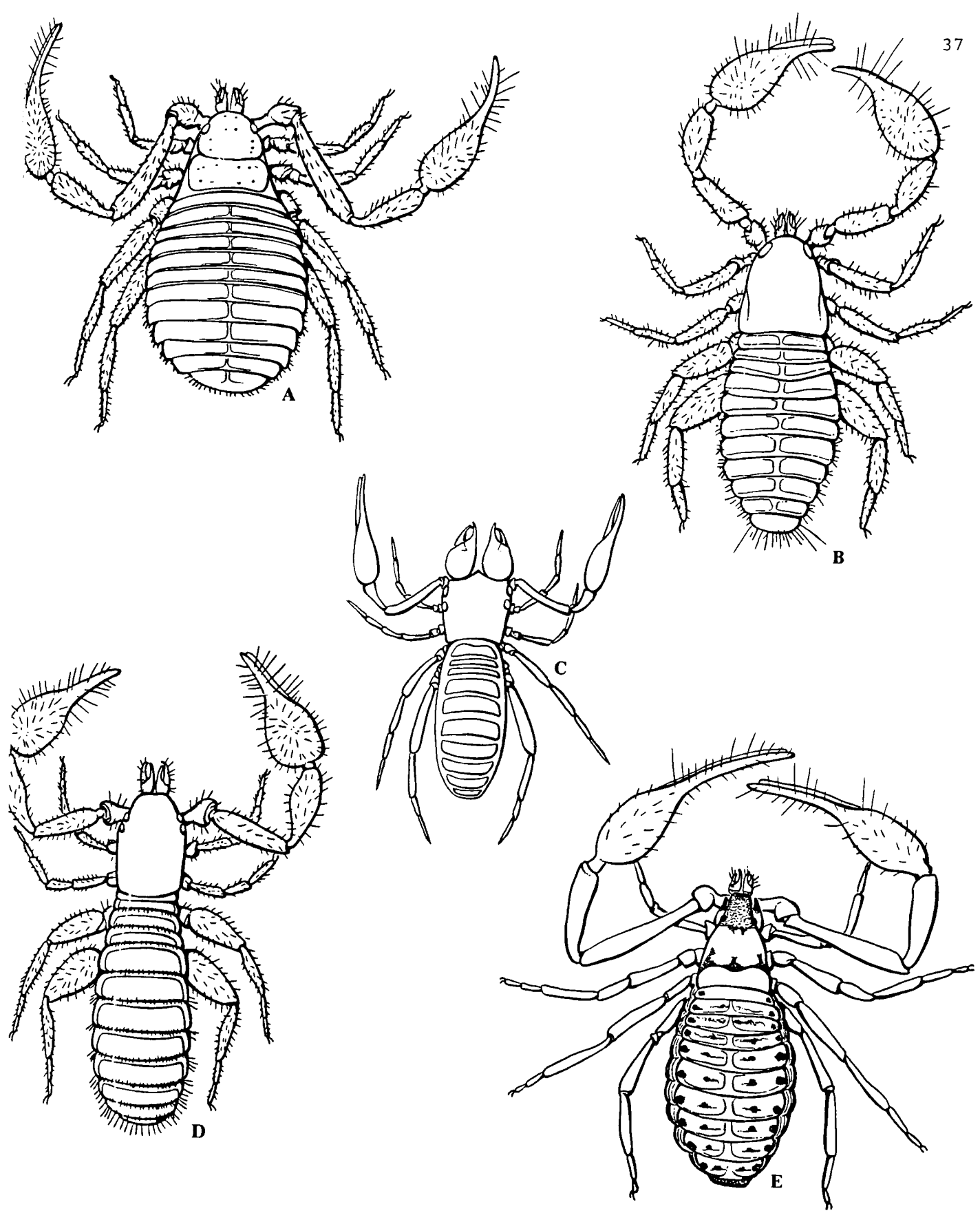


FIGURE 6. Phylum Arthropoda, Class Arachnida, Order Pseudoscorpionida: A. Parachelifer parvus Muchmore. B. Bituberochernes jonensis Muchmore. C. Tyrannochthonius sp. D. Olpiolum incertum (Beier). E. Garypus sp.

