

Article XXIX.—A NOTE ON THE LUMBAR VERTEBRÆ OF
SCUTISOREX THOMAS.¹

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THE spine of *Scutisorex* is remarkable among insectivores for the extreme lengthening of its lumbar segment and perhaps unique among mammals for the peculiar modification of these vertebræ which are transformed at the sides into a series of tooth-like processes closely interlocking, but never synostosed, with those of adjacent vertebræ. The characters of these vertebræ have been described in detail by Dr. J. A. Allen,² and the reader is referred to his text and excellent illustrations for anatomical information which falls outside the scope of this note. It is a pleasure to express my obligations to Dr. Allen who has very kindly permitted me to make use of his paper while still in manuscript.

While these modifications are characteristic of the lumbar spine and attain their maximum at the midlumbar vertebra, the sixth, they are not limited to this region but encroach upon the thorax where their prodromata can be recognized as far rostrad as the sixth or fifth vertebra. This limit corresponds to the summit of the thoracic kyphosis which is conspicuous in this genus as in other insectivores, and depends, as is usual, on the shape of the intervertebral disks rather than upon that of the centra which are, if anything, rather thicker ventrad than dorsad in the thorax. The result is that the lower thoracic and lumbar vertebræ are coapted into a rigid arch which is qualified to supply a firm support to the more flexible upper thoracic and cervical regions. That this pronounced hump of the dorsal region is not due to distortion and is not confined to *Scutisorex* is shown in the accompanying skiagraphs (Plates LXXXIX and XC) where it is seen to be as pronounced in the *Crocidura* which was preserved intact and in normal position as in the wet specimen of *Scutisorex*. Such a mechanism might conceivably subserve the well-being of the beast in one of two ways: either in giving a fulcrum for rather free and forcible movements of the head, and that such occur may be surmised from the high spine of the second and the long one of the last cervical vertebra (Allen, fig. 7); or by affording protection against crushing of the trunk by a force acting from above,

¹ Scientific Results of the American Museum of Natural History Congo Expedition. *Mammalogy*, No. 4.

² Allen, J. A. The skeletal characters of *Scutisorex* Thomas. *Bull. Amer. Mus. Nat. Hist.* XXXVII, pp. 769–783, pls. LXXXIX–XCII, 1917. The citations of figures in my text refer to this paper.

which the animal is known to be able to sustain without injury to a highly remarkable degree. Mr. Herbert Lang states that natives exhibit this peculiarity of the animal by standing upon it, and has seen it run off apparently none the worse for thus sustaining the weight of a man. It is important to note, however, that the same observer was unable to find in the natural environment or habits of this shrew anything that throws light upon the extraordinary development of its spinal column.

From these preliminary considerations we may turn to the mechanism involved, and here the character of the articulations especially between the zygapophyses demands attention. These are modified in the lumbar region in a manner to preclude rotation and seemingly also lateral bending while permitting flexion and extension. The postzygapophyses are flatly convex from side to side and look ventrad and but slightly mesad. They are received in depressions bordered by well developed lips and it is these lips which interfere with the transverse gliding of the surfaces incident to rotation. In the lower thorax the lips subside but it is precisely here that another contrivance limiting rotation comes into play (Allen, figs. 4 and 5). The spines of the last three thoracic vertebræ are bifid, and each receives the spine of the next following vertebra between its points. The spine of the ninth is similarly modified but is too short to reach that of the tenth, and here rotation in the dried skeleton first becomes possible while it is excluded between the tenth and eleventh thoracic vertebræ and thence caudad. In connection with these bifid spines it is interesting to note a row of small spicular processes of the neural arch immediately mesial to the postzygapophyses in the caudal portion of the lumbar series, which rostrad converge and approach the spines. It is their union with those processes which in the lower thorax gives these elements their bifid character.¹

A provision against extension, not otherwise limited, exists in the spines of the lumbar vertebræ. These are subrectangular, of moderate elevation attaining a maximum at the middle of the series, and so expanded sagittally that they are all but in contact, and actually so when the vertebræ are bent dorsad thus affording a bony obstacle to movement in this direction (Allen, fig. 7).

Thus the lumbar spine is deprived of mobility in the sense of extension and rotation by slight modifications of its normal processes. It remains to consider the highly peculiar changes that have affected the lateral regions of the vertebræ. These are initiated in the middle of the thorax by the

¹ In these provisions for limiting rotation the spine of *Scutisorex* differs from that of *Crociodura* which has the usual simple zygapophyses and spinous processes.

appearance of conical tubercles on the margins of the transverse processes. The sixth vertebra has them only on its caudal margin, from the seventh caudad they beset both margins of the transverse process and increase rapidly in number and extent, reaching ventrad continuously as far as the facette for the capitulum of the rib and when this makes defect taking its place and encroaching though only to a slight degree upon the centra. These last in general bear but one short spicule on each side at the junction with the pedicle and even this is lacking upon the last three lumbar vertebrae which, however, are marked by a faint median ridge; on the other hand, the involvement is at its maximum in the 2d-5th lumbar, where the fronts of the centra are tuberculate and their margins crenulated. Further the mass of spicules projects ventrad in the lumbar series, most markedly at its middle so that this region of the vertebral column is transformed into an osseous gutter open ventrad (Allen, figs. 4-7).

A consequence of the modification of the side of the vertebrae is a displacement of the intervertebral foramina, which are displaced ventrad and dorsad and appear somewhat as do the sacral foramina. The ventral ones are formed largely at the expense of the rostral vertebra of each pair and are situated between the spicule arising from the body and the lateral mass of each vertebra. To these orifices a faint furrow may be followed from the vertebral canal on the caudal surface of each vertebra. These foramina may become reduced in size by coalescence of their bounding spicules; this is the case of those of the sixth, seventh and eighth pairs in the spine I have examined. In these the foramen is included wholly in the more rostral vertebra and is so minute that a reduction in size of the ventral division of the corresponding nerve must be inferred. The dorsal foramina are represented by small orifices lateral to the postzygapophyses, between them and the most mesial spicule of the lateral mass. They likewise are continued to the vertebral canal by shallow grooves on the caudal surfaces of the vertebrae.

The lateral mass of each vertebra consists of a plate of dorsoventral orientation, thickly and irregularly beset on both its rostral and caudal surfaces with slender conical processes or spicules of bone. These consist of a row at the periphery and in the vertebrae of largest size a second row smaller, often mere tubercles, between them and the vertebral canal (Allen, figs. 4-7). Those on the caudal surface are in general slightly larger. This disproportion permits of slight movement, flexion or lateral bending, between adjacent vertebrae notwithstanding the intimate interlocking of the spicules of successive vertebrae.

The question then arises, what elements of the vertebrae are involved in this spicular transformation? The condition of the lower thoracic verte-

bræ makes it clear that the transverse processes and pedicles are, but the great increase of the mass in the lumbar region requires additional explanation. It will be remembered that the capitular facette in the thorax forms the mesial limit of the change. Further caudad the spicules occupy this region also. It would seem therefore that the ankylosed costal element in the lumbar region becomes transformed into spicules. This deduction is strengthened by the position of the nervous foramina and by the contours of the rostral and caudal surfaces of the bones which are curiously like sacral vertebræ. Not only has the costo-transverse space been filled up as usual, but the costal process has expanded laterad and ventrad quite apart from its secondary equipment with spicules. The ventral tips of these modified ribs form the edges of the gutter which characterizes this portion of the spine.

These lumbar vertebræ have therefore undergone a change in general form such as is usual only in the sacral segment. To this as a mere formal statement of the approximation in shape of the lumbar costal element to that of the sacral series there can be no serious objection; but are we warranted in taking these vertebræ to be examples of actual sacralization? In other words, can the form of the costal element, abstraction made of its spicules, be accounted for together with the lengthening of the lumbar series numerically by a backward shift of the pelvis *en masse* along the spine? Some support may be gained for such an assumption in the variations within a species of the level of the first sacral vertebra. In man, for example, the first sacral may be the 24th or the 26th instead of as is usual the 25th of the series. Further, transitional vertebræ having the character of a sacral on one side, of a lumbar on the other, are among the not infrequent variations of the human spine. By way of historical explanation it has been shown that there is a numerical shortening of the spine among primates with the assumption of the upright position, a shortening which from a mechanical standpoint is obviously advantageous. For a time it was believed that this abbreviation of the spinal column was recapitulated in the development of the individual by a movement forward of the sacrum along the spine after the skeletal elements involved had been laid down in the membrane.¹ But this has been found erroneous by subsequent observers² and there are no grounds for holding that the number of presacral vertebræ are diminished during development. We can therefore accept

¹ Rosenberg, E. Ueber die Entwicklung der Wirbelsäule und das Centrale carpi des Menschen. *Morph. Jahrb.*, Bd. I, 1876.

² Holl, M. Ueber die richtige Deutung der Querfortsätze der Lendenwirbel und die Entwicklung der Wirbelsäule des Menschen. *Sitzungsb. d. K. Akad. d. Wiss. Math.-Naturwiss. Klass. Wien*, Bd. 85, 1882. Paterson, A. M. The human sacrum. *Sci. Trans. Royal Soc. Dublin*, Vol. 5, 1893. Bardeen, C. R. Studies of the development of the human skeleton. *Am. Jour. Anat.*, Vol. 4, 1905.

a shift of the pelvis only in a phyletic sense as revealed by discrepancies in the number of dorso-lumbar vertebrae among related species. Such differences are pronounced in the dorso-lumbar vertebrae of insectivores, their number ranging from 13 in *Myogale* and *Talpa* (Flower) to 21 in *Crocidura* (Allen), so that the first lumbar vertebra varies from the 21st of the total series in the former to the 29th in the latter. *Scutisorex* represents the upper limit of variation in this respect, having 14 thoracic and 11 lumbar vertebrae (Allen); the first sacral is accordingly the 33d of the vertebral series. This numerical lengthening of the presacral spine can hardly be accounted for otherwise than by a caudal shifting of the pelvis in the evolution of the long spined genera. But this granted, there is no evidence that such additional lumbar vertebrae ever retain any trace of their previous sacralization and even were the possibility admitted for purposes of argument, the assumption would explain too much in the case under consideration for the whole lumbar segment is similarly modified.

If then we cannot associate the unusual form of the costal element of the lumbar vertebrae with an ancestral more advanced position of the pelvis, we are in no better case if we attempt to explain this peculiarity as anticipatory of a forward shifting of the pelvis and for the same reasons. The relation of pelvis to spine is definitive from its first appearance in the embryo and the number of vertebrae involved is far in excess of any possible advance of the pelvis.

As there is no known developmental process, to excess or deficiency in which variation in the position of the pelvis may be attributed, we arrive at the conclusion that germinal factors are the presumptive cause of differences in the number of presacral vertebrae, whether in this case of *Scutisorex* a single mutation be operative or a series alike in direction, constituting an orthogenetic process and affecting at the same time the number of presacral vertebrae and the form of the costal elements in the lumbar segment.

In *Scutisorex* the widest lumbar vertebra is the 6th, that is, the 28th of the total series (Allen, figs. 4 and 5). If, on account of its breadth, it be taken as representing what was formerly the first sacral, it would follow that the shifting of the pelvis over five vertebrae to the 33d had taken place in a single mutation, for otherwise on the foregoing assumption its successive positions would each have obliterated the traces of its preceding one. What little plausibility there may be in such a line of reasoning is enhanced rather than diminished by the fact that the nearby related *Crocidura* has two species in which there are 27 presacral vertebrae, and the first sacral therefore corresponds numerically to the broad lumbar of *Scutisorex*, the 28th of the vertebral series. But great reserve is necessary in view of the

plasticity of bone under the mechanical factors of stress and the broadening of this vertebra in *Scutisorex* may be due to its position in the dorso-lumbar arch.

The difficulty we feel in the presence of such extreme modifications as this lumbar lengthening and spicular formation, is the absence of intermediate forms to connect them with usual conditions obtaining within the order. In a species not otherwise aberrant one or two salient peculiarities are encountered, which in a single organ or system remove it widely from its nearest congeners. Analogous cases are afforded by the stomach of *Semnopithecus*, the tracheal bulla of *Taxidea*,¹ the peculiarly curved trachea of *Bradypus*² and the spermaceti-organ of the *Physeterinae*. The lack of knowledge of intermediate related forms deprives us of a basis for classifying them as examples of orthogenesis or as the cumulative result of selection of fluctuating variations; and the absence of analogous modifications in members of other orders of similar habitus gives little ground for designating them as adaptations.

Here it may be well to point out that these interlocking spicules are in no way comparable to the accessory articulations of *Xenarthra*, primarily because they are not articular: they are not covered with cartilage but are embedded in the ligamentous tissue which surrounds the spine, as could be ascertained from the wet specimen available for study. That the spicules are the result of ossification in this tissue or in attached tendons is an assumption hard to avoid. They are present largely but not exclusively in the domain of the ilio-costalis. Very unfortunately this muscle was damaged in skinning the animal and thereafter desiccated almost beyond recovery. I do not think, however, that I am mistaken in believing that I traced several of its tendons to the tips of spicules. The ventral gutter of the lumbar region was largely and towards the pelvis completely filled with muscle, the psoas minor, psoas major and quadratus lumborum being all of them well developed and arising by numerous slips from the ventral tip and mesal surface of the costal elements. The plane of the psoas parvus was prolonged rostrad to the diaphragm by a series of muscular slips which arose from the centra at and about their single spicule on each side and coursed obliquely ventrad and caudad to the tip of the costal process of a more caudal vertebra. The groove on each side dorsally between the transverse process and spine was occupied by a feebly developed sacrospinalis, its feebleness bearing out the inference of loss of extension in this segment.

¹ Huntington, G. S. The eparterial bronchial system of the Mammalia. *Annals New York Acad. Sci.*, Vol. 11, 1898.

² Specimen in the Department of Anatomy, Columbia University.

There is then some evidence for the associations of spicule formation with ossification at points of tendon insertion and perhaps of tendons themselves, but there is no marked peculiarity of the musculature¹ ascertainable to explain why it occurs in precisely this genus and no other. Whether the underlying process is biologically allied to changes which in man are referable to disease is perhaps worthy of discussion in view of Larger's² recently published theories on this subject. In general the spicules are clean cut and have little but their irregularity to suggest disease. Here and there, however, they are thickened or even fused together — this applies only to adjacent spicules of the same vertebra, there is no synostosis between vertebrae — and in a very few places small bony nodules are present. Elsewhere the skeleton is hardly open to the suspicion of degeneration save perhaps in the rugose surface of the parietals and a small and doubtful calcification of the ligamentum nuchæ which did not show in the skiagraph. The spicules do not closely resemble either in situation or appearance the ossified muscles of dinosaurs described by Dollo³ and interpreted as evidences of racial degeneration by Larger. Further the spicules of an immature skeleton are not materially different from those of the larger adults and an abnormal process of this sort might perhaps be expected to become more pronounced with age.

Morphologically therefore we must conclude that the peculiarities of the lumbar vertebrae of *Scutisorex* consist in the unusual size of the costal elements and the production from their surfaces and from the amalgamated transverse processes of osseous spicules at the sites of muscular insertions and origins, a process possibly predisposed to by the relative immobility of the spine occasioned by the character of its zygapophyses and spinous processes, and resulting in an arch of great strength able to resist pressure from above and to afford support to vigorous movements of the head and forelimbs. It is not evident that these modifications are useful, but is it not necessary to assume that mutations are always favorable, nor that a useless or even slightly detrimental structure must at once disappear or entail the extinction of the species, for another factor comes into play, the severity of the struggle for existence. While the general process of evolution secures a harmony between organism and environment, luck or cunning may afford a respite to impending fate for a time or in a minority of instances.

¹ Leche, W. Zur Anatomie der Beckenregion bei Insectivora, mit besonderer Berücksichtigung ihrer morphologischen Beziehungen zu diejenigen anderer Säugethiere. Kongl. Svenska Vetenskaps-Akad. Handl., B. 20, No. 4, Stockholm, 1883.

² Larger, R. Théorie de la contre-évolution ou dégénérescence par l'hérédité pathologique. Paris. 1917.

³ Dollo, L. Note sur les ligaments ossifiés des dinosauriens de Bernissart. Arch. de Biol., T. 7, 1887.