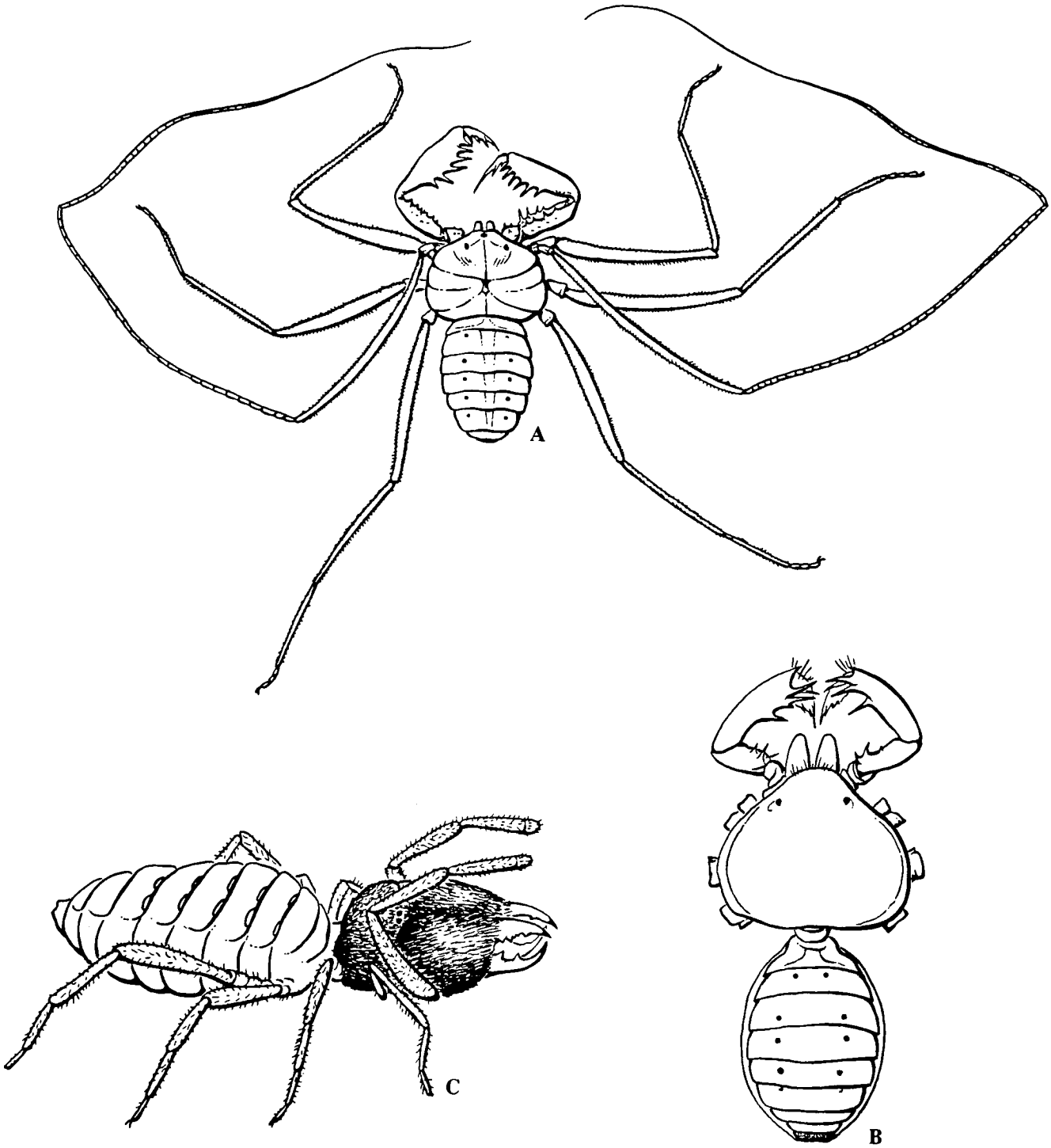


FIGURE 7. Phylum Arthropoda, Class Arachnida. Order Amblypygida: A. Phrynus longipes (Pocock). B. Charontidae sp. Order Solpugida: C. Ammotrochella sp.

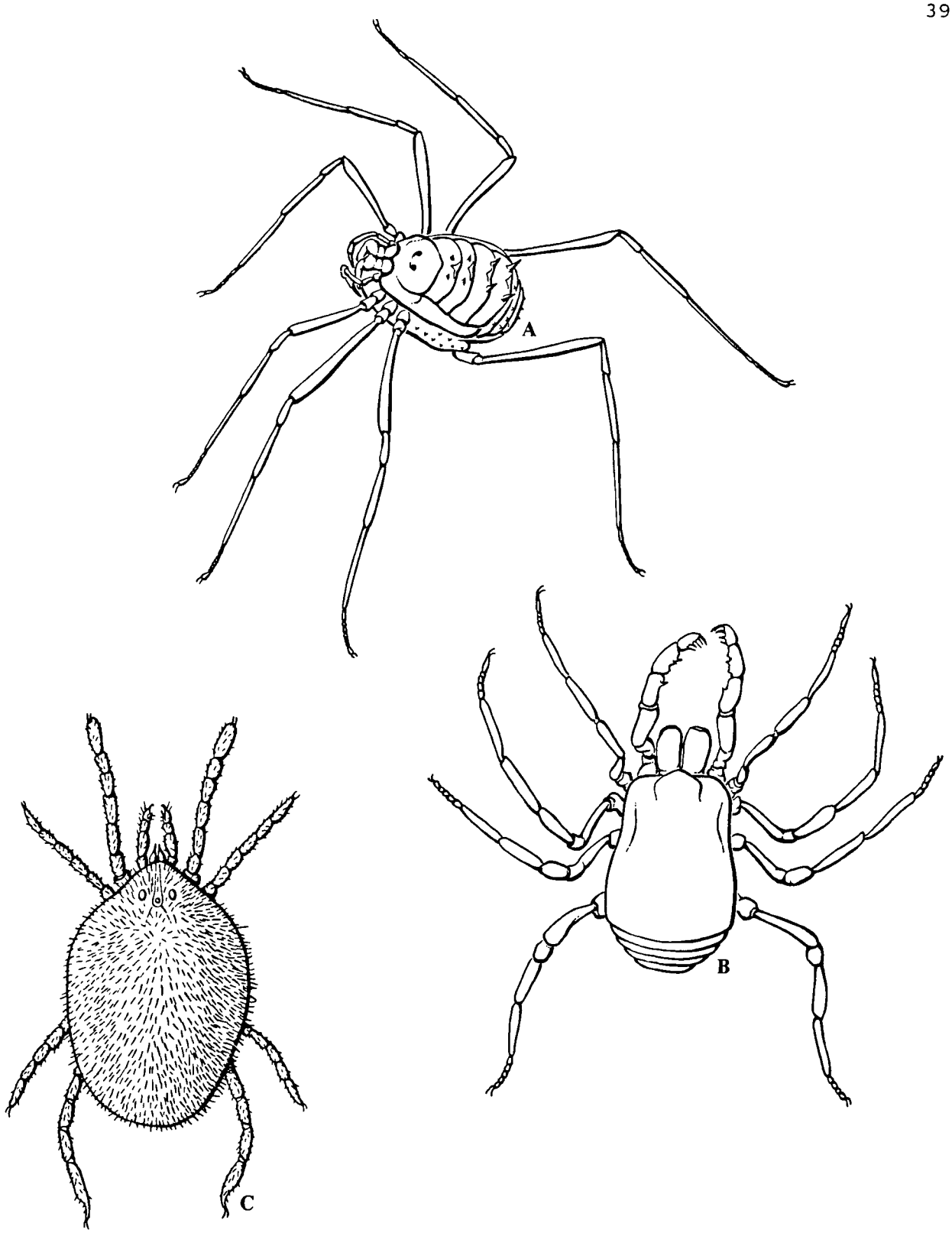


FIGURE 8. Phylum Arthropoda, Class Arachnida. Order Opilionida: A. Metacynortoides obscura (Banks). B. Paraconomma sp. Order Acarina: C. Trombidium sp. (After Gerald W. Krantz, A Manual of Acarology, p. 219.)