While it seems necessary to ascribe the lengthening of the lumbar spine of *Scutisorex* to mutation, it is not certain that the spicular processes of the vertebræ are so immediately dependent upon changes in the germ-plasm. The extreme plasticity of bone and its sensitiveness to changes in the internal medium as well as to mechanical forces dispose one to see in the osseous system the summation of many factors. Like the blood vessels, determined by mechanical laws, and presenting in their changing patterns an integration of the relative rates of growth of all the parts of the developing organism, so the skeleton in the detailed conformation of its many parts is the resultant of many chemical and physical factors and through their determinants rather than independently may be represented in the chromosomes. In this connection much interest attaches to Larger's insistence upon the resemblances of certain skeletal types among existing and extinct animals to conditions of the human skeleton associated with abnormalities of the ductless glands. It seems not too much to hope that these and other chemical alterations of the internal medium may throw light upon modifications of the bony structures at present inexplicable or referred solely to mechanical causes.

INDEX TO VOLUME XXXVII.

New names of genera, subgenera, species, and subspecies are printed in **heavy-faced type**, also the main reference in a series of references.

- ABBOTTANA clemataria, 102.
 Abraeus dufaui, 203.
 Acalles longulus, 217.
Acanthocleithron, 654, **720**, 749.
 chapini, 655, 656, **721**.
 Acanthopterygii, 738.
 Achatodes zeæ, 61.
 Acherdoa ferraria, 63.
 Achlarus lycidas, 27.
 Achryson surinamum var. pallens, 209.
 Acidalioides eoides, 69.
 Acmæodera contigua, 205.
 cruenta, 205.
 Acolastus amyntas, 26.
 Acolobicus lineaticollis, 201.
 Acoloithus falsarius, 107.
 rectarius, 107.
 Acris gryllus, 621.
 Acritus analis, 202.
 atomulus, 202.
 Acrobasis comptoniella, 129.
 evanescentella, 129.
 tenuella, 129.
 Acrolophus cervinus, 147.
 hulstellus, 147.
 plumifrontellus, 147.
 Acronycta persuasa, 53.
 xyliniformis, 54.
 Acylomus cubiensis, 199.
 detractus, 199.
 quadrispinosus, 199.
 Adejeania brasiliensis, 229.
 Adelocera subcosta, 204.
 Aderocharis conifer, 199.
 obscurior, 199.
 Adetus lherminieri, 210.
 Adimerus dubius, 201.
 Æaphes decoloratus, 205.
 Ægintha, 261.
 Ægithus clavicornis, 200.
 Æolus elegans, 205.
 Æthria rubipectus, 339.
 Africa, botanical regions of, 744.
 African fishes, distribution of, 746-752.
 Afrida ydatodes, 47.
 Agathodes monstrialis, 114.
 Agkistrodon contortrix, 632.
 Agnomonia anilis, 75.
 Agraulis vanillæ, 13.
 Agriochoerus, 573, 574.
 Agrotis dapsilis, 57.
 ypsilon, 57.
 Ahasverus advena, 201.
 Aidemosyne, 261.
 Alabama argillacea, 65.
 Alamosa bipunctella, 134.
 Alarodia slossoniæ, 106.
 Alcis luridula, 96.
 Alcothoe caudata, 108.
 Alestes, 679, 747.
 bimaculatus, 657, **680**.
 carmesinus, 654, 662, **681**.
 grandisquamis, 656, 658, 660, 662, **681**.
 imberi, 658, 660, 661, **680**.
 liebrechtsii, 656, 657, 660, 661, **679**.
 longipinnis, 660, **680**.
 macrolepidotus, 657, 658, 660, 661, **680**.
 macrophthalmus, 657, 659, 661, **679**.
 nurse, 658, **680**.
 schoutedeni, 658, 660, **680**.
 Allabenchelys, 748.
 Allecula flavipes, 214.
 Allen, J. A., skeletal characters of *Scutisorex* 769-784.
 Allen, J. A., Lang, Herbert, and Chapin,

- James P., the American Museum Expedition collection of bats, 405-563.
- Allomops**, 470.
- Alloperdita**, 241.
- Allothrombium pulvinus*, 157.
- Allotria elonympha*, 74.
- Alloxaxis dorsalis*, 215.
- Almodes terraria*, 86.
- Alphitobius diaperinus*, 214.
- piceus*, 214.
- Alypia octomaculata*, 52.
- wittfeldi*, 52.
- Amadina*, 261, 262, 263, 276.
- erythrocephala*, 276.
- fasciata*, 276.
- Amarginops**, 654, **713**, 749.
- platus*, 655, 662, **713**.
- Amauresthes*, 261, 262, 274.
- fringilloides*, 274.
- Ambia striatalis*, 121.
- Amblygnathus vitraci*, 195.
- Amblyospiza*, 261, 262, 263, 267.
- capitalba saturata*, 267.
- Amblyrhiza*, 185.
- Amblyrhizinæ*, 186.
- Amblyscirtes meridionalis*, 33.
- vialis*, 33.
- Ametris nitocris*, 86.
- Ammalo eglensis*, 48.
- egensis* var. *inopinatus*, 48.
- insulata*, 48.
- tenera*, 48.
- Amobiopsis ornata*, 221.
- Amolita fessa*, 66.
- roseola*, 66.
- sentalis*, 66.
- Ampeloeca myron enotus*, 42.
- versicolor*, 42.
- Amphibius*, 749.
- Amphichiromys*, 833.
- Amphilius notatus*, 655, 658, **715**.
- Amphion nessus*, 42.
- Amyna octo*, 65.
- orbica*, 65.
- Anabantidæ*, 738, 751.
- Anabas*, 752.
- congius*, 662, **732**.
- nanus*, 656, 657, 658, 659, 662, **732**.
- nigropannosus*, 657, 659, 662, **732**.
- Anacampsis argyrothamniella*, 143.
- lagunculariella*, 143.
- Anæa portia*, 18.
- Analeis fulvicornis*, 217.
- Ananca vittata*, 215.
- Anania florella*, 112.
- Anaphora morrisoni*, 147.
- propinqua*, 147.
- tenuis*, 147.
- Anaplectes*, 261, 262, 263, **271**.
- melanotis*, 271.
- rubriceps*, 271.
- Anartia jatrophae*, 16.
- Anatrytone arogos*, 35.
- logan*, 35.
- vitellius*, 35.
- Ancharius*, 749.
- Anchastus rufescens*, 205.
- Anchiceratops*, 281.
- Anchonus suillus*, 216.
- Ancodon*, 573, 574.
- Ancyloxypha numitor*, 30.
- Andersonia*, 750.
- Andrena* (*Andrena*) **æquatorialis**, 235.
- (*Andrena*) **boswendica**, 236.
- Anepischetos bipartita*, 67.
- Angel Peak region, geology of, 821, 822.
- Ania lombaria*, 101.
- Anisolabis annulipes*, 638.
- ambigua*, **638**.
- janeirensis*, 638.
- maritima*, 635, **638**.
- minuta*, **639**.
- Anisonchus sectorius*, 822.
- Anisota consularis*, 44.
- stigma*, 44.
- Anomala undulata*, 208.
- Anomalospiza*, 261, 262.
- Anomis serrata*, 66.
- Anorthodes tarda*, 54.
- Anosia berenice*, 20.
- plexippus*, 20.
- Ansorgia*, 749.
- vittata*, 660, 710.
- Anthanassa frisia*, 14.
- texana*, 14.
- texana* var. *seminole*, 15.
- Anthonomus elegans*, 217.
- julichi*, 217.

- Anthonomus varipes*, 217.
 Anthony, H. E., new fossil rodents from Porto Rico, with additional notes on *Elasmodontomys obliquus* and *Heterosomys insulans*, 183–189; a new rabbit and a new bat from Neotropical Regions, 335–337; two new fossil bats from Porto Rico, 565–568.
Antiblemma inexacta, 77.
 inexacta var. *minorata*, 77.
Anticarsia ferruginea, 77.
 gemmatilis, 76.
Antimachus, 214.
 roudeni, 214.
Antispila eugeniella, 144.
Apæcasia deductaria, 95.
 extremaria, 95.
Apantesis arge, 50.
 michabo, 50.
 nais, 51.
 phyllira, 50.
 placentia var. *flammea*, 51.
 vittata, 50.
 vittata var. *phalerata*, 51.
 vittata var. *radians*, 50.
Apate francisca, 207.
 terebrans, 207.
Apatela afflicta, 53.
 brumosa, 53.
 chionochroa, 53.
 clarescens, 53.
 furcifera, 53.
 hamamelis, 53.
 impressa, 53.
 lætifica, 53.
 lithospila, 53.
 lobeliæ, 53.
 longa, 54.
 oblinita, 54.
 tritona, 53.
Apatelodes angelica, 82.
 angelica var. *indistincta*, 82.
 torrefacta, 82.
 torrefacta var. *floridana*, 82.
Apatemys, 833, 837.
Apatosaurus, 357.
 minimus, 358.
Apatura misippus, 14.
Apenes morio, 195.
 opaca, 195.
 parallela, 195.
 variegata, 195.
Aphanolemur gibbosus, 854.
Aphelops, 576.
Aphodius granarius, 208.
 granarius var. *undescribed*, 208.
Aphrissa statira, 10.
Aphthona compressa, 211.
 maculipennis, 212.
Apion portoricanum, 218.
Apolema carata, 95.
Apostrophia charithonia, 20.
Aproærema crotalariella, 121, 143.
Aræcerus fasciculatus, 220.
Archæopteryx, 307.
Archips argyropsila, 139.
 georgiana, 139.
 obsoletana, 139.
 rosaceana, 139.
Ardops, 336.
 haitiensis, 336.
Aresia parva, 47.
Argynnis cybele, 14.
Argyria argentana, 126.
 auratella, 126.
 differentialis, 126.
 lacteella, 126.
 multilineatella, 126.
 nivalis, 126.
Aristotelia ivæ, 142.
Arius, 749.
 africanus, 655, 662, **716**.
Arsilonche henrici, 54.
Arta statalis, 123.
Artace punctistriga, 86.
Asciodes anormalis, 114.
 gordialis, 113.
Aspidoglossa vulnerata, 195.
Aspidomorpha bajula, 212.
Asprotilapia, 750.
Atactopsis, 229.
 facialis, 229.
Atænius figurator, 208.
 gracilis, 208.
 imbricatus, 208.
 rhyticephalus, 208.
 stercorator, 208.
 terminalis, 208.

- Atalopedes campestris, 30.
 Atethmis subusta, 61.
 Athena eleucha, 17.
 peleus, 17.
 Athetis prima, 54.
 Atholus confinis, 203.
 Athyreus tridentatus var. castaneus, 208.
 Atlides haesus, 22.
 Atomus **longilinea**, 155.
 niger, 154.
 Atopochilus, 749.
 Atractocerus, 206.
 brasiliensis, 206.
 Atreus plebeja, 38.
 Attelabus bipustulosus, 217.
 foveipennis, 217.
 mutabilis, 217.
 Atteva aurea, 140.
 gemmata, 141.
 Auchenoglanis, 749.
 ballayi, 656, 657, 658, 659, 660, 662, **716**.
 occidentalis, 656, 657, 658, 662, **715**.
 Aulonium bidentatum, 201.
 Autographa abrota, 64.
 basigera, 64.
 biloba, 64.
 brassicæ, 64.
 egena, 64.
 ou, 64.
 oxygramma, 64.
 rogationis, 64.
 verruca, 64.
 Automeris io lilith, 44.
 Azelina atrocolorata, 101.
 rectissima, 101.
 zalissaria, 101.

 BACTRA lanceolana, 137.
 verutana, 137.
 Bagrus, 749.
 ubangensis, 662, 656, 658, 662, **710**.
 Bandera carneela, 134.
 Barbus, 748.
 atromaculatus, 655, 657, 658, 661, 662, **697**.
 candens, 655, 661, **701**.
 caudovittatus, 656, 658, **697**.
 Barbus, **dolichosoma**, 655, 656, **700**.
 fasolt, 659, 661, **696**.
 holotænia, 656, 657, 658, 659, 661, **697**.
 musumbi, 655, 660, **697**.
 pleuropholis, 655, 656, 659, 661, 662, **698**.
 rubripinnis, 655, 660, **699**.
 Barilius, 748.
 kingsleyæ, 658, **703**.
 lujæ, 661, **702**.
 salmolucius, 655, 656, 659, 660, 661, **702**.
 ubangensis, 656, 659, **702**.
 weynsii, 656, 660, 661, **702**.
 Baris tabaci, 218.
 Barornis regens, 307.
 Basilarchia archippus, 17.
 astyanax, 17.
 floridensis, 17.
 Basilodes pepita, 63.
 Basilona imperialis, 45.
 Bathilda, 261.
 Bathybates, 751.
 Batocera rubus, 210.
 Batonota rugosa, 212.
 Bayonia, 751.
 Bdella peregrina var. **iowaensis**, 150.
 tenuirostris, 149.
 Bedellia minor, 145.
 Bellura gortynoides, 60.
 melanopyga, 60.
 Belonoglanis, 750.
 tenuis, 658, 659, 662, **723**.
 Belonuchus gagates, 199.
 Belophorus maculatus, 218.
 militaris, 218.
 Bembidium fastidiosum, 194.
 Benta floridella, 128.
 malanogrammos, 128.
 malanogrammos var. diluculella, 128.
 speciosella, 128.
 Berginus, 202.
 bahamicus, 202.
 Blastobasis eriobotryæ, 144.
 guilandinæ, 144.
 Blepharomastix ebulealis, 113.
 magnalis, 113.

- Blepharomastix ranalis, 113.
 stenialis, 113.
 Bleptina caradrinalis, 80.
 inferior, 80.
 inferior var. medialis, 80.
 Bomolocha baltimoralis, 81.
 bijugalis, 81.
 citata, 81.
 manalis, 81.
 umbralis, 81.
 Borolia ligata, 60.
 Botanebius, 217.
 Botrodon, 201.
 Brachinus gilvipes, 195.
 Brachyceratops, 281.
 Brachycope, 261, 262, 271.
 anomala, 245, 271.
 Brachypeplus mutilatus, 203.
 Brachysphænus marginatus, 200.
 Brachyspiza capensis, 587.
 capensis antillarum, 333.
 Brenthus anchorago, 218.
 turbatus, 218.
 Brepidium isophthalma, 25.
 Brown, Barnum, a complete skeleton of
 the horned dinosaur *Monoclonius*, and
 description of a second skeleton show-
 ing skin impressions, 281-306.
 Bruchus amicus, 213.
 chinensis, 213.
 obtectus, 213.
 rufimanus, 213.
 sallei, 213.
 Bruchus sinuatus, 213.
 tetricus, 213.
 Bryconæthiops, 747.
 microstoma, 656, 657, 659, 660, 661,
 662, **678**.
 yseuxii, 655, 678, **679**.
 Bucculatrix ivella, 145.
 Bufo americanus, 621.
 fowleri, 622.
 Buprestis decora, 205.
 lineata, 205.
 CABERODES confusaria, 102.
 juncturaria, 102.
 Cænopus, 576.
 Cænurgia convalescens, 72.
 Calamichthys, 746.
 Calandra linearis, 218.
 oryzæ, 218.
 Calaspidea grossa, 212.
 Calasymbolus excæcatus, 39.
 Calephelis cænius, 22.
 virginiensis, 22.
 virginiensis virginiensis, 21.
Calera, 134.
 albicostella, 134.
 Calidota strigosa, 51.
 Callichroma elegans, 209.
 Callicista columella, 24.
 Callicore clymena, 17.
 Callidryas eubule, 9.
 eubule var. sennæ, 10.
 Callignathus, 364.
 Callomegas, 209.
 Callopietria floridensis, 71.
 Calosoma alternans, 195.
 calidum, 195.
 Calpodes ethlius, 33.
 Calycopis cecrops, 24.
 Calymmaderus bibliothecarum, 206.
 Campometra amella, 77.
 cinetipalpis, 77.
 mima, 77.
 Campptogramma stellata, 93.
 Canidia scissa, 62.
 Cantharis, 216.
 Canthidium melanocephalum, 207.
 Capnodes punctivena, 77.
 rufinans, 78.
 Capua lentiginosana, 139.
 Caradrina spilomela, 54.
 Carama cretata, 106.
 Carcharinus acronotus, 875.
 commersonii, 873.
 limbatus, 874.
 milberti, 874.
 obscurus, 873.
 Carcinops troglodytes, 202.
 Caripeta angustiorata, 95.
 angustiorata var. latorata, 95.
 aretaria, 95.
 Carphophis amœnus, 631.
 Carpophilus (Colopterus) amputatus,
 203.
 (Colopterus) truncatus, 203.

- Carpophilus dimidiatus*, 203.
 dimidiatus var. *mutilatus*, 203.
 hemipterus, 203.
Caryoborus nucleorum, 213.
Casandria inflexa, 57.
 nigroguttata, 57.
Casinyceris argynnis, 408, 412, 421, **511**.
Casnonia insignis, 195.
Catia drury, 31.
 drury var. *egeremet*, 32.
Catocala alabamæ, 74.
 amasia, 74.
 amatrix, 73.
 amica, 74.
 amica var. *androphila*, 74.
 amica var. *suffusa*, 74.
 cara, 73.
 clintoni, 74.
 coccinata, 73.
 coccinata var. *sinuosa*, 73.
 cratægi, 74.
 epione, 73.
 ilia, 73.
 jair, 74.
 micronympha, 74.
 micronympha var. *gisela*, 74.
 micronympha var. *hero*, 74.
 micronympha var. *ouwah*, 74.
 mulierecula, 73.
 sappho, 73.
 similis, 74.
 ultronia, 73.
 ultronia var. *celia*, 73.
 vidua, 73.
Catopyrrha coloraria, 95.
 coloraria var. *dissimilaria*, 95.
 sphæromacharia, 95.
 sphæromacharia var. *perolivata*, 95.
Cautethia grotei, 40.
Celama obliquata, 47.
 sorghiella, 47.
Celerio lineata, 43.
Celina grossula, 196.
Centropus burchelli, 249.
 monachus, 249.
 neumanni, 249.
Cerathyla, 797, 801–812.
 bubalus, 797, 808.
 johnsoni, 798–803.
Cerathyla panamensis, 809.
Ceratocis, 207.
Ceratonia catalpæ, 38.
 undulosa, 38.
Ceratops, 281.
Cercyon nigriceps, 197.
 quisquilius, 197.
 variegatum, 197.
Cercyonis alope, 18.
 pegala, 18.
Cerotoma ruficornis, 211.
 trifurcata, 211.
Cerura scitiscrupta, 84.
Chabuata lutina, 59.
Chærephon (*Lophomops*) **abæ**, 410, 411,
 412, 414, **464–466**, 487, **553**.
 (*Lophomops*) **chapini**, 410, 412,
 414, 460, **461–463**, 487, **551**.
 (*Lophomops*) **cristatus**, 410, 411,
 414, **463–487**, **552**.
 frater, 410, 412, **456–458**, **546**.
 russatus, 410, 412, 414, **458–460**,
 487, **547–551**.
 sp. indet., 410, 411, **460**, **551**.
Chæridium insulare, 207.
Chætocnema apricaria, 212.
Chalcodermus pupillatus, 217.
Chalcoela iphitalis, 127.
Chalcolepidius obscurus, 204.
 validus, 204.
Chalcophana, 210.
 furvida, 210.
Chalepus sanguinicollis, 212.
Chalinitis olealis, 123.
Champsochromis, 751.
Chamyris cerintha, 69.
Channallabes, 748.
 apus, 659, 660, 661, 662, **707**.
 Chapin, James P., the classification of
 the Weaver-Birds, 243–280; see also
 Allen, J. A.
 Chapman, Frank M., descriptions of
 new birds from Santo Domingo and
 remarks on others in the Brewster-
 Sandford Collection, 327–334.
Characinidæ, 736, 747.
Charadra deridens, 52.
 illudens, 53.
 sudena, 53.

- Chelæthiops*, 748.
 elongatus, 656, 661, **704**.
Chelonarium punctatum, 204.
Chelydra serpentina, 624.
Chelymorpha angusticollis, 212.
 argus, 212.
 flavicollis, 212.
 multipunctata, 212.
 polysticha, 212.
 swartzii, 212.
Cherostus, 213.
 jamaicensis, 213.
Chilo densellus, 127.
 squamulellus, 127.
Chilocampyla dyariella, 145.
Chilochromis, 751.
Chilocorus cacti, 200.
Chiloglanis, 749.
 batesii, 658, **720**.
Chilotilapia, 751.
Chipota perlepiddella, 135.
Chiromantis rufescens, 811.
Chiromyoides, 833.
Chlorida festiva, 209.
Chloridea virescens, 61.
Chlorippe alicia, 18.
 celtis, 18.
 clyton, 18.
 flora, 18.
Chlorissa pistaceata, 88.
 subroceata, 88.
Chlorochlamys chloroleucaria, 88.
Chloropeta, 249.
Chloropteryx tepperaria, 88.
Choreutis carduiella, 141.
 carduiella var. *busckiella*, 141.
Chriacus, 828.
Chrysichthys, 749.
 acutirostris, 655, 657, **710**.
 brevibarbis, 662, **710**.
 cranchi, 657, 662, **711**.
 delhezi, 656, 658, 660, 662, **711**.
 duttoni, 662, **711**.
 furcatus, 657, **710**.
 longibarbis, 662, **711**.
 ornatus, 659, 660, 662, **711**.
 punctatus, 656, 662, **711**.
 thomeri, 660, 662, **711**.
 wagenaari, 656, 660, **711**.
Chrysobothris denticulata, 205.
 lepida, 205.
 tranquebarica, 205.
Cichlidæ, 738, 750.
Cicindela argentata var. *pallipes*, 194.
 boops, 194.
 cardini, 194.
 cubaba, 194.
 marginata, 194.
 olivacea, 194.
 suturalis, 194.
 suturalis var. *guadeloupensis*, 194.
 suturalis var. *hebræa*, 194.
 trifasciata, 194.
 viridicollis, 194.
Cicinnus melsheimeri, 104.
Cilea pulchellus, 199.
Cindaphia bicoloralis, 117.
Cinglis albidula, 89.
 compensata, 89.
Cinnamopteryx, 263.
Cipex schwarzi, 636.
Cirphis calpota, 60.
 subpunctata, 59.
Cissia eurytus, 19.
 sosybius, 19.
Citharidium, 748.
Citharinus, 748, 759.
 congicus, 658, 661, **689**.
 gibbosus, 656, 658, 661, **689**.
Citheronia regalis, 44.
 sepulchralis, 45.
Cladis nitidula, 200.
Cladorchis, 866.
 gigas, 867–870.
 helostomatis, 866.
 pangasii, 866.
Clæotus rufopiceus, 208.
Clariallabes, 748.
Clarias, 748.
 angolensis, 656, 658, 659, 661, **707**.
 breviceps, 655, 661, **706**.
 bythipogon, 656, 658, 659, 660, 661, 662, **707**.
 lazera, 704.
 malaris, 655, 661, **705**.
 platycephalus, 659, 661, **705**.
 submarginatus, 658, **706**.
 zygouron, 655, 659, **704**.

- Clarotes, 749.
 Clemensia albata, 48.
 Clemmys **nuchalis**, 624.
 Cleora defectaria, 97.
 indicataria, 99.
 pampinaria, 99.
 pergracilis, 98.
 umbrosaria, 98.
 vellivolata, 99.
 Clivina bipustulata, 195.
 Clupediæ, 747.
 Clytospiza, 252, 261, 263, 275.
 nonteiri, 244, 245, 275.
 Cobubatha numa, 69.
 olivacea, 69.
 Cocceius pylades, 27.
 Coccinella 9-notata, 200.
 Coccopygia, 261, 263.
 Coccotrypes anonæ, 220.
 bakeri, 220.
 hubbardi, 220.
 robustus, 220.
 thrinaxis, 220.
 Coccyzus americanus, 249.
 erythrophthalmus, 249.
 Cochlidion y-inversa, 106.
 y-inversa var. parallela, 106.
 Cocytius antæus medor, 37.
 Cœlotaxis, 213.
 Cœnocalpe parinotata, 93.
 Cogia breviceps, 363.
 Colænis julia, 13.
 julia var. delila, 13.
 Colaspis fastidiosa, 211.
 femoralis, 211.
 lebasi, 211.
 obscura, 211.
 suffriani, 210.
 Coleophora octagonella, 144.
 Coleotechnistes citriella, 144.
 Coleura gallarum nilosa, 408, 410, 424,
 487, **516**.
 Coliuspasser, 245, 256, 261, 262, 263, 273.
 concolor, 257, 273.
 macroura, 273.
 Colpodes ellipticus, 195.
 Coluber constrictor, 629.
 Coluocera maderæ, 204.
 Comacla simplex, 47.
 Composita fidellissima, 82.
 Conchylodes diphteralis, 112.
 platinalis, 113.
 Conibius, 213.
 Conoderus, 205.
 Conotelus conicus, 203.
 Conotrachelus coronatus, 217.
 lineola, 217.
 presbyta, 217.
 Copecrypta ruficauda **devia**, 227.
 Copelatus angustatus, 196.
 posticatus, 196.
 Copicucullia alfarata, 60.
 Copidita simplex, 215.
 tenella, 215.
 Copipanolis cubilis, 57.
 stigma, 57.
 Coproporus, 199.
 Coptocyclus bistrispunctata, 21.
 guttata, 212.
 guttata var. fuliginosa, 212.
 propinqua, 212.
 subsignata, 212.
 Coptodera festiva, 195.
 Coptodisca condaliæ, 144.
 Cordylopeza nigrinodis, 123.
 Corematodus, 751.
 Coriscium randiella, 146.
 Correbidia bicolor, 340.
 Corticaria ferruginea, 204.
 Cosmophila doctorium, 66.
 erosa, 65.
 texana, 66.
 xanthindyma, 66.
 Cosmopteryx attenuatella, 144.
 floridanella, 144.
 ipomœæ, 144.
 minutella, 144.
 Cosmosoma auge, 339.
 myrodora, 45.
 Cossonus hamiltoni, 218.
 impressus, 218.
 Cossula magnifica, 108.
 Cosymbia myrtaria, 89.
 Crambidia pallida, 47.
 uniformis, 47.
 Crambus decorellus, 125.
 extornalis, 126.
 extorralis, 125.

- Crambus hastiferellus*, 125.
 haytiellus, 125.
 mutabilis, 125.
 multilinellus, 125.
 satrapellus, 125.
 teterrellus, 125.
Cremastobombycia verbesinella, 145.
Cressonia juglandis, 39.
Criocephalus cubensis, 209.
Crocidolomia palindialis, 111.
Crocidophora pustuliferalis, 115.
Crocidura nyansæ kivu, 770-773, 776-779, 784.
 turba nilotica, 784.
Cromeria, 747.
Cromeriidæ, 735, 747.
Crotalus horridus, 632.
Cryphalus mucromifer, 220.
Cryptobatrachus, 805, 806.
 boulengeri, 805.
Cryptobranchus allegheniensis, 598.
Cryptocephalus squalens, 210.
 viridipennis, 210.
Cryptolechia obsoletella, 143.
Cryptorhopalum scutellare, 202.
Cryptorhynchus batataæ, 217.
 lapathi, 217.
 longus, 217.
Cryptospiza, 261, 262, 263.
Cultroribula confinis var. **magna**, 162.
Cunningtonia, 750.
Cyanopsis, 228.
 costalis, 228.
Cyathissa percara, 54.
Cyclocephala notata, 208.
 tridentata, 208.
Cycloneda sanguinea, 200.
Cycloplasis panicifoliella, 144.
Cyclopodia greeffi, 559.
Cylas formicarius, 218.
Cylindera flava, 209.
 puberula, 209.
Cylindromasicera prima, 232.
Cymatophora abbreviata, 95.
 bicolorata, 95.
 cervinaria, 94.
 distribuaria, 95.
 distribuaria var. *transitaria*, 95.
 floridensis, 95.
 Cymatophora latiferrugata, 94.
 nervata, 94.
 nicetaria, 94.
 color, 94.
 pustularia, 94.
 solitaria, 94.
Cynothrissa, 655, 677.
Cyprinidæ, 736, 748.
Cyrtocara, 751.
Cyrtosoma lherminieri, 214.
Cysteophora pervertipennis, 92.
Cystineura cana, 15.

DACODERUS dominicensis, 213.
Dactylosternum, 197.
 abdominale, 197.
 advectum, 197.
 flavicorne, 197.
 subdepressum, 197.
Dahana atripennis, 46.
Damæus brevitarsus, 164.
 minutus, 164.
Dannemora edentella, 134.
Dasylophia anguina, 83.
 anguina var. *puntagorda*, 83.
Datana floridana, 82.
 integerrima, 82.
 modesta, 82.
Deltatherium, 822, 825.
 fundaminis, 823, 824.
Dendrobates braccatus, 812.
Dendroblaptus, 209.
Depressaria amissella, 143.
 amyrisella, 143.
Derallus rudis, 196.
Derelomus albidus, 217.
Dermaptera, West Indian, 635-651.
Dermestes caninus, 202.
 carnivorus, 202.
 vulpinus, 202.
Desmia funeralis, 111.
 geminalis, 111.
 tages, 111.
Desmognathus fusca, 609.
 monticola, 608.
 ochrophæa carolinensis, 609.
 quadramaculata, 607.
Dexosarcophaga, 221.
 transita, 221.

- Diabrotica bivittata*, 211.
 gramineæ, 211.
 innuba, 211.
 melanocephala, 211.
 ochreata, 211.
 pulchella, 211.
Diacrisia isabella, 50.
 virginica, 49.
Diadophis punctatus, 630.
Diallagama lutea, 67.
Diaperis maculata, 214.
Diaphania hyalinata, 115.
 infimalis, 115.
 nitidalis, 114.
 niveocilia, 115.
 olealis, 114.
 quadristigmalis, 115.
 sibillalis, 115.
Diaphanomyia, 229.
 aurea, 229.
Diaprepes abbreviatus, 216.
 balloui, 216.
 comma, 216.
 famelicus barbadensis, 216.
Diasemia janassialis, 117.
 magdalena, 117.
 nigralis, 117.
 ramburialis, 117.
Diastema tigris, 64.
Diastictis argyralis, 112.
Diatræa crambidoides, 126.
 saccharalis, 126.
Diatropura, 261, 262, 273.
 progne, 273.
Diatryma, 307–324, **321**.
 ajax, 307, 322.
 gigantea, 307, 318, 322.
 regens, 322.
 steini, 310, **322**.
Diatrymæ, 321.
Diatrymidæ, 321.
Diceratherium, 576.
Dichogama amabilis, 113.
 bergii, 113.
 redtenbacheri, 113.
Dichomeris citrifoliellus, 142.
 eupatoriellus, 142.
Dichorda iridaria, 88.
 rectaria, 88.
Dichymolomia pegasalis, 127.
Dicrepidius elegans, 205.
 ignotus, 205.
Didasys belæ, 46.
Didelphis, 574.
Didymictis haydenianus, 825.
Dinemellia, 262, 263, 265.
 boehmi, 265.
 dinemelli, 245, 265.
Dineutes longimanus, 196.
 metallicus, 196.
Dinotopterus, 749.
Diomedea epomophora, 861.
 exulans, 861–864.
 (Rhothonia) sanfordi, 861–864.
 sanfordi, 862.
Dioryctria clarioralis, 129.
Diplocœlus, 200.
Diplodocus, 815–819.
Dipthera fallax, 54.
Dircetus pygmæa, 81.
Discognathus, 748.
 dembeensis, 655, 656, **695**.
 ornatus, 655, 661, **696**.
Dissacus, 828.
Distichodus, 748.
 affinis, 656, 657, 658, 660, **686**.
 antonii, 658, 661, **687**.
 atroventralis, 661, **687**.
 dembeensis, **695**.
 fasciolatus, 656, 658, 660, 661, **687**.
 langi, 654, 658, **687**.
 lusosso, 656, 658, 660, 661, **688**.
 maculatus, 656, 658, 660, 661, **686**.
 sexfasciatus, 656, 658, 660, 661, **688**.
Ditoma carinata, 201.
Diviana eudoriella, 132.
 verecuntella, 132.
Divitiaca ochrella, 131.
 parvuella, 131.
 simulella, 131.
Dœimodus, 750.
Dolba hylæus, 38.
Dolichorrhinia planatella, 131.
Doru albipes, 636, **649**.
 bimaculatum, 649.
 lineare, 636, **648**.
Doryodes bistriaris, 66.
 spadaria, 67.

- Doumea, 750.
 alula, 655, 656, 658, 662, **722**.
 typica, 722.
 Drapetes tunicatus, 205.
 Drasteria erectea, 72.
 Drepanoplectes, 261, 262.
 Drosophila ampelophila, 347-353.
 Dunn, Emmett R., reptile and amphibian collections from the North Carolina Mountains, with especial reference to salamanders, 593-634.
 Dynamis politus, 218.
 Dynastes argentata, 208.
 lagaii, 208.
 vulcan, 208.
 Dyscinetus barbatus, 208.
 picipes, 208.
 trachypygus, 208.
 Dysodia flagrata, 108.
 floridanus, 108.
 speculifera, 107.
 Dyspteris abortivaria, 92.