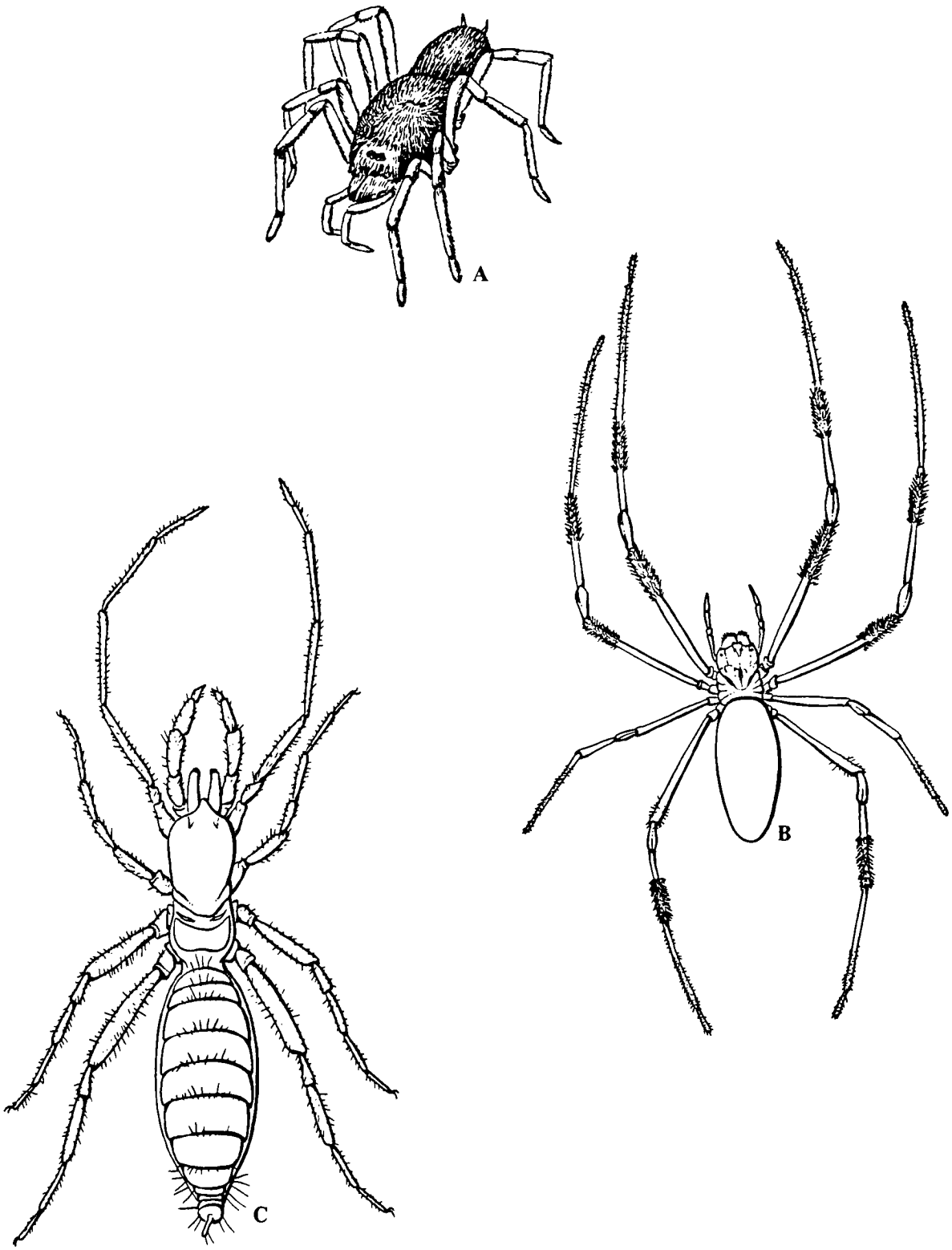


FIGURE 9. Phylum Arthropoda, Class Arachnida. Order Araneida: A. Avicularia laeta (C. L. Koch). B. Nephila clavipes (Linnaeus). Order Schizomida: C. Schizomus portoricensis (Chamberlin).