 EARWIGS (*Dermaptera*), studies in West Indian, 635-651.
 Eastman, Charles R., dentition of *Hydrocyon* and its supposed allies, 757-760.
 Eburia decemmaculata, 209.
 Echiaster bupthalmus, 198.
 distinctus, 198.
 impressicollis, 198.
 sharpi, 198.
 waterhousii, 198.
 Ecpantheria albicornis, 340.
 deflorata, 50.
 deflorata var. denudata, 50.
 Ectoconus, 573.
 Ectodus, 751.
 Ectropis crepuscularia, 99.
 Egrylon filaria, 78.
 Eidolon helvum, 406, 407, 408, 411, 412, **414**, **497**.
 Elaphe obsoleta, 629.
 Elaphidion glabratum, 209.
 irroratum, 209.
 manum, 209.
 signaticolle, 209.
 tomentosum, 209.

 Elasmodontomyinae, 186.
 Elasmodontomys, 185.
 Elasmopalpus floridellus, 130.
 lignosellus, 130.
 melanellus, 130.
 petrellus, 130.
 Eleutherodactylus lineatus, 793-797.
 martinicensis, 796, 811.
 miliaris, 795.
 petropolitanus, 812.
 Elophila bifascialis, 121.
 claudialis, 121.
 drumalis, 121.
 fulcalis, 121.
 slossonalis, 121.
 Elwyn, Adolph, effect of humidity on pupal duration and on pupal mortality of *Drosophila ampelophila*, 347-353.
 Elytrogona bulla, 212.
 quadrodecimmaculata, 212.
 Emballonuridae, 414, 486.
 Emblema, 261, 262.
 Emesis caeneus, 22.
 Emmiltis sparsaria, 92.
 Empyreuma affinis, 339, 343.
 affinis haytiensis, 339.
 anassa, 339, **343**.
 pugione, 339, 342.
 Enantiopus, 751.
 Enarmonia tristrigana, 138.
 Enemothrombium **ovalis**, 156.
 penicillifer, 156.
 Engraulicypris, 748.
 congicus, 655, 656, 660, **703**.
 Ennearthron delicatulum, 207.
 Ennomos subsignarius, 100.
 Enodia creola, 18.
 portlandia, 18.
 Eohippus, 574.
 Eois australis, 92.
 balistraria, 91.
 bonifata, 90.
 davisi, 90.
 demissaria, 90.
 eburneata, 91.
 ferrugata, 90.
 hilliata, 91.
 lacteolata, 92.

- Eois lævitaria*, 91.
 lanceolata, 91.
 micropterata, 92.
 nimbicolor, 91.
 obfusaria, 92.
 ossularia, 91.
 parvularia, 90.
 peralbata, 91.
 refractaria, 92.
 russata, 90.
 scintillaria, 90.
 suavata, 92.
Eomoropus, 576.
Epagoge demissana, 139.
 sulphurana, 139.
Epargyreus tityrus, 27.
 zestos, 27.
Ephesia cordelia, 74.
 polygama, 74.
Ephimia, 197.
Ephymia, 197.
Epicauta, 216.
 annulicornis, 216.
Epicorsia mellinalis, 117.
Epidromia delinquens, 75.
Epierus cubensis, 203.
 waterhousei, 203.
Epiglæa apiata, 61.
 sericea, 61.
Epimecis virginiana, 100.
 virginiana var. *dendraria*, 100.
Epipaschia interruptella, 127.
 superatalis, 127.
 zelleri, 127.
Episemasia morbosa, 93.
Episimus argutanus, 138.
 augmentanus, 138.
Epistor lugubris, 40.
 ocypete, 40.
Epitrix cucumeris, 211.
 fuscata, 211.
 parvula, 211.
Epizeuxis æmula, 79.
 americanis, 79.
 gopheri, 79.
 lubricalis, 79.
 scobialis, 79.
Epomophorus anurus, 408, 411, **420**, **508**.
 franqueti, 417.
Epomophorus pusillus, 421.
 wahlbergi haldemani, 408, 411, **421**, **509**.
Epomops franqueti, 406.
 franqueti franqueti, 406, 408, 411, 412, 413, **417**, **500**.
Eptesicus ater, 409, 411, 413, **443**, 487, **533**.
 faradjius, 410, 411, 413, **444**, 487, 489, 490, **534**.
 garambæ, 410, 412, 413, **445**, 487, **535**.
 minutus, 412, 413.
 minutus minutus, 410, **445**, 486, **535**.
 tenuipinnis, 409, 412, **443**, **533**.
Equidæ, 574.
Equus, 575.
Ercta ornatalis, 111.
Erebus odora, 79.
Eretmodus, 751.
Erinnyis alope, 39.
 crameri, 39.
 ello, 39.
 lassauxii merianæ, 39.
 obscura, 39.
 cenotrus, 39.
Erodiscus morio, 217.
Erynnis attalus, 32.
 leonardus, 32.
 meskei, 32.
 metea, 32.
Erythræus phalangiulus, 153.
 quadratus, 153.
Erythrura, 261, 262.
Estigmene acraea, 50.
 congrua, 50.
Estrilda, 261, 262, 263, 278.
 astrild massaica, 278.
 astrild minor, 278.
 atricapilla, 278.
 melpoda, 278.
 nonnula, 278.
Estrildinæ, 244, 251, 261, 263, **273–280**.
Ethmia confusella, 143.
Etiella rubribasella, 131.
 schisticolor, 131.
 zinckenella, 130.
Euacidalia sericeata, 88.

- Eublemma carmelita*, 68.
 flammicincta, 68.
 laphyra, 68.
Euborellia ambigua, 635, **638**.
 annulipes, 635, **640**.
 minuta, 635, **639**.
Eucalyptera bipuncta, 66.
 humeralis, 66.
Eucatagma amyrisella, 146.
Eucelatoria australis aurescens, 226.
Eucereon carolina, 46.
Euchætias egle, 51.
Euchilichthys, 749.
 dybowskii, 656, 658, 660, 662, **720**.
 guentheri, 656, 658, 659, 662, **720**.
 royauxi, 658, 662, **720**.
Euchlæna amcenaria, 101.
 astylusaria, 101.
astylusaria var. *tiviaria*, 101.
 pectinaria, 101.
 vinulentaria, 101.
Euclea delphinii, 105.
 nanina, 105.
Eucosma circulana, 137.
 constrictana, 138.
 desertana, 138.
 floridana, 138.
 giganteana, 137.
 lineana, 138.
 minutana, 138.
 ochraceana, 137.
 perplexana, 138.
 quinquemaculana, 137.
 strenuana, 138.
 tripartitana, 138.
 vandana, 138.
Eucosmophora sideroxytoniella, 145.
Eucrostes dominicaria, 88.
Eudamus proteus, 26.
Eudule meridiana, 92.
Eueana niveociliaria, 88.
Euerythra phasma, 49.
Eugnathichthys, 747.
 eeetveldii, 656, 658, 660, 661, **683**.
 macroterolepis, 656, 658, 659, 660,
 661, **684**.
Euherrichia granitosa, 71.
 mollissima, 71.
Eulia amatana, 140.
Eulia mariana, 140.
Euloewiopsis, 222.
 setosa, 222.
Eumæus atala, 22.
Eumestleta cinnamomea, 68.
 minima, 68.
 obliqualis, 68.
Eumolpus imperialis, 210.
Eunectes occidentalis, 196.
Eunica monima, 17. '
 tatila, 17.
Eunomia columbina, 339.
Eunystalea indiana, 83.
Eupalus parvus, 151.
Euphorticus pubescens var. *æneolus*, 195.
Euphyes metacomet, 34.
Euphysetes, 364.
 grayii, 362.
 macleayii, 363.
 pottsii, 363.
Eupithecia miserulata, 92.
 nebulosa, 92.
Euplectes, 261, 262.
Eupseudosoma involuta florida, 48.
Eupsyche hugon, 23.
 m-album, 23.
 martialis, 23.
 telea, 23.
Euptoieta claudia, 13.
Eurema delia, 12.
 euterpe, 11.
 euterpe var. *alba*, 12.
 gnatheme, 12.
 jucunda, 12.
 nicippe, 11.
Eurhinus festivus, 218.
Eurymus eurytheme, 10.
 philodice, 11.
Euryscelis suturalis, 209.
Eusepes porcellus, 217.
Euscopoliapteryx, 223.
 nebulosa, 224.
Eustixia popula, 119.
Eustroma diversilineata, 93.
Eustrotia apicosa, 67.
 flaviguttata, 67.
 strigularia, 67.
Eutelia pulcherrima, 65.
 pyrastis, 65.

- Euthisanotia unio*, 63.
Euthyatira candida, 85.
Eutolyte rolandi, 57.
Eutomus cornatus, 213.
 fulvomaculatus, 212.
 sulcatus, 213.
Eutrombidium corticis, 155.
Eutropius, 749.
 congensis, 657, 658, 661, **708**.
 debauwi, 656, 659, 660, **708**.
 gastratus, 655, 658, 660, 662, **708**.
 grenfelli, 656, 658, 659, 660, 662, **708**.
 liberiensis, 657, **709**.
 niloticus, 656, 658, 662, **708**.
Euwanessa antiopa, 15.
Euxestus erithacus, 200.
 piciceps, 200.
Euxoa insulsa, 58.
Euzophera semifuneralis, 131.
Everes comyntas, 25.
Evergestis dyaralis, 111.
 rimosalis, 115.
Ewing, H. E., new Acarina. Descriptions of new species and varieties from Iowa, Missouri, Illinois, Indiana, and Ohio, 149–172.
Exelis pyrolaria, 96.
Exochomus uva, 200.
Exyra semierocea var. *hubbardiana*, 68.

FAGITANA littera, 61.
 obliqua, 61.
Feltia annexa, 58.
 malefida, 58.
Feniseca tarquinius, 25.
Fentonia marthesia, 84.
Forbes, Wm. T. M., notes on West Indian Syntomidæ and Arctiidæ (Lepidoptera), 339–345.
Forficelisa annulipes, 640.
 curvicauda, 640.
Forficula albipes, 649.
 americana, 637.
 bidens, 640.
 bimaculata, 649.
 dorsalis, 641.
 linearis, 648.

Forficula maritima, 638.
 unidentata, 647.
Formicilabia, 641.
 caribea, 636, **642**.
Foudia, 261, 262, 263, 271.
 madagascariensis, 271.
Fringillidæ, 262.
Fruva apicella, 70.
 fasciatella, 70.
 parvula, 70.
Furnarius rufus, 588, 589, 592.
Fustiger haytiana, 197.

GABERASA ambigualis, 80.
Galasa rubidana, 123.
Galaxias, 743, 750.
Galaxiidæ, 738, 750.
Galerita beauvoisi, 195.
Galgula partita, 67.
Galleria mellonella, 127.
Gasterosteidæ, 752.
Gasterosteus, 752.
Gastornis, 319.
 edwardsi, 320.
 klaasseni, 320.
 parisiensis, 320.
Gastrotheca, 811, 812.
Gelechia coloradensis, 143.
Genyomyrus, 746.
 donnyi, 659, 673.
Genyornis, 309, 311.
Geothlypis æquinoctialis cucullata, 589.
Gephyrochromis, 751.
Gephyroglanis, 749.
 congicus, 662, **714**.
 longipinnis, 656, 658, 662, **714**.
Geshna cannalis, 121.
Gibbium psylloides, 206.
Gigantichthys, 759.
Ginglymostoma sp., 765.
Givira anna, 108.
 basalis, 108.
 francesca, 108.
Glaphria basiflavalis, 110.
 fulminalis, 110.
 glaphyralis, 110.
 sesquialtrialis, 110.
Glauconycteris alboguttatus, 410, 412, 414, **449**, 487, **539**.

- Glauconycteris humeralis*, 410, 411, 412, 414, **448**, 486, **539**.
papilio, 410, 411, 413, **447**, 487, 489, 490, **538**.
Glena cognataria, 99.
texanaria, 99.
umatillaria, 99.
Globicornis fulvipes, 202.
Glyphidocera floridanella, 142.
Glyphonyx quadraticollis, 205.
Glyptocera consobrinella, 130.
Glyptoscelis aeneipennis, 210.
hobsoni, 210.
Gnathobagrus, 654, **711**, 749.
depressus, 655, 657, **712**.
Gnathonemus, 746.
curvirostris, 657, 661, **673**.
cyprinoides, 661, **672**.
elephas, 656, 657, 659, 661, **672**.
greshoffi, 656, 657, 659, 661, **672**.
ibis, 656, 657, 659, 661, **673**.
leopoldianus, 662, **671**.
livingstonii, 655, 662, **671**.
mirus, 656, 657, 659, 660, 661, **672**.
monteiri, 656, 657, 659, 660, 661, **671**.
moori, 659, **670**.
numenius, 661, **673**.
petersii, 657, 659, 660, 662, **670**.
rhynchophorus, 656, 657, 659, 660, 661, **672**.
stanleyanus, 657, 659, 660, 661, **671**.
tamandua, 657, 661, **672**.
Gnorimoschema terracottella, 142.
Gobiesox yuma, 876.
Gonodes liquida, 54.
Gonodonta nutrix, 64.
unica, 63.
Gonodontis antidiscaria, 101.
hypochraria var. *homuraria*, 101.
obfirmaria, 101.
Gortyna u-alba, 61.
Gracilaria bursarella, 145.
sebastianella, 146.
Grammatotria, 751.
Grammodes smithii, 75.
Grammodia caicus, 40.
Granatina, 261, 263.
 Granger, Walter, notes on Paleocene and Lower Eocene mammal horizons of northern New Mexico and southern Colorado, 821-830.
 Granger, Walter, and Gregory, W. K., a revision of the Eocene Primates of the genus *Notharctus*, 841-859. See also Matthew, W. D.
Graphiphora culea, 60.
oviduca, 60.
vindemialis, 60.
 Gregory, William K., see Granger, Walter.
 Griscom, Ludlow, see Nichols, John Treadwell.
 Grossbeck, John A., insects of Florida. IV. Lepidoptera. Edited by Frank E. Watson, 1-147.
Gyascutus carolinensis, 205.
Gymnalabes 748.
Gymnarchus, 746.
Gynandropus guadeloupensis, 194.
Gyrinophilus danieli, 613.
Gyrinus rugifer, 196.
HADENA *miseloides*, 56.
patina, 56.
tapeta, 56.
turbulenta, 56.
Hæmorrhagia diffinis, 41.
thysbe, 41.
thysbe var. *cimbiciformis*, 41.
thysbe var. *floridensis*, 41.
thysbe var. *fuscicaudis*, 41.
Halecia aureomicans, 205.
Halisidota cinctipes, 49.
longa, 49.
tessellaris, 49.
Haltica ignita, 211.
subaurea, 211.
Haplochilus elegans, 658, 659, 662, **725**.
multifasciatus, 662, **725**.
platysternus, 655, 662, **724**.
singa, 662, **725**.
spilauchen, 662, **725**.
Haplochromis, 750.
desfontainesii, 656, 662, **727**.
moffati, 655.
strigigena, 655, 662, **727**.
Haplotaxodon, 751.

- Haptoncus luteolus, 203.
 Harpaglæa venustula, 61.
 Harpyia borealis, 84.
 cinerea, 84.
 Harrisina americana, 107.
 australis, 107.
 Harrismemna trisignata, 54.
 Hebard, Morgan, see Rehn, James A. G.
 Hedypleta indicata, 113.
 Heilipus, 217.
 elegans, 217.
 Heliocheilus albidentina, 62.
 paradoxus, 62.
 Heliopetes syrichtus, 28.
 Heliophana mitis, 63.
 Heliophila commoides, 60.
 extincta, 60.
 juncicola, 60.
 latiuscula, 59.
 linita, 60.
 multilinea, 60.
 pallens, 59.
 pendens, 60.
 phragmitidicola, 60.
 pilipalpis, 59.
 unipuncta, 59.
 velutina, 59.
 Heliospiza, 261.
 noomeæ, 259.
 Heliothis armigera, 62.
 Hellula undalis, 115.
 Hemerocampa inornata, 85.
 Hemerophila dyari, 141.
 Hemeroplanes parce, 40.
 Hemicacodon, 829.
 Hemiargus ammon, 25.
 hanno, 25.
 Hemichromis, 751.
 bimaculatus, 662, **731**.
 fasciatus, 656, 657, 659, 660, 662,
 731.
 Hemileuca maia, 44.
 Hemipeplus marginipennis, 201.
 Hemirhipus fascicularis, 204.
 Hemistichodus, 747.
 Hemithlæus baldwini, 823.
 Hemitilapia, 751.
Heptaxodon, 183.
 bidens, 183.
Heptaxodontinæ, 186.
 Herculia sordidalis, 122.
 Herse cingulata, 37.
 cingulata var. decolorata, 37.
 Hesperornis, 307.
 Heterachthes, 209.
 ebenus, 209.
 Heterarthron gonagra, 207.
 Heteraspis nana, 210.
 Heterhyphantes, 263.
 Heterobranchus, 748.
 longifilis, 661, 707.
 Heterocampa astarte, 83.
 biundata, 83.
 guttivitta, 84.
 lineata, 83.
 obliqua, 83.
 picta, 83.
 subrotata, 83.
 umbrata, 83.
 Heterochiromys, 833.
 Heterodon platirhinos, 632.
 Heterohyus, 833.
Heteropsomyinæ, 189.
 Heteropsomys insulans, 189.
 Heterotis, 746.
 Hexeris enhydris, 108.
 Hilarotes chalcoptera, 205.
 Hipparion whitneyi, 575.
 Hippodamia convergens, 200.
 13-punctata, 200.
 Hipposideros **abæ**, 409, 411, **432**, 487,
 489, **525**.
 caffer, 406, 487, 489.
 caffer centralis, 409, 411, 412, 413,
 430, **523**, **559**.
 caffer **niapu**, 409, 413, **431**, 486,
 525.
 cyclops, 406.
 gigas **niangaræ**, 409, 413, **438**, 487,
 491, **527**.
 langi, 409, 411, 412, 413, **434-438**,
 486, 489, **526**.
 nanus, 409, 411, 413, **434**, 487, **525**.
 Hipposyus, 843.
 formosus, 842, 849, 850.
 robustior, 842, 852, 853.
 Historis odius, 18.
 Histurgops, 261, 262, 263.

- Holomelina aurantiaca*, 49.
 aurantiaca var. *brevicornis*, 49.
 diminutiva, 49.
 læta, 49.
 rubicundaria, 49.
Holotrochus smithi, 198.
Homaledra heptathalama, 145.
 sabalella, 145.
Homœosoma differtella, 133.
 electellum, 133.
 stypicellum, 133.
 uncanale, 133.
Homohadena infixa, 57.
Homophæta æquinoctialis, 211.
Homophyla krugi, 212.
Homopsomys, 187.
 antillensis, 187.
Homopyralis contracta, 72.
 monodia, 72.
 tantillus, 72.
Homosassa ella, 134.
Hoplias, 757.
Horia auriculata, 216.
 maculata, 216.
Hormoschista pagenstecheri, 71.
Hulstia dulciella, 131.
Hussakof, L., fossil fishes collected by the American Museum Congo Expedition, 761-767.
Hyamia perditalis, 71.
Hyblæa puera, 72.
Hydriomena australata, 93.
 floridata, 93.
 latirupta, 93.
 neomexicana, 93.
Hydrochus pallipes, 196.
 rugosus, 196.
Hydrocyon, 747, **757-760**.
 forskallii, 758.
 goliath, 661, **678**.
 lineatus, 657, 658, 660, 661, **678**, 757.
Hydrophilus tenebrioides, 197.
Hyla, 805.
 abbreviata, 812.
 evansi, 807.
 fuhrmanni, 803-812.
 goeldii, 807.
 ohausi, 808.
 pickeringi, 620.
Hyla versicolor, 620.
Hylephila phylæus, 30.
Hylodes anomalous, 806.
 palmatius, 806.
 ramiformis, 806.
Hylonomus, 804.
Hyloscirtus, 804, 812.
 bogotensis, 805.
 boulengeri, 805.
 fuhrmanni, 805-812.
Hymenia fascialis, 111.
 perspectalis, 110.
Hypargos, 261, 262, 263, 276.
 dybowskii, 245.
 schlegeli, 245, 276.
Hyparpax perophoroides, 84.
 perophoroides var. *tyria*, 84.
Hypatus bachmani, 21.
Hypena ancara, 81.
Hypenodes macula, 79.
Hypenula cacuminalis, 80.
Hyperæschra georgica, 83.
Hyperaspis apicalis, 200.
 connectens, 200.
Hypermegethes, 261, 262.
Hyperopisus, 746.
Hyphantornis, 261, 262, 263, 269.
 cucullatus, 269.
 cucullatus bohndorffi, 269.
Hyphantria cunea, 50.
 cunea var. *punctata*, 50.
Hyphanturgus, 261, 262, 263, 270.
 aurantius, 270.
 nigricollis, 271.
 ocularius, 270.
Hypocala andremona, 74.
Hypocheira, 257, 261, 262, 263.
 chalybeata, 279.
 ultramarina, 279.
Hypolampsis nigrina, 211.
Hypolophites mayombensis, 765.
Hypoprepia miniata, 48.
Hypoptus insularis, 216.
Hyporhagus æneus, 214.
 marginatus, 214.
Hypothenemus abdominalis, 219.
 amplipennis, 219.
 brunneipennis, 219.
 ceibæ, 219.

- Hypothenus eruditus*, 220.
 flavipes, 219.
 lineatifrons, 219.
 moschata, 219.
 obscurus, 219.
 parvus, 219.
 pilosus, 219.
 plumeria, 220.
 sacchari, 219.
Hypsignathus monstrosus, 408, 411, 413,
 418, 482, 485, **502-508**.
Hypsorhapha hormos, 72.
 monilis, 72.
Hypsotropa luteicostella, 134.
Hyrachyus, 576.
Hysterosia inopiana, 140.
- ICHTHYFAUNÆ, African fresh-water, 739.
Iohthyoborus, 747.
Ichthyornis, 307.
Ide lithosina, 143.
 vestalis, 143.
Iesta lisetta, 126.
 Ignacio region, geology of, 826-830.
Illice unifascia, 47.
 striata, 48.
 subjecta, 47.
Immyrta bumeliella, 130.
Inopeplus præusta, 201.
Ischiodontus oblitus, 204.
Ischyrrhiza, 759.
Isichthys, 746.
Isochætes beutenmülleri, 106.
Isolomalus nanulus, 203.
Isomera sericea, 214.
 valida, 214.
Isoparce cupressi, 38.
- JASPIDIA nana*, 54.
 teratophora, 54.
Jocara incrustalis, 127.
 perseella, 127.
Jodia rufago, 61.
 Jonas, Anna I., Pre-Cambrian and Triassic diabase in eastern Pennsylvania, 173-181.
Julidochromis, 751.
Junonia cœnia, 16.
 lavinia, 16.
- KAKOPODA *cincta*, 78.
Kerivoula cuprosa, 406, 410, 411, 412,
 452, 487, 489, 491, **542**.
Kneria, 747.
Kneriidae, 735, 747.
Kogia breviceps, list of specimens, 361-364; historical, 364; measurements, 364; skull as a whole, 368-383; cranial bones, 383-389; comparison of *Kogia* and *Physeter*, 399-402; literature, 402.
 floweri, 363, 364.
 grayi, 363, 364.
 pottsii, 364.
 simius, 364.
- LABEO, 748.
 annectens, 656, 661, **693**.
 ansorgii, 655, 651, **695**.
 chariensis, 655, 656, 658, 661, **694**.
 coubie, 655, 661, **690**.
 cyclopinnis, 654, 661, **690**.
 falcipinnis, 658, 661, **692**.
 forskalii, 655, 661, **693**.
 greenii, 656, 658, 661, **693**.
 intermedius, 655, 660, 661, **694**.
 kirkii, 655, 661, **693**.
 lineatus, 661, **689**.
 longipinnis, 658, 660, 661, **690**.
 macrostoma, 658, 660, 661, **690**.
 nasus, 661, **693**.
 ogunensis, 655, 656, **695**.
 parvulus, 655, 656, **693**.
 parvus, 655, 656, 658, 660, 661, **695**.
 sorex, 655, 661, **691**.
 velifer, 655, **690**.
 weeksii, 656, 658, 661, **689**.
- Labia brunnea*, 647.
 curvicauda, 636, **640**.
 dorsalis, 636, **641**.
 mæklini, 642.
 pulchella, 647.
 trinitatis, 641.
 unidentata, 641.
Labidura bidens, 636, **640**.
Labochilotes, 750.
Labogestoria gibbicollis, 201.
Laccophilus americanus, 196.
 proximus, 196.

- Lachnophorus leucopterus*, 194.
Lachnopus curvipes, 216.
 valgus, 216.
Lactica scutellaris, 211.
Lamophloeus adustus, 201.
 iteratus, 206.
 pusillus, 201.
Lætilia coccidivora, 131.
Lagoa pyxidifera, 106.
Lagochirus araneiformis, 210.
Lagonostieta, 261, 262, 263, 277.
 brunneiceps, 277.
 rara, 277.
 rendalli, 277.
 rhodopareia, 277.
Lamna appendiculata, 765, 766.
Lamprologus, 751.
 obliquus, 655, 656, 658, 662, **731**.
Lamprolophus lithella, 145.
Lampropeltis getulus, 630.
 triangulum, 630.
 Lang, Herbert, field notes on *Scutisorex*,
 781-783.
 Lang, Herbert, and Chapin, James P.,
 distribution and ecology of Central
 African Chiroptera, 479-496; field
 notes on African Chiroptera, 497-560.
Lapara bombycoides, 38.
 coniferarum, 38.
 halicarnia, 38.
Lapethus, 201.
Laphygma frugiperda, 56.
 frugiperda var. *obscura*, 56.
Lasioderma serricorne, 206.
Latebraria amphipyroides, 79.
Lates niloticus, 658, 662, 725.
Lathropus costatus, 202.
Lavia frons, 489.
 frons affinis, 409, **427**, 487, 490, **520**.
Lebia biteniata, 195.
 elevata, 195.
 viridis, 195.
Lema confusa, 210.
 dorsalis, 210.
 intermedia, 210.
 Leng, Charles W., and Mutchler,
 Andrew J., supplement to prelimi-
 nary list of the Coleoptera of the West
 Indies, 191-220.
Lepidosirenidae, 735, 746.
Lepidotus congolensis, 761-765.
Lepipolys perscripta, 57.
Leptoceratops, 281.
Leptocypris, 748.
 modestus, 661, 702.
Leptodactylus lineatus, 795, 796.
 melanotus, 795, 796.
 mystacenus, 812.
Leptoglanis, 749.
Leptomeris æmulata, 90.
 lautaria, 90.
 ostentaria, 90.
 plantagenaria, 90.
 roseotincta, 90.
Leptostylus, 210.
 argentatus, 210.
 præmorsus, 210.
Leptotes theonus, 26.
Lepturges guadeloupensis, 210.
Lerema accius, 32.
Lerodea eufala, 34.
 loammi, 33.
 maculata, 33.
 osyka, 34.
Leucania luteopallens, 59.
Leuciscus, 748.
Leucoptera erythrinella, 146.
 guettardella, 146.
Leucothyreus vicentia, 208.
Leurognathus marmorata, 611.
Liaccarus fusiformis, 161.
Ligyris cordatus, 208.
 juvencus, 208.
Limnotherium, 843.
 tyrannus, 849.
Limochroes arpa, 34.
 byssus, 34.
 palatka, 34.
 streckeri, 34.
 yehl, 34.
Lineodes contortalis, 119.
 integra, 119.
 interrupta, 119.
 triangularis, 119.
Linura, 261, 262.
Lioderma interruptum, 203.
 quadridentatum, 203.
Lipoptycha maculana, 138.

- Lispinus claviger*, 198.
 impar, 198.
 insularis, 198.
Listropoda schmidlii, 559.
Litargus balteatus, 202.
Lithacodia bellicula, 67.
Lithocharis ochracea, 199.
Lithodytes, 794.
Litodonta hydromeli, 83.
Litolibrus princeps, 199.
Litoprosopus futilis, 77.
Loberus testaceus, 202.
Lobiopa insularis, 203.
Lobogestoria, 204.
Lomanaltes eductalis, 81.
Lophiodon, 576.
Lophodonta angulosa, 83.
Lower Animas Valley, geology of, 823-826.
Loxia megaplaga, 331.
Loxodon africanus, 865.
Loxostege albiceralis, 116.
 albiceralis var. *floridalis*, 116.
 dasconalis, 116.
 helvialis, 116.
 mancalis, 116.
 nasionalis, 117.
 similalis, 117.
Ludovix, 217.
Luperus placidus, 211.
Lussa abseuzalis, 57.
 filifera, 57.
Lycophotia incivis, 58.
Lycorea cleobæa, 21.
Lycopholis foveicollis, 207.
Lyetus, 207.
Lygropia chromalis, 114.
Lygyrus fossulatus, 208.
Lymire, 344.
 albipennis, 344, 345.
 candida, 339, **344**.
 edwardsi, 46, 339, 344.
 fulvicollis, 344.
 melanocephala, 344, 345.
 metamelas, 344.
 senescens, 339, 344, **345**.
 strigivenia, 344.
Macaria bisignata, 94.
 infimata, 94.
 maculifascia, 94.
 præatomata, 94.
 punctolineata, 94.
MacCallum, G. A., a new species of Trematode (*Cladorchis gigas*) parasitic in elephants, 865-870.
Machærhamphus anderssoni, 493.
Macraspis tristis, 208.
Macratrìa, 215.
Macromerus lanipes, 217.
Macrorhyncolus, 218.
Macrosiagon, 216.
 basalis, 216.
 cruentum, 216.
 discicolle, 216.
 sordidum var. *major*, 216.
Macrostola lutea, 203.
Macrothea unicoloralis, 123.
Madoryx pseudothyreus, 40.
Magusa dissidens, 57.
 orbifera, 57.
Malacopterygii, 735.
Malacosoma americana, 86.
 detritum, 211.
Malimbus, 261, 262, 263, 269.
 coronatus, 269.
 erythrogaster, 269.
 malimbicus, 270.
 nitens, 269.
 rubricollis centralis, 270.
 spinibarbis, 209.
Malopterurus, 750.
 electricus, 656, 657, 658, 662, **723**.
Mamestra capsularis, 59.
 erecta, 59.
 florida, 59.
 laudabilis, 59.
 lustralis, 59.
Manatha nigrita, 105.
Marasmalus basalis, 65.
 inficita, 65.
Marasmia cochrusalis, 111.
 floridalis, 112.
 trapezalis, 112.
Marathyssa ventilator, 65.
Marcusenius, 746.
 nigripinnis, 656, 657, 659, 661, **667**.

- Marcusenius **osborni**, 654, 659, **667**.
 plagiostoma, 656, 657, 661, **669**.
 psittacus, 656, 657, 660, 661, **669**.
 pulverulentus, 657, **667**.
 retrodorsalis, 654, 659, **668**.
 tumifrons, 656, 661, **669**.
 wilverthi, 657, 661, **670**.
 Marmara *guilandinae*, 146.
 Massala *larina*, 77.
 Mastacembelidae, 738, 752.
 Mastacembelus, 752.
 congicus, 656, 658, 659, 660, 662, **733**.
 Matthew, W. D., a Paleocene bat, 569–571; absence of the pollex in *Perissodactyla*, 573–577; the dentition of *Nothodectes*, 831–839.
 Matthew, W. D., and Granger, Walter, the skeleton of *Diatryma*, a gigantic bird from the Lower Eocene of Wyoming, 307–326.
 Medon *cingulatus*, 199.
 Megadermidae, 414, 486.
 Megadytes *fraternus*, 196.
 giganteus, 196.
 Megaloglossus *woermanni*, 482.
 Megalops *humeralis*, 198.
 laeviventris, 198.
 smithii, 198.
 Megalopyge *opercularis*, 106.
 Megapenthes *sturmii*, 205.
 Megathymus *cofaqui*, 35.
 yuccae, 35.
 Megilla *maculata*, 200.
 Megistops *granulatus*, 212.
 Melalopha *inclusa*, 82.
 inclusa var. *jocosa*, 82.
 Melanchroia *cephise*, 103.
 geometroides, 103.
 regnatrrix, 103.
 Melanolophia *canadaria*, 99.
 Melanophila *notata*, 205.
 Melanophthalma *distinguenda*, 204.
 Melanopteryx, 261, 262, 263, 269.
 maxwelli, 269.
 nigerrimus, 269.
 Melanthus *brunnea*, 28.
 Melioptis *famelica*, 72.
 jucunda, 72.
 Melioptis *limbolaris*, 72.
 sinualis, 73.
 Melitara *prodenialis*, 131.
 Melittia *satyriniformis*, 108.
 Memythrus *asilipennis*, 110.
 palmii, 109.
 scepsiformis, 109.
 seminole, 110.
 Menesta *melanella*, 142.
 Meroptera *pravella*, 130.
 Merostenus *attenuatus*, 209.
 Merychippus, 574.
 Mescina *estrella*, 131.
 Meskea *dyspteraria*, 108.
 Mesoborus, 747.
 crocodilus, 657, 658, 660, **684**.
 Mesohippus, 574.
 Mesomphalia *aenea*, 212.
 exclamationis, 212.
 Mestra *floridana*, 15.
 Metachroma *cubæcola*, 210.
 suffriani, 210.
 terminalis, 210.
 Metamasius *sericeus*, 218.
 Metanema *quercivoraria*, 101.
 Metaponia *obtusa*, 69.
 Methia *punctata*, 209.
 Methorasa *argentilinea*, 71.
 cordata, 71.
 monetifera, 71.
 Metriochroa *psychotriatella*, 146.
 Micralestes, 655, 679, 747.
 acutidens, 656, 658, 660, **682**.
 altus, 656, 659, 660, **682**.
 stormsi, 656, 662, **682**.
 Micranops *brunneus*, 199.
 Micranthus, 751.
 Microcausta *flavipunctalis*, 117.
 Microligea **montana**, 330.
 Micropteropus *pusillus*, 408, 412, **421**, **510**.
Microsiphonorhis, 329.
 brewsteri, 329.
Microstomatichthyoborus, 654, **685**, 747.
 bashforddeani, 654, 660, **685**.
 Microsynodontis, 749.
 batesii, 659, 719.
 Microsyops *uintensis*, 854.