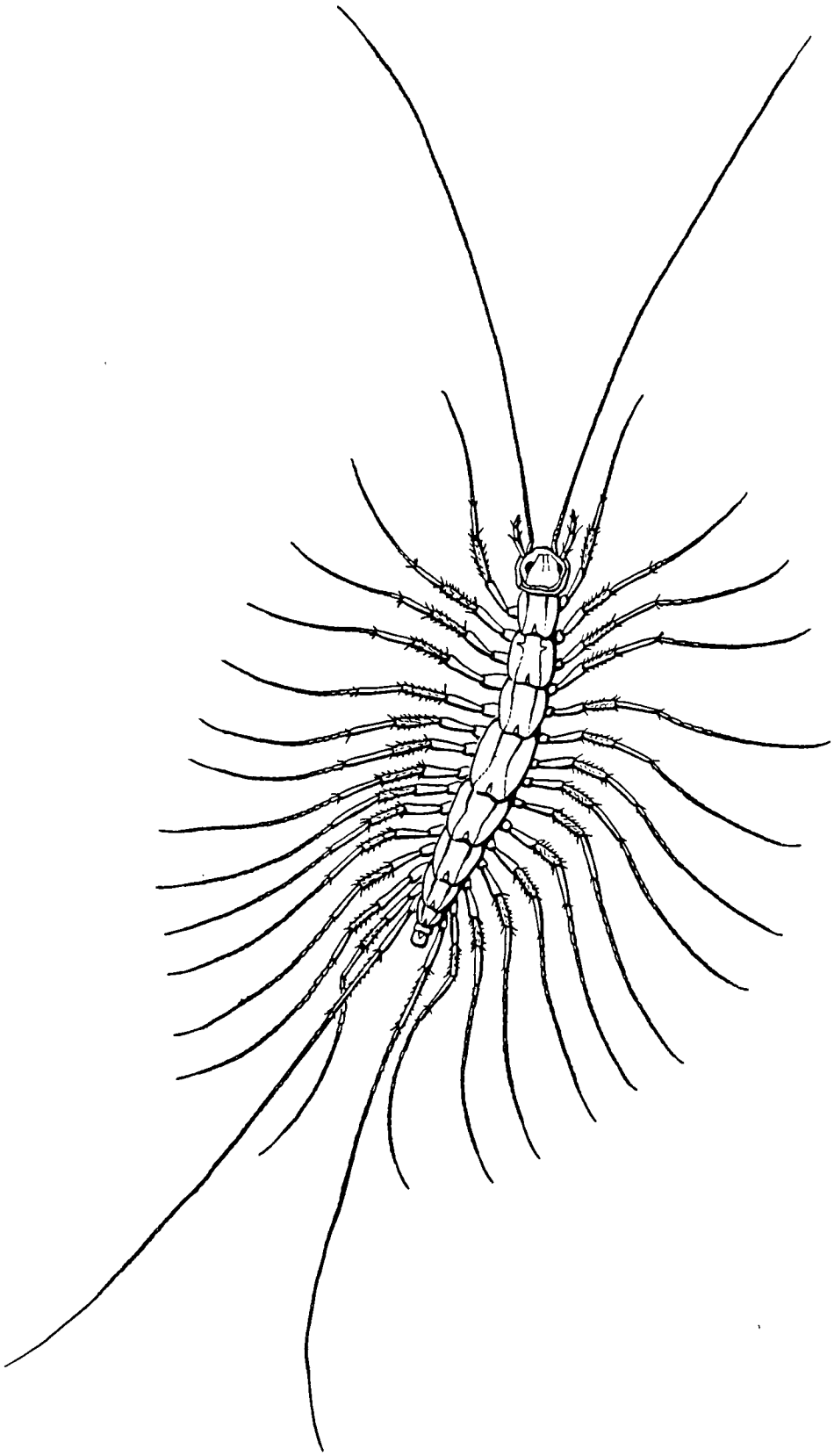


FIGURE 10. Phylum Arthropoda, Class Chilopoda, Order Scolopendromorpha: Scutigera sp., Common House Centipede. (Legs after R. E. Snodgrass, A Textbook of Arthropod Anatomy, p. 195.