- Microthrissa*, 655, 676, 747.
Mieza igninix, 140.
 Miller, Leo E., field notes on *Molothrus bonariensis* and *M. badius*, 579–592.
Mimetillus moloneyi, 410, 411, 412, 413, **446**, 486, **535**, 537.
Mimus saturninus modulator, 592.
Mineola indigenella nebulella, 129.
Miniopterus breyeri vicinior, 410, 411, 414, **450**, 487, **539**.
 inflatus, 410, 413, **451**, 487, **540–542**.
Minthea rugicollis, 207.
Minthoplagia rafaelli, 226.
Mioclænus opisthacus, 823.
 turgidus, 822, 823, 825.
Miohippus, 574.
Mirosternus lævis, 206.
Mitoura acis, 24.
 damon, 24.
Mixodectes, 825.
Mochocus, 750.
Molossidæ, 414, 486.
Molothrus badius, 590–592.
 bonariensis bonariensis, 580–590.
Monista personata, 198.
Monoclonius, 281, 285.
 cutleri, 289, 301–386.
 flexus, 287.
 nasicornus, 286–306.
Monocrepidius bifoveatus, 205.
Monodes trientiplaga, 56.
Monœdus, 201.
 guttatus, 201.
 lecontei, 201.
Monohammus titillator, 210.
Monoleuca obliqua, 106.
 subdentosa, 105.
 sulfurea, 105.
Monophyllus frater, 565.
Monoptilota nubilella, 129.
 Mook, Charles C., criteria for the determination of species in the Sauropoda, with description of a new species of *Apatosaurus*, 355–360; fore and hind limbs of *Diplodocus*, 815–819.
Mops (Allomops) **faradjius**, 410, 414, **476**, 487, **557**.
 (Allomops) **nanulus**, 410, 413, 414, **477**, 558.
 Mops (Allomops) **occipitalis**, 410, 411, 412, 414, **474**, **557**.
 (Allomops) **osborni**, 410, 412, 414, 470, **473**, 487, 491, **555**.
 congicus, 410, 412, 414, **467**, 487, **554**.
 midas, 410, 412, **466**, 487, **554**.
 nanulus, 487.
 niangaræ, 410, 413, 414, **468**, 487, **555**.
 occipitalis, 487.
 trevori, 410, 412, 414, 487, **469**, **555**.
Mordella scutellaris, 215.
Morio monilicornis, 195.
Mormyridæ, 735, 746.
Mormyrops, 746.
 attenuatus, 656, 657, 659, 660, 661, **667**.
 breviceps, 655, 657, **666**.
 deliciosus, 656, 657, 660, 661, **666**.
 masuianus, 666.
 microstoma, 657, **666**.
 sirenoides, 656, 657, 659, 660, **666**.
Mormyrus, 746.
 bumbanus, 656, 657, 661, **673**.
 caballus, 656, 657, 661, **674**.
 ovis, 656, 657, 661, **673**.
 proboscirostris, 661, **674**.
 rume, 661, **674**.
Moropus, 576.
Morrisonia confusa, 59.
 mucens, 59.
 rileyana, 59.
 sectilis, 59.
Munia, 261, 262, 263, 274.
 oryzivora, 248, 274.
 Murphy, Robert Cushman, a new albatross from the west coast of South America, **861–864**.
Musicoderus nigrocoeruleus, 198.
 Mutchler, Andrew, J., see Leng, Charles W.
Myeloides bistriatella, 128.
 dulciella, 128.
 duplipunctella, 128.
 obnupsella, 128.
 oporedestella, 129.
 transitella, 128.
Myliobatis dispar, 765.

- Myochrous brevicornis*, 211.
 denticollis, 211.
Myomyrus, 746.
 macrodon, 657, 659, 661, **670**.
 macrops, 656, 657, **670**.
Myonycteris wroughtoni, 408, 412, **422**,
 511.
Myopterus albatrus, 406, 410, 413, **453**,
 487, **543**.
Myotis bocagii, 487, 489.
 bocagii bocagii, 409, 412, **439**, 487,
 527.
 bocagii cupreolus, 409, 411, 412,
 440, 486, **528**.
 bocagii hildegardeæ, 409, 411, **440**,
 487, **529**.

NACERDA, 215.
Nacoleia hampsoni, 113.
Nacophora phigalaria, 100.
 quernaria, 100.
 ypsilon, 100.
Nandidæ, 750.
Nannalthiops, 747.
Nannæthiops tritæniatus, 659, **686**.
Nannocharax, 748.
 brevis, 661, **688**.
 elongatus, 656, 658, 660, **689**.
 fasciatus, 656, **688**.
 tænia, 658, 659, 660, **689**.
Nannochromis, 750.
 squamiceps, 655, 662, **730**.
Napata chalybea, 339.
Nathalis iole, 9.
Natrix septemvittata, 627.
 sipedon, 628.
Nausibius dentatus, 202.
Nealyda kinzelella, 142.
 pisioniæ, 142.
Necrosorex, 833.
Negetia formosalis, 47.
Neisna, 262.
Nelicurvius, 261, 262, 263, 271.
 nelicourvi, 271.
Nemachilus, 748.
Nematidium mustela, 201.
Nemognatha, 216.
Nemoria auranticolorata, 88.
 mimosaria, 87.

Nemosoma, 204.
Neoarchytas inambarica aurifrons, 228.
Neoborus, 747.
Neochmia, 261, 262.
Neocyphus pudens, 216.
Neodavisia singularis, 127.
Neolebias, 747.
Neonympha gemma, 19.
 phocion, 19.
Neoplagiaulax molestes, 821.
Neoplynes eudora, 48.
Nephopterx pergratialis, 130.
Nephopteryx furfurella, 130.
Nepytia fumosaria, 95.
Neshyphantes, 263.
Nesocharis, 252, 261, 278.
 capistrata, 245, 278.
Niauchenoglanis, 749.
Nichols, John Treadwell, ichthyological
 notes from a cruise off southwest
 Florida, with description of *Gobiesox*
 yuma, p. **873-877**.
Nichols, John Treadwell, and Griscom,
 Ludlow, fresh-water fishes of the
 Congo Basin obtained by the American
 Museum Congo Expedition, 1909-
 1915, 653-756.
Nigrita, 261, 262, 263, **274**.
 brunnescens saturator, 274.
 canicapilla, 274.
 fusconota, 245, 275.
 luteifrons, 274.
Noble, G. K., the systematic status of
 some Batrachians from South America,
 793-814.
Noctua lubricans, 58.
 spretæ, 58.
Noda fusca, 210.
 luteicornis, 210.
Nola lagunculariæ, 47.
Nomophila noctuella, 116.
Nonagria oblonga, 61.
Noropsis hieroglyphica, 63.
Notharctinaæ, 842.
Notharctus, 845.
 affinis, 843, 848, **850**.
 anceps, 843, 847, **849**.
 crassus, 843, **854**.
 matthewi, **845**.

- Notharctus nunienus*, 843, **845**.
osborni, 843, 846, **848**.
pugnax, 843, **853**.
sp., 846.
tenebrosus, 843, 844, **851**.
tyrannus, 843, 844, **851**.
uintensis, **856**.
venticolus, 843, 844, **846**.
- Nothodectes*, 831-839.
dubius, 931.
gidleyi, 832-836.
sp., 828.
- Nothopleurus maxillosus*, 209.
- Notiospiza*, 261, 262.
- Notoglandium*, 749.
- Notopteridæ*, 735, 746.
- Notopterus*, 746.
- Notophthalmus viridescens*, 620.
- Nycteridæ*, 414, 486.
- Nycteris arge*, 409, 411, 412, **426**, 486, 495, **519**.
avakubia, 409, 411, 413, **426**, 486, **519**.
grandis, 406.
hispidæ, 406, 409, 411, 412, 413, 425, **487**, **517**.
major, 409, 411, 412, 427, **487**, **520**.
pallida, 409, 411, 413, **425**, 487, 489, **518**.
- Nycticejus schlieffenii*, 447.
- Nyctinomus aloysii-sabaudia*, 487.
ansorgei, 410, 411, **453**, 487, 495, **543**.
cisturus, 410, 413, **455**, 487, **545**.
frater, 414, 487.
leonis, 410, 412, **454**, 487, **544**.
midas, 466.
ochraceus, 410, 412, 414, **455**, 487, **545**.
- Nymphula allionealis*, 120.
australis, 120.
hyralis, 120.
icciusalis, 120.
maculalis, 119.
maculalis var. *foeminalis*, 119.
maculalis var. *masculinalis*, 119.
- Nympula nebulosalis*, 120.
nomophilalis, 120.
obliteralis, 120.
- Nympula obscuralis*, 120.
- Nyridela acroxantha*, 345.
chalciope, 339, 345.
xanthocera, 345.
- OCALA dryadella*, 132.
- Ochlodes sassacus*, 32.
- Odaxothrissa*, 676, 747.
ansorgii, 657, **677**.
losera, 661, **677**.
- Odontaspis macrota*, 765.
- Ædionychis cyanipennis*, 211.
- Æstrogaster fumosus*, 223.
- Æstrogastros similis*, 223.
- Ogdoconta cinereola*, 65.
- Oiketicus abbotii*, 104.
- Olene achatina*, 85.
atomaria parallela, 85.
basiflava meridionalis, 85.
cinnamomea, 85.
leucophæa, 85.
manto, 85.
plagiata, 85.
- Olethreutes andromediana*, 137.
devotana, 137.
rosaochreana, 137.
- Oligia agrotina*, 56.
chalcedonia, 55.
exesa, 55.
festivoides, 55.
fuscimacula, 55.
grata, 55.
nucicolora, 55.
- Oligostigma seminealis*, 120.
vittatalis, 120.
- Omalodes klugi*, 203.
ruficlavis, 203.
- Ommaleskia**, 227.
fumosa, 227.
- Omoطلا distincta*, 212.
- Omototus fulvopubescens*, 211.
- Omphalocera cariosa*, 122.
- Onchosaurus*, 759.
mira, 759.
pharao, 759.
- Oncideres amputator*, 210.
- Onychocerus scorpio*, 210.
- Oosternum costatum*, 197.
- Opharus bimaculata*, 340.

- Ophideres apta, 77.
 Ophiocephalidæ, 738, 752.
 Ophiocephalus, 752.
 obscurus, 657, 658, 659, 660, 662,
 733.
 Ophiomedon anthracinus, 198.
Opsophasiopteryx, 222.
 mima, 223.
 Oreodon, 573, 574.
 Oreopeleia **leucometopius**, 327.
 Oreta odona, 86.
 Oribata **quadrisetosa**, 161.
 Oribatella achipteroides var. **australis**,
 160.
 Oribatula **clavata**, 162.
 Orthonana ceutrostrigaria, 93.
 obstipata, 92.
 Orthosia aurantiago, 61.
 chlorophora, 61.
 Orthosoma brunneum, 209.
 Ortygospiza, 261, 262.
 Oryzornis, 262.
 Osorius fauveli, 198.
 Ospromenidæ, 738, 751.
 Ostariophysi, 736.
 Osteoglossidæ, 735, 746.
 Othyphantes, 261, 262, 263, 270.
 baglafecht, 270.
 Otomops martiensseni, 406.
 Oxydia vesulia, 102.
 Oxydrepanus rufus, 195.
 Oxynodera variegata, 212.
 Oxytelus insignitus, 198.
 Ozognathus, 206.

 PACHNÆUS citri, 216.
 marmoratus, 216.
 Pachydrus obniger, 196.
 Pachylia ficus, 40.
 resumens, 40.
 Pachyotus altilis, 410, 411, **447**, 487,
 538.
 nigrita nux, 410, 412, **447**, 486, **538**.
 Pachyphantes, 261, 263.
 superciliosus, 267, 268.
 Pachyzancla bipunctalis, 116.
 periusalis, 116.
 phæopteralis, 116.
 Pæctes abrostoloides, 65.

 Pæctes devincta, 65.
 lunodes, 65.
 oculatrix, 65.
 pygmæa, 65.
 Pæderus thoracicus, 198.
 Palaminus coriaceus, 198.
 insularis, 198.
 Palatka nymphæella, 132.
 Palpidia pallidior, 48.
 Palthis asopialis, 81.
 Paludipasser, 259, 261.
 Palyas auriferaria, 102.
 Panagæus fasciatus, 195.
 quadrisignatus, 195.
 thomæ, 195.
 Panapoda rufimargo carneicosta, 75.
 Pangrapta decoralis, 71.
 Panthea furcilla, 52.
 Pantodon, 746.
 buchholzi, 657, **674**.
 Pantodontidæ, 735, 746.
 Pantographa limata, 114.
 Pantolambda, 573.
 cavirictus, 823.
 Panula inconstans, 72.
 remigipila, 72.
 Papilio andræmon bonhotei, 6.
 aristodemus, 6.
 celadon, 8.
 cresphontes, 6.
 devilliers, 5.
 glaucus, 6.
 glaucus var. australis, 6.
 glaucus var. turnus, 6.
 marcellus, 7.
 marcellus var. floridensis, 8.
 marcellus var. lecontei, 8.
 marcellus var. telamonides, 8.
 palamedes, 7.
 philenor, 5.
 polydamus, 5.
 polyxenes asterias, 5.
 ponceana, 6.
 thoas, 5.
 troilus, 7.
 troilus var. texanus, 7.
 Parachma nua, 123.
 ochracealis, 123.
 Paradosis flegia, 114.

- Paragrotis messoria, 58.
 tessellata, 58.
 Parailia, 749.
 longifilis, 662, 710.
 Paralindria partita, 203.
 Parallelia bistriaris, 75.
 Paramphilius, 749.
 Paramphistomum aspidonectes, 866.
 papillostomum, 866.
 Paramys, 574.
 Parandra lævis, 209.
 Paraphago, 747.
Paraphasiopsis, 232.
 mellicornis, 232,
 Paraphractura, 750.
 tenuicauda, 662, **723**.
Paratactopsis, 230.
 setosa, 230.
 Paratheresia **brasiliensis**, 222.
 Paratilapia, 750.
 longipinnis, 655, 658, **728**.
 macrocephala, 660, **727**.
 xenodon, 655, 660, **729**.
 Paratrytone howardi, 33.
 Parauchenoglinis, 749.
 Paretroplus, 751.
 Paridæ, 262.
Parodomyia, 225.
 paradoxica, 226.
 Parmoptila, 254, 261, 262, 263, **274**.
 jamesoni, 245, 255, **274**.
 woodhousei, 274.
 Paromalus parallelus, 203.
 Passalus interruptus, 207.
 tlascala, 207.
 unicornis, 207.
 Patalene infensata, 102.
 olyzonaria, 102.
 siculata, 102.
 syzygiaria, 102.
 Patissa flavicostella, 123.
 flavifascialis, 123.
 sordidalis, 123.
 vestaliella, 123.
 xantholeucalis, 123.
 Pelecopselaphus strictus, 205.
 Pellonula, 676, 747.
 acutirostris, 661, **675**.
 congica, 656, 659, 661.
 Pellonula (Microthrissa) royauxi, 677.
 (Pœcilothrissa) congica, 676.
 royauxi, 656, 659, 661.
 tenuis, 654, 656, 661, **675**.
 vorax, **675**.
 Pelmatochromis, 751.
 lateralis, 656, 658, 660, 662, **730**.
 Peloribates **iowaensis**, 160.
 Pelosoma, 197.
 Pelycodus, 841.
 frugivorus, 841, 857.
 jarovii, 857.
 ralstoni, 841, 857.
 trigonodus, 841, 857.
 tutus, 857.
 Penicillidia fulvida, 559.
 senegalensis, 559.
 Pentacodon, 825.
 Pentomacrus fasciatus, 209.
 Peoria approximella, 134.
 Peosina pandrosa, 79.
 Percnoptilota fluviata, 92.
 Perdita, 241.
 (Alloperdita) **novæangliæ**, 241.
 (Cockerellia) **bequaerti**, 241.
 halictoides, 241.
 Peridinetus maculatus, 217.
 poeyi, 217.
 Peridroma digna, 58.
 infecta, 58.
 margaritosa, 58.
 Perigea apameoides, 55.
 cervina, 55.
 concisa, 55.
 cupentia, 55.
 epopea, 55.
 icole, 55.
 pulverulenta, 55.
 selenosa, 55.
 sutor, 55.
 vecors, 55.
 xanthioides, 55.
 Periogonia lusca interrupta, 41.
 Periptychus carinidens, 823, 828.
 rhabdodon, 822, 825.
 rhabdodon var. fissus, 823.
 sp. nov., 828.
 Perissodactyla, absence of the pollex in,
 573-577.

- Pero honestarius, 102.
 Perrisodus, 751.
 Petalia arge, 426.
 major, 427.
 Petalium pulicarium, 206.
 Petersius, 655, 679, 747.
 caudalis, 656, **683**.
 hilgendorfi, 657, **683**.
 occidentalis, 655, 656, 658, 660, 661, **683**.
 woosnami, 656, 658, 659, 660, 661, **683**.
 Petrocephalus, 746.
 ballayi, 661, **667**.
 sauvagii, 656, 657, 659, 660, 661, **667**.
 simus, 656, 657, 659, 661, **667**.
 Petrochromis, 750.
 Phacellodomus rufifrons, 592.
 Phæcasiophora confixana, 137.
 Phænonotum, estriatum, 197.
 Phænotypus palmarum, 197.
 Phæocyma æruginosa, 78.
 benesignata, 78.
 calycanthata, 79.
 cingulifera, 79.
 curema, 78.
 declarans, 79.
 edusina, 78.
 exhausta, 78.
 fictilis, 78.
 lunata, 78.
 obliqua, 78.
 sexplagiata, 79.
 undularis, 78.
 viridans, 78.
 Phago, 747.
 boulengeri, 658, 659, **684**.
 intermedius, 660, **684**.
 Phaleria variabilis, 213.
 Phalonia angulatana, 140.
 bomonana, 140.
 bunteana, 140.
 ziscana, 140.
 Pharmacis sartana, 140.
 Phaulex albipes, 649.
 Phenacodonts, 828.
 Phenacodus, 573.
 Phenacolemur, 833, 837.
 Phylagraula slossonæ, 103.
 Philetairus, 251, **252-254**, 261, 262, 263, 267.
 socius, 252, 253, 267.
 Philhydrus melanocephalus, 197.
 nebulosus, 197.
 ochracea, 197.
 Philothermus puberulus, 201.
 Phiprosopus callitrichoides, 67.
 Phlæotrya mexicana, 215.
 Phlyctænia desistalis, 117.
 ferrugalis, 117.
 helvalis, 117.
 tertialis, 117.
 Phoberia atomaris, 75.
 Phocides batabano, 26.
 Phœbis agarithe, 10.
 argante, 10.
 Pholidornis, 261, 262, 263.
 Pholus achemon, 42.
 fasciatus, 42.
 labruscæ, 42.
 pandorus, 41.
 satellitia posticatus, 41.
 vitis, 42.
 Phormoplectes, 261, 262, 270.
 herberti, 270.
 Phororhachos, 307.
 Phractolæmidæ, 735, 747.
 Phractolæmus, 747.
 Phractura, 750.
 schapirhynchura, 659, 723.
 Phrudocentra centrifugaria, 87.
 Phrygonis argentiostrata, 103.
 Phthinolophus indentanus, 138.
 Phthiracarus **pectinatus**, 165.
 Phurys bistrigata, 76.
 campanilis, 76.
 lima, 76.
 perspicua, 76.
 vinculum, 76.
 Phycanassa viator, 33.
 Phyciodes phaon, 14.
 tharos, 14.
 Phyllocnistis intermediella, 146.
 Phyllomedusa iheringii, 811.
 Phyllonemus, 749.
 Phylloncyteris **major**, **567**.
 Phyllophaga (Lachnosterna) patruelis, 208.

- Phyllops **vetus**, 337.
 Physalia, 749.
 Physeter (Euphysetes) *simus*, 362.
 Physonota *gigantea*, 212. .
 Piesmopoda *filiolella*, 129.
 subrufella, 129.
 Pigmeophorus **quadratus**, 166.
 Piletocera *bufalis*, 121.
 simplicialis, 121.
 Pilocrocis *inguinalis*, 112.
 plumbicostalis, 112.
 ramentalis, 112.
 tripunctata, 112.
 tristigmalis, 112.
 Pinipestis *amatella*, 129.
 Pinophilus *latipes*, 198.
 vermiformis, 198.
 Pipistrellus **abaensis**, 409, 411, 413, **442**,
 487, **531**.
 musculus, 409, 411, **443**, 482, 486,
 489, **532**.
 nanus, 409, 411, 412, 413, **441**, 487,
 489, **529-531**.
 Plathyphena *scabra*, 81.
 Platœceticus *gloveri*, 105.
 Platychora *labasi*, 203.
 Platydemia *antematum*, 214.
 apicale, 214.
 pivicorne, 214.
 Platynota *flavedana*, 139.
 metallicana, 139.
 rostrana, 139.
 tinctana, 139.
 Platyptilia *crenulata*, 135.
 edwardsii, 135.
 Platysenata *videns*, 54.
 Platyæniodus, 751.
 Platytes *punctilineella*, 126.
 Plecodus, 751.
 Plectromerus *dentipes*, 209.
 Pleonectyptera *albooctaliata*, 67.
 geometralis, 67.
 habitalis, 67.
 pyralis, 67.
 Plesiadapidæ, 833.
 Plesiadapis, 833, 836.
 Plestiodon *quinquelineatus*, 627.
 Plethodon *æneus*, 602.
 dorsalis, 602.
 Plethodon *erythronotus*, 602, **606**.
 glutinosus, 603.
 jordani, 602.
 metcalfi, 602, **604**.
 shermani, 602.
 wehrlei, 602.
 yonahlossee, 598-603.
 Pleurasympieza *smithii*, 57.
 Pleuroprucha *insulsaria*, 88.
 Ploceëlla, 261, 262, 268.
 javanensis, 368.
 Ploceidæ, **243-280**: proposed classifica-
 tion of, 261; Reichenow's classifica-
 tion of, 262; Shelly's classifica-
 tion of, 263.
 Ploceinæ, 243, 244, 251, 261, 262, 263;
 dry-season or winter plumages in,
 259.
 Plocepasser, 261, 262, 263, 266.
 mahali, 266.
 melanorhynchus, 266.
 superciliosus, 266.
 Ploceus, 261, 262, 263, 268.
 baya, 268.
 manyar, 268.
 Plusia *ærea*, 64.
 Plutella *maculipennia*, 141.
 Poephila *contempta*, 76.
 deleta, 76.
 erasa, 76.
 herbicola, 76.
 pacalis, 76.
 quadrifilaris, 75.
 turbata, 76.
 Podiasa *chiococcella*, 146.
 Pœcilothrissa, 655, 677.
 Poephila, 261, 279.
 gouldiæ, 279.
 Polycentropsis, 750.
 Polycesta *angulosa*, 205.
 porcasta, 205.
 thomæ, 205.
 Polyderces *zonatus*, 217.
 Polygaster **brasiliensis**, 224.
 Polygonia *interrogationis*, 15.
 Polygrammata *hebraica*, 54.
 Polyhymno *luteostrigella*, 141.
 Polypteridæ, 734, 746.
 Polypterus, 746.

- Polypterus congicus*, 657, 661, **664**.
 ornatipinnis, 656, 657, 662, **664**.
 palmas, 657, 661, 662, **665**.
Pontia monuste, 8.
 monuste var. *phileta*, 9.
 protodice, 9.
 rapæ, 9.
Poospiza melanoleuca, 589.
 whitii, 588, 589.
Porrina sanguinea, 62.
Potamothrissa, 655, 677.
 Pre-Cambrian and Triassic diabase in
 eastern Pennsylvania, 173–181.
Prenes nero, 35.
 ocola, 35.
 panoquin, 35.
 panoquinoides, 35.
Prepodes, 216.
Prionapteryx achatina, 125.
 nebulifera, 125.
Prionoxystus robinæ, 108.
Pristis pectinatus, 876.
Prochalia pygmæa, 105.
Prodenia commelinæ, 56.
 dolichos, 56.
 eridania, 56.
 ornithogalli, 56.
 ornithogalli var. *eudipta*, 56.
Prodoxus quinquepunctella, 146.
Prolabia, **643**.
 arachidis, 636.
 dominicæ, 636, **643**.
 jamaicana, 636, **645**.
 unidentata, 636, **647**.
Prolimacodes badia argentimacula, 106.
Pronuba yuccasella, 146.
Proroblemma testa, 69.
Proserpinus guaræ circæ, 42.
Prostemodes dominicensis, 209.
Prosternodes cinnamipennis, 209.
Prostomeus brunneus, 142.
Protambulyx carteri, 39.
 rubripennis, 38.
 strigilis, 38.
Protapirus, 576.
Prothymia rhodarialis, 67.
 semipurpurea, 68.
Protogonodon, sp. nov., 822.
Protoparce brontes cubensis, 37.
 quinquemaculata, 37.
 rustica, 37.
 sexta, 37.
Protopterus, 746.
 dolloi, 657, 659, **665**.
Psalis americana, 635, **637**.
 buscki, 637.
 colombiana, 637.
 distincta, 637.
 gagathina, 637.
 procera, 637.
 robusta, 637.
Psaphidia resumens, 57.
Pseudanaphora arcanella, 147.
Pseudanarta aurea, 57.
Pseudanthroëcia coracias, 78.
Pseudomus semicribratus, 217.
Pseudomyia minima, 45.
Pseudonigrita, 261, 262, 266.
 arnaudi, 266.
Pseudospermestes, 261.
Pseudosphinx tetrio, 39.
Psiloptera aurifera, 205.
Psittacotherium, 822.
Psychomorpha epimenis, 63.
 euryrhoda, 63.
Psyllobora lineola, 200.
 nana, 200.
Pterætholix bullula, 65.
Pterocharis eggersi, 194.
Pterophorus bipunctatus, 135.
 cervinicolor, 136.
 inquinatus, 136.
 kellicottii, 135.
 monodactylus, 135.
 perplexus, 136.
 rhynchosiæ, 135.
 simplicius, 136.
 unicolor, 136.
Pteropus edulis, 482.
 haldemani, 421.
Ptinus niveicollis, 206.
Pyania tristis, 214.
 undata, 214.
Pygarcia abdominalis, 51.
 grossbecki, 51.
 vivida, 51.
Pyragra buscki, 636.
Pyragropsis buscki, 635, **636**.

- Pyrallis farinalis*, 122.
 manihotalis, 122.
Pyrausta acronalis, 118.
 æglealis, 118.
 illibalis, 118.
 inornatalis, 119.
 laticlavata, 118.
 orphisalis, 118.
 oxydalis, 118.
 penitalis, 118.
 phœnicealis, 118.
 signatalis, 119.
 submedialis, 118.
 theseusalis, 118.
 thestealis, 118.
 tyralis, 119.
Pyrenestes, 261, 262, 263, 276.
 ostrinus, 276.
 ostrinus gabunensis, 276.
Pyrgus tessellata, 28.
Pyromelana, 261, 262, 263, 272.
 flammiceps, 272.
 oryx, 272.
Pyromorpha centralis, 107.
Pyrophila tragopoginis, 56.
Pyrophorus longipennis, 205.
Pytilia, 261, 262, 263, 276.
 melba belli, 276.
 phænicoptera emini, 276.

QUELEA, 245, 261, 262, 263, 272.
 æthiopica, 272.
 cardinalis, 272.
 quelea, 272.

RACHEOSPILA atrapes, 87.
 catachloa, 87.
 cupidenaria, 87.
 extremaria, 87.
 gerularia, 87.
 hollandaria, 87.
 jaspidiaria, 87.
 lixaria, 86.
 rubrolinearia, 87.
 saltusaria, 88.
 sitellaria, 87.
 viridipurpurea, 87.
Rana catesbeiana, 623.
 clamitans, 623.
 Rana opisthodon, 812.
 palustris, 623.
Raphygnathus pectinatus, 151.
Rasbora, 748.
Rehn, James A. G., and Hebard, Morgan,
 studies in West Indian earwigs (Der-
 maptera), 635-651.
Reichenowia, 261, 262.
Remigia repanda, 75.
 repanda var. *disseverans*, 75.
 repanda var. *marcida*, 75.
Renia fraternalis, 80.
 salusalis, 80.
 sobrialis, 80.
 sobrialis var. *larvalis*, 80.
Rhabdoides cellus, 27.
Rhabdoptera picipes, 211.
Rhacius sulcatulus, 214.
Rhacophorus schlegeli, 812.
Rhantus calidus, 196.
Rhaphidorrhynchus nitidicollis, 218.
Rhinolophidæ, 414, 486.
Rhinolophus abæ, 409, 411, 413, **428**,
 487, **523**.
 axillaris, 409, 411, 413, **429**, 487,
 523.
 hildebrandti eloquens, 409, 410,
 428, 487, **522**.
Rhinopoma microphyllum, 488, 495.
Rhinoptera sp., 766.
Rhipidandrus micrographus, 213.
Rhipidophorus, 216.
Rhipiphorus sordidum, 216.
Rhizopertha pusilla, 207.
Rhizophagus heydeni, 203.
Rhodophora gauræ, 62.
Rhombodera bicolor, 195.
 flavipes, 195.
Rhothonia, 861.
Rhynchophorus palmarum, 218.
Roeselia minuscula, 47.
Rupela albinella, 123.
 unicolor, 124.
Rutela formosa, 208.

SABULODES politia, 102.
 transversata, 102.
Saccolaimus peli, 406, 407, 408, 411, 412,
 413, **424**, 482, 486, **515**, 559.

- Sacium instabile*, 199.
Salebria afflictella, 130.
 celtidella, 130.
 georgiella, 130.
 slossonella, 130.
Salia interpuncta, 81.
Salmo, 747.
Salmonidæ, 747.
Salpornis salvadori, 259.
Samea ecclesialis, 112.
 multiplicalis, 112.
Samia cecropia, 43.
Sannina uroceriformis, 109.
Sarasota plumigerella, 128.
Sarcodaces, 747.
 odoë, 656, 657, 659, 660, 661, 662, **677**.
Satyrodes canthus, 18.
Scelolophia crossii, 89.
 pannaria, 89.
 purpurascens, 89.
 rubrotincta, 89.
Sceloporus undulatus, 627.
Scelorthus pisoniella, 144.
Scepsis fulvicollis, 46.
Schilbe, 749.
 congolensis, 656, 659, 660, **710**.
 mystus, 657, 658, 662, **709**.
Schinia arefacta, 62.
 espea, 62.
 lynx, 62.
 marginata, 62.
 meskeana, 62.
 petulans, 62.
 saturata, 62.
 trifascia, 62.
 tuberculum, 62.
Schizotherium, 576.
Schizura apicalis, 84.
 concinna, 84.
 ipomœa, 84.
 semirufescens, 84.
Schoenobius melinellus dispersellus, 124.
 unipunctellus, 124.
 sordidellus, 124.
 tripunctellus, 124.
Schubotzia, 751.
 Schulte, H. von W., the skull of *Kogia breviceps*, 361-404; a note on the lumbar vertebræ of *Scutisorex*, 785-792.
Sciagraphia aucillaria, 94.
 continuata, 93.
 granitata, 93.
 simulata, 94.
Sciocharella pertenuis, 199.
Sciocharis bakeri, 199.
Scirophaga consortalis, 124.
 perstrialis, 124.
Scirus simplex, 150.
Scolecocampa liburna, 66.
Scopæus angusticollis, 199.
 antennalis, 199.
 auripilis, 199.
 marginatus, 199.
 simpliciollis, 199.
 umbra, 199.
Scoparia basalis, 122.
 strigalis, 122.
Scoteinus schlieffenii, 410, 413, **447**, 487, **536**.
Scotophilus altilis, 447.
 nigrita nux, 447.
 nux, 406.
Scotozous ruppelii, 409, 413, **443**, 486, **533**.
 tenuipinnis, 486.
Scutisorex congieus, skeletal characters, 769-781.
 field notes on, 781-783.
 lumbar vertebræ, 785-792.
 taxonomic status, 781.
Scymnus loewii, 200.
 ochroderus var. *cyanipennis*, 200.
 thoracicus, 200.
Scythris trivinctella, 144.
Seiractia echo, 51.
Selenis monotropa, 78.
Selenophorus aeneocupreus, 194.
 alternans, 194.
 chalybæus, 194.
 cuprinus, 194.
 discopunctatus, 194.
 falvilabris, 194.
 integer, 194.
 parumpunctatus, 194.
 propinquus, 194.
 pyritosus, 194.