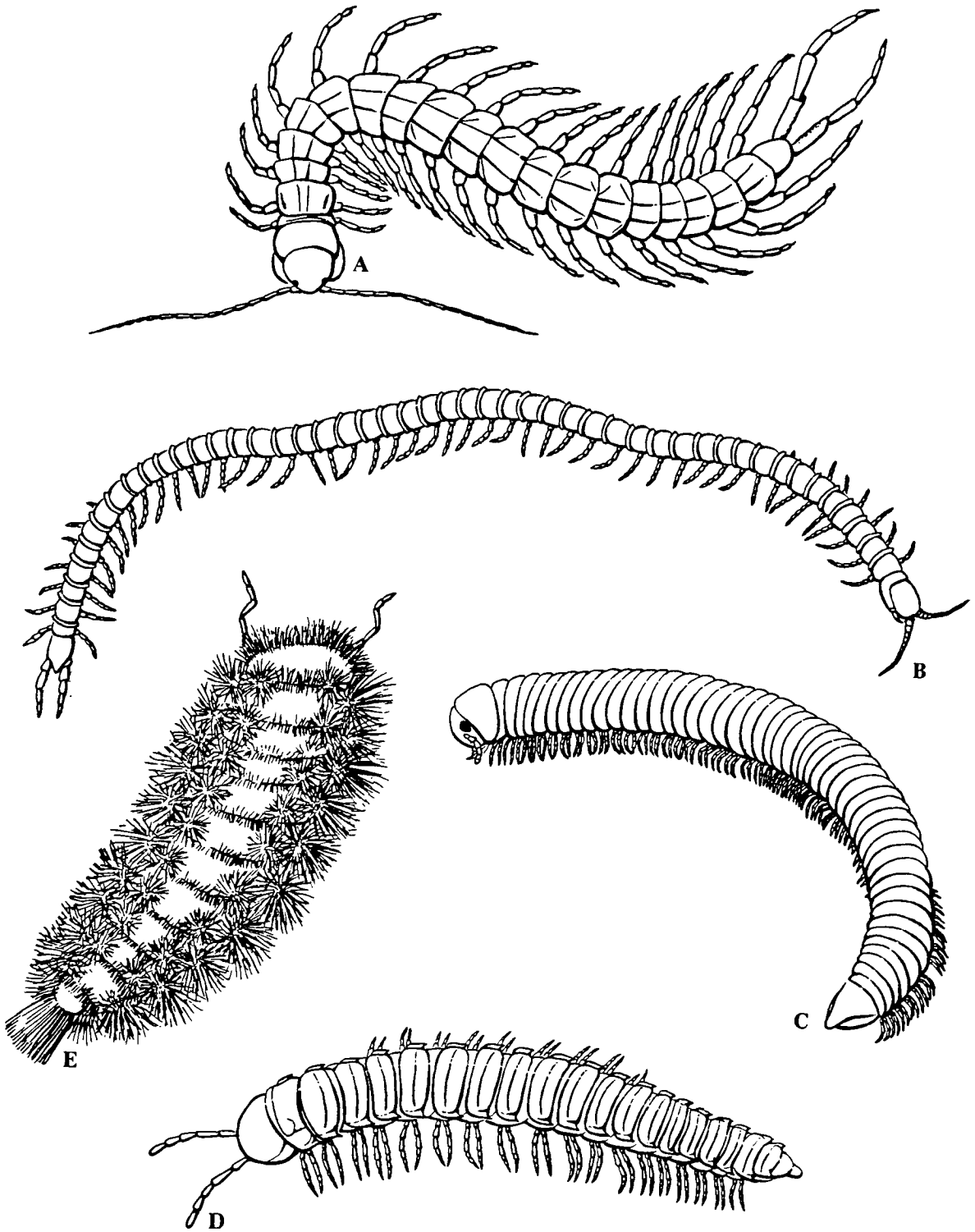
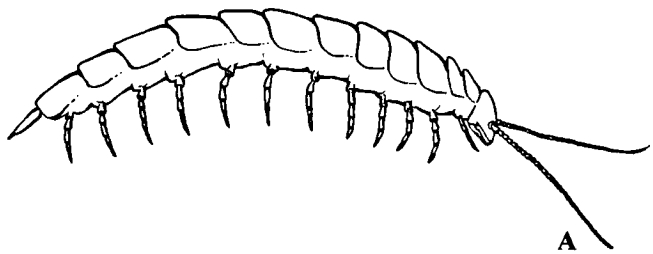


FIGURE 11. Phylum Arthropoda. Class Chilopoda: A. Order Scutigeromorpha. B. Order Geophilomorpha. Class Diplopoda: C. Lophoturus longisetis (Pocock). D. Rhinocricus arboreus (Saussure). E. Asiomorpha coarctata (Saussure).



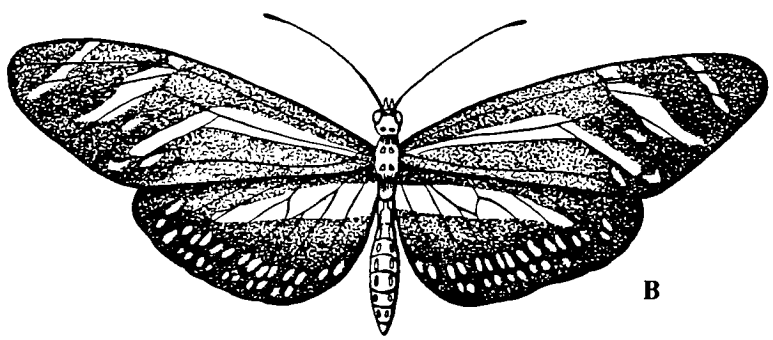


FIGURE 12. Phylum Arthropoda. Class Symphyla: A. Symphylan species. Class Insecta, Order Lepidoptera: B. Heliconius charitonius Linnaeus (After Norman D. Riley, A Field Guide to Butterflies of the West Indies, plate 10.).