- Selenophorus sinuatus*, 194.
Selidosema cypressaria, 96.
 humarium, 96.
 insaria, 99.
 muricolor, 99.
Semnopsyche diana, 14.
Seneca tumidulella, 131.
Senta enervata, 54.
Sericoptera virginaria, 100.
 virginaria var. *vestalis*, 100.
Sesia fadus, 41.
 tantalus zonata, 41.
Setiostoma xanthobasis, 141.
Sharpia, 263.
Siavana repanda, 75.
Sibine stimulea, 105.
Sigela basipunctaria, 69.
 penumbrata, 69.
Siluranodon, 749.
Siluridæ, 736, 748, 749.
Silvanus rectus, 201.
 surinamensis, 201.
Simochromis, 750.
Simyra albovenosa, 54.
Sinoxylon floridanum, 207.
Sisyrhypena orciferalis, 80.
Sitagra, 261, 262, 263, 268.
 heuglini, 268.
 luteola, 268.
 monacha, 268.
 tænioptera, 268.
Slossonella tenebrosa, 106.
Smicrips hypocoroides, 203.
 Smith, Herbert H., see Townsend,
 Charles H. T.
Solenoptera, 209.
Sparganothis taracana, 139.
Spathodus, 751.
Spelerpes bislineatus, 618.
 ruber ruber, 616.
 ruber schencki, 613-616.
Spermestes, 262, 273.
 cucullata, 273.
 poensis stigmatophora, 273.
Spermestinæ, 244, 262.
Spermophagus hoffmanseggii, 213.
Spermospiza, 244, 252, 261, 262, 263,
 275.
 guttata, 275.
 Spermospiza poliogenys, 275.
Sphæcelodes vulneraria, 103.
Sphenophorus liratus, 218.
 longicollis, 218.
 quadrisignatus, 218.
 sacchari, 218.
 sordidus, 218.
Sphida anoa, 61.
 obliqua, 60.
Sporæginthus, 261, 277.
 subflavus, 277.
Sporopipes, 261, 262, 263, 266.
 frontals, 266.
 squamifrons, 266.
Spragueia dama, 70.
 leo, 70.
 onagrus, 70.
 transmutata, 70.
Staganopleura, 261, 262.
Stannoderus apicalis, 198.
 bernhaueri, 198.
 dissimilis, 198.
 varians, 198.
Staphylus hayhurstii, 28.
Stappersia, 751.
Statina roseotinctella, 134.
Steatocranus, 750.
 gibbiceps, 662, 727.
Steganura, 258, 261, 262, 280.
 paradisea, 258, 280.
Steirastoma depressum, 210.
Stelidota geminata, 203.
 runderata, 203.
Stenia indianalis, 121.
Steniodes gelliasalis, 122.
Stenodontes exsertus, 209.
Stenophyes huronalis, 116.
Stenoptilia pallistriga, 137.
Stenoptycha pterophoralis, 119.
Stenotrachelys approximaria, 96.
Stenous tibialis, 195.
Stenus (Mesotenus) lucens, 198.
Stephanoderes cubensis, 219.
 depressus, 219.
 elongatus, 219.
 flavicollis, 219.
 gossypii, 219.
 minutus, 219.
 nitidipennis, 219.

- Stephanoderes nitidulus*, 219.
 obesus, 219.
 obliquus, 219.
 opacifrons, 219.
 setosus, 219.
 squamosus, 219.
 subconcentralis, 219.
 subopacicollis, 219.
 unicolor, 219.
Sternechus, 216.
 pectoralis, 216.
 vicinus, 217.
Stethoxus insularis, 197.
 intermedius, 196.
Stictospiza, 261, 262.
Stigmella condaliafoliella, 145.
 myricafoliella, 145.
Stilicopsis auripilis, 198.
 circumflexus, 198.
Stilicus agnatus, 198.
 cupreus, 198.
 insularis, 198.
 jucundus, 198.
Stizocera, 209.
Stizoptera, 261.
Stomatorhinus, 746.
 humilior, 661, 670.
 microps, 657, 661, 670.
Stomyles celia, 33.
 fusca, 33.
 textor, 33.
Storeria occipitomaculata, 629.
Strategus julianus, 208.
 syphax, 208.
 tricornis, 208.
Stratiotes iracundus, 195.
Strymon titus, 25.
Styracopus phaseoli, 217.
Styracosaurus, 281.
Sufetula diminutellus, 110.
Sycobrotus, 263.
Sylectra erycata, 71.
Sylepta elevata, 114.
 fluctuosalis, 114.
 masculinalis, 114.
 obscuralis, 114.
 penumbralis, 114.
Sylviidæ, 263.
Sylvilagus gabbi consobrinus, 335.
Sylvilagus somereni, 769.
Symmerista albifrons, 83.
Symplectes, 261, 262.
Synanthedon exitiosa, 108.
 exitiosa var. *fitchii*, 108.
 floridensis, 109.
 geliformis, 109.
 marica, 109.
 pictipes, 109.
 pyri, 109.
 ruficornis, 109.
 sapygæformis, 109.
 seminole, 109.
 texana, 109.
Synchita granulata, 201.
 laticollis, 201.
Synchlora ærata, 87.
 denticularia, 87.
 hulstiana, 87.
 xysteraria, 87.
Synclera traducalis, 111.
Syneda faceta, 73.
 graphica, 73.
 graphica var. *media*, 73.
Synelys enucleata, 89.
 nigrocandida, 89.
 subquadrata, 89.
 timandrata, 89.
 umbilicata, 89.
Synodontis, 749.
 acanthomias, 656, 658, 660, 662, **716**.
 afro-fischeri, 655, 658, 660, 662, **716**.
 alberti, 657, 662, **718**.
 angelicus, 662, **717**.
 decorus, 656, 657, 658, 660, 662, **719**.
 depauwi, 656, 657, 658, 660, 662, **717**.
 greshoffi, 656, 658, 660, 662, **718**.
 longirostris, 662, **717**.
 notatus, 657, 662, **719**.
 pleuropis, 656, 658, 660, 662, **719**.
 soloni, 662, **717**.
 tenuis, 655, **717**.
Syntomeida epilais jucundissima, 45.
 ipomeæ, 45.
Syringosoma, 232.
 pennipes, 233.

- TACHYRIS margarita, 8.
 margarita var. neumoeegenii, 8.
 Tachys picturatus, 194.
 Tachyta autumnalis, 194.
 Tæniopygia, 261, 262.
 Tæniotes scalaris, 210.
 Tallula atrifascialis, 128.
 Tampa dimediatella, 134.
 Tanagra bonariensis, 580.
 Taphousus mauritanus, 406, 408, 411,
 412, 413, **423**, 487, 490, 495, **513**.
 peli, 424.
 sudani, 408, 411, **423**, 487, **514**.
 Tarache aprica, 70.
 aprica var. ceyvestenis, 70.
 biplaga, 70.
 candefacta, 70.
 delecta, 70.
 quadriplaga, 70.
 tenuscens, 70.
 terminimaculata, 70.
 tetragona, 70.
 Tegeocranus **subniger**, 163.
Tegoribates, 158.
 subniger, 159.
 Telea polyphemus, 44.
 Teleoceras, 576.
 Teleostean vertebra, 766.
 Telephanus cribratus, 201.
 strictus, 201.
 Telmatochromis, 751.
 Telmatolestes, 843.
 crassus, 852.
 Temnochila hubbardi, 204.
 Tenebroides transversicollis, 204.
 Tenuipalpus **erythreus**, 152.
 Terastia meticolosalis, 115.
 Terias blakei, 12.
 Terrapene carolina, 626.
 Tetanolita mynesalis, 80.
 palligera, 80.
 Tetrabothynus, 216.
 Tetracha acutipennis, 193.
 carolina, 193.
 carolina var. occidentalis, 193.
 sobrina, 193.
 sobrina var. antiguana, 193.
 sobrina var. infuscata, 193.
 Tetracænodon, 822, 825.
 Tetrænura, 261, 262.
 Tetralopha querciella, 128.
 robustella, 128.
 subcanalis, 128.
 Tetraonyx 4-maculatus, 216.
 Tetrodon mbu, 658, 659, 660, 662,
 733.
 miurus, 662, **734**.
 Textor, 262, 263, 265.
 albirostris, 249–250, 265.
 albirostris intermedius, 265.
 albirostris senegalensis, 251.
 niger, 265.
 Textoridæ, 250.
 Thalpochara ætheria, 68.
 Thamnophis sirtalis, 629.
 Thanaos brizo, 29.
 funeralis, 30.
 horatius, 29.
 icelus, 29.
 juvenalis, 29.
 nævius, 29.
 petronius, 29.
 platus, 30.
 somnus, 28.
 terentius, 29.
 Thaneroclerus, 206.
 buqueti, 206.
 girodi, 206.
 Thaumatopsis floridella, 126.
 pectinifer, 126.
 Thecla favonius, 24.
 wittfeldii, 24.
 Theoborus theobromæ, 220.
 Therina fervidaria, 100.
 fiscellaria, 100.
 Thermonectes circumscriptus, 196.
 margineguttatus, 196.
 Thespies macareus, 33.
 Thinobius miricornis, 198.
 Thinocharis fuscina, 199.
 amithi, 199.
 Thinolestes, 843.
 Tholeria reversalis, 117.
 Thoracophorus guadalupensis, 198.
 Thorybes daunus, 28.
 Thraupis bonariensis, 587.
 Throscidium invisible, 199.
 Thymelicus baracoa, 31.

- Thymelicus brettus*, 31.
 cernes, 31.
 otho, 31.
Thyridopteryx ephemeræformis, 104.
 pallidoventa, 104.
Thyris lugubris, 107.
Thysania zenobia, 79.
Thysanopsis, 231.
 albicauda, 231.
 Tiffany beds, 829.
 Tilapia, 750.
 acuticeps, 655, 662, **726**.
 andersonii, 726.
 boulengeri, 662, **726**.
 christyi, 656, **726**.
 dolloi, 662, **726**.
 fasciata, 662, **726**.
 lepidura, 659, 662, **726**.
 melanopleura, 657, 658, 660, 662, **726**.
 stigmatogenys, 655.
 stormsi, 662, **727**.
 tholloni, 726.
 williamsii, 662, **727**.
Timetes chiron, 17.
Tinea seminoella, 146.
Tioga apastella, 128.
Tlascala finitella, 130.
Tolyte mintæ, 86.
Tomarus acutus, 202.
Tomitherium, 843.
 rostratum, 849, 850, 851.
Tornos cinctarius, 96.
 scolopacinaria, 96.
Torosaurus, 281.
Tortrix chioccana, 140.
 ivana, 140.
 peritana, 139.
 seminolana, 140.
Tosale oviplagalis, 123.
 Townsend, Charles H. T., second paper on Brazilian Muscoidea collected by Herbert H. Smith, 221-233.
Trachelizus linearis, 218.
Trachyderes succinctus, 210.
Trachyglanis, 750.
Trachyoribates zeteki, 159.
Trachyuropoda longa, 158.
Trama detrahens, 77.
Trama hinna, 77.
Trematocara, 751.
Tribolium confusum, 214.
 ferrugineum, 214.
 Tricentes, 822, 825.
Triceratops, 281.
Trichinochæta, 224.
 orbitalis, 224.
Trichoptilus centetes, 135.
 lobidactylus, 135.
Trichostibas calligera, 141.
 parvula, 141.
Trichotaphe condaliavorella, 142.
 flavocostella, 142.
 melantherella, 142.
Trigonias, 576.
Tripselia fryeri, 559.
Tripudia quadrifera, 69.
Trivolusia roseopennella, 134.
Trochiloleskia, 226.
 flava, 227.
Trogoderma insulare, 202.
Trogolemur, 833, 837.
Trogophloeus aridus, 198.
 smithi, 198.
Tropæa luna var. *dictynna*, 43.
Tropheus, 750.
Tropisternus chalybeus, 197.
 collaris, 197.
 lateralis, 197.
 ovalis, 197.
Trox suberosus, 208.
Trypetes guildini, 217.
Tryphæa semirufa, 202.
Typophorus viridicyaneus, 211.
Tyrissa multilinea, 69.
 UINTASOREX, 833, 837.
Uloma retusa, 214.
Ulophora caricæ, 129.
Ulosomus furo, 217.
 laticaudis, 217.
Ulosonia biimpressa, 214.
Uræginthus, 261, 262, 278.
 bengalus, 278.
Uranotes melinus, 23.
Urobrachya, 261, 262, 263.
Uroloncha, 261, 263.
Utetheisa, 340.

- Utetheisa bella*, 52.
 bella var. *terminalis*, 52.
 bella var. *venusta*, 52.
 elata, 342.
 ornatrix, 51.
 ornatrix bella, 341, 342.
 ornatrix ornatrix, 341, 342.
 ornatrix stretchii, 341, 342.
 ornatrix venusta, 341, 342.
 pulchella, 342.
 semara, 342.
- VANESSA atalanta*, 15.
 cardui, 15.
 huntera, 15.
- Varicorhinus*, 748.
- Varneria atrifasciella*, 133.
- Vespertilio bocagii*, 439.
 hispidus, 425.
 minuta, 445.
 nanus, 441.
 rüppellii, 443.
 vampyrus helvus, 414.
- Vespertilionidæ*, 414, 486.
- Vesperugo* (*Vesperus*) *moloneyi*, 446.
- Vesperus tenuipinnis*, 443.
- Victorina steneles*, 16.
- Vidua*, 261, 262, 263, 279.
 serena, 250, 256, 257, 279.
- Viduinæ*, 243, 244, 263.
- Viereck, Henry L., new species of bees of the genus *Andrena*, from Equatorial Africa, in the American Museum of Natural History, 235-239; contributions to our knowledge of the bee genus *Perdita*, 241-242.
- WALSINGHAMIA diva*, 141.
 slossonia, 141.
- Watson, Frank E., see Grossbeck, John A.
- Wekiva nodosella*, 134.
- Whydahs, general view of, 256.
- Wunderia**, 133.
 neæriatella, 133.
- XANTHOMELANOPSIS brasiliensis**, 233.
- Xanthopastis timais*, 63.
Xanthophilus, 261, 262, 263.
 capensis, 250.
 xanthops, 270.
- Xanthoptera nigrofimbria*, 68.
 semiflava, 68.
- Xanthotype crocataria*, 100.
- Xenocharax*, 748.
- Xenochromis*, 751.
- Xenomystus*, 746.
 nigri, 657, 662, 674.
- Xenopomatchichthys*, 747.
- Xenotilapia*, 751.
- Xyleborus affinis*, 220.
 ferrugineus, 220.
 grenadensis, 220.
 inermis, 220.
 perforans, 220.
 sacchari, 220.
- Xylestia pruniramiella*, 146.
- Xylocleptes carbonarius*, 220.
 limbatus, 220.
- Xylographus*, 206.
- Xylopertha*, 207.
- Xylophanes chiron nechus*, 43.
 pluto, 43.
 porcus, 43.
 porcus continentalis, 43.
 tersa, 43.
- Xylophilus* (*Hylophilus*) *atomarioides*, 215.
 (*Hylophilus*) *halticiodes*, 215.
- YPOPHÆMYIA malacosomæ brasiliensis**, 231.
- ZALE horrida*, 78.
Zanclognatha lituralis, 79.
- Zanycteris paleocenus**, 569-571, 831.
- Zerena cæsonia*, 10.
- Zonæginthus*, 261.
- Zophobas morio*, 214.
- Zuphium americanum*, 195.
- Zygæna lichas*, 343.
- Zygosturmia protoparcis meridionalis*, 231.
- Zylomeira torquata*, 207.