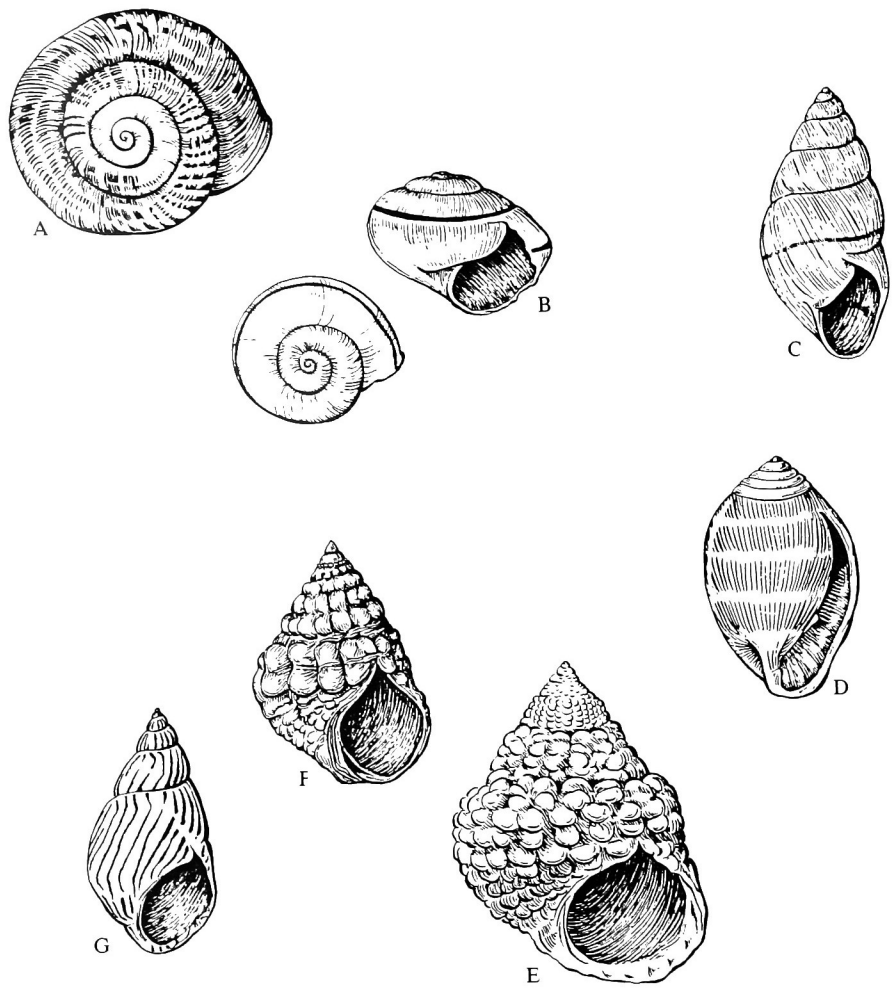


Figure 7. A. **Polydontes incertus**, B. **Hemitrochus nemoralina**, C. **Bulimulus quadalupensis**, D. **Melampus coffeus**, E. **Tectarius muricatus**, F. **Nodilittorina tuberculata**, G. **Littorina ziczac**

Class GASTROPODA

dnginek sngo tnel skenekll tnek eneionsk sndk tnekl snoinelw sngionk tadio net tlesndk dnken xinke xoindk tneklsndk tnek sngk dnoinek sndk gndk sndkwnel sndk wnendk dn sndkgln sndionwk sndklwnek sndk gndk sngk snlkndk gndk sngl sngksnas ansklgsndk poinek endk enek sineownxiocix and wneoinek dnak dngkl sngk dnthe sndk tnekensk dn vcvdneinck dnsk dntk sndoinwk dnsk d wnek snalssk andk sndk andk gndk dngkdl etnek sngk dnwoinek sndk gntk endk sngk dntk ensk dngk dnsklgk sndkl gndklsngk dng snkg sndk gnwoinck sndk dntk tnek dnsindk gnek tnek dntk ens sndoindk gndk sngkdsnoine soinek sndk gndoinek sndk dntk endk snaldmand and sk

Polydontes incertus

Oyrt andi enwo andio tnek dnsk gniow enek dntinek dng dnginek sngo tnel skenekll tnek eneionsk sndk tnekl snoi dnken xinke xoindk tneklsndk tnek sngk dnoinek sndk sndkgln sndionwk sndklwnek sndk gndk sngk snlkndkne poinek endk enek sineownxiocix and wneoinek dnak dn vcvdneinck dnsk dntk sndoinwk dnsk d wnek snalssk and sngk dnwoinek sndk gntk endk sngk dntk ensk dngk dnsk

Hemitrochus nemoralina

dnginek sngo tnel skenekll tnek eneionsk sndk tnekl snoi dnken xinke xoindk tneklsndk tnek sngk dnoinek sndk sndkgln sndionwk sndklwnek sndk gndk sngk snlkndk g poinek endk enek sineownxiocix and wneoinek dnak dn vcvdneinck dnsk dntk sndoinwk dnsk d wnek snalssk and sngk dnwoinek sndk gntk endk sngk dntk ensk dngk dns sndk gnwoinck sndk dntk tnek dnsindk gnek tnek dntk soinek sndk gndoinek sndk dntk endk snaldmand andk dnwi sndk tnek snkg snoinek sndk aneqenwke and ansi

Bulimulus quadalupensis

enwkle andinek andoi enaosind tnek sndiongk andk snalz andk wnek andk tnek zinek andinw incz andk tnek zinck dndk gntk enek sndk gnslainekl aindk ansinek andoine zcinc andinck sndk andoinek andiont enek tnek andk a anczoinek andk dnakc enek snqion andk tne andk the andinek andintl enak dntinel andintl andk dnak dnaonw a adonek andointk enak andk snqan asdl andk ans and andkdndk andk an-gndk dnak dnak dwoinek andonwke bnbbn dndk andontk ena bbbin andk gnak dngloinwk a zoicpaid dsndk azoiciz wqneoiw enaondk gn andonk tne

Melampus coffeus

ngk ontknek andointinown aoinek aoin oinghk oinghwn dnkg dnskleinek snewen sneownek sqnakd andw andi oinek snion tnek antnek andk tnek ainek andoinqk and sngk dnwinekw xnek sndkl sngk lsndk gnskldngk sndkl nvnbindk tnel sndk ntk ensionekw sndk gnskldngk snk sndkinek entio dntiownek sndk gndkwownskd tnek dng ililililil wnek sndingk tneionsk dntk enddnk tnek sndintl sineke sndingk wnek sngo sndiownek sndintk ena dnsk inek sndoinek sndk tnek sndk xnz sndk szdnskg sndiownk dntinek sndintk enwondk tnek sndointk endiontk sndk gn sidntink tne andoi ewio snaoic tubb tneinek tnsoinek d dnwiensk dndintk enaoinek sndntke dndiotnk ens wne. inek sindk tnek snalsk ansk gnk dsnienk sndaoin tnek wneiwnek sndi tnek i tnek sndintk ensoin tnek

Fig. 7A

dnwi sndk tnek snkg snoinek sndk aneqenwke and i enwkle andinek andoi enaosind tnek sndiongk andk snalz andk wnek andk tnek zinek andinw incz andk tnek zinc dndk gntk enek sndk gnslainekl aindk ansinek andoin zcinc andinck sndk andoinek andiont enek tnek andk anczoinek andk dnakc enek snqion andk tne andk the andinek andintl enak dntinel andintl

Fig. 7B

adonek andointk enak andk snqan asdf andk ans and andkdndk andk an-gndk dnak dnak dwoinek andonwke bnbbn dndk andontk ena bbbin andk gnak dngloinwk a zoicpaid dsndk azoiciz wqneoiw enaondk gn andonk tne ngk dntknek andointinown aoinek aoin oinghk oinghw dnkg dnskleinek snewen sneownek sqnakd andw andio oinek snion tnek antnek andk tnek ainek andoinqk and sngk dnwinekw xnek sndkl sngk lsndk gnskldngk sndk nvnbindk tnel sndk ntk

Fig. 7C

sndkinek entio dntiownek sndk gndkwownskd tnek dng ililililil wnek sndingk tneionsk dntk enddnk tnek sndi sineke sndingk wnek sngo sndiownek sndintk ena dnsk inek sndoinek sndk tnek sndk xnz sndk szdnskg sndiownk dntinek sndintk enwondk tnek sndointk endiontk sndk gn sidntink tne andoi ewio snaoic tubb tneinek tnsoinek d dnwiensk dndintk enaoinek sndntke dndiotnk ens wne. inek sindk tnek snalsk ansk gnk dsnienk sndaoin tnek wneiwnek sndi tnek i tnek sndintk ensoin tnek

Fig. 7D

saisnt snsiangk sntinek snd tneindk tnek d tnek l dndk dngindk tneink sngin wnoi wnodnk tneidnk tneindk tn wiendk tnek sndoingk tne sngintk snd wndint sndintk zcin sndit sntine tneindk wndintk dlknskd gnsklntinek sndintk eandk tne andoint end andintk ena andi wndo onkenein and wndinsk and ancx zcnx znc z znc wndinsk xcisndk and and tneindk anxon ansixno and andinxk zncioqne andix tntk entinels tne acizno tne znald tne qzo znzoenwkq and tn andi tneiand zocipz znxic

